

Ethnobotany, Phytochemistry, Pharmacological Activities and Therapeutic Potential of *Kigelia africana*: A Comprehensive Review

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ABSTRACT

The present research comprehensively studies the ethnobotanical, phytochemical and pharmacological profile of *Kigelia africana* (Lam.) Benth. (Bignoniaceae) often known as the sausage tree. The main goal is to connect traditional healing practices in Africa with modern health care by gathering global literature on its biological use, structural parts and industrial prospects. This study assesses the peer-reviewed literature on the distribution, traditional use, extraction methods and therapeutic characteristics of the plant through a literature search that includes historical ethnobotanical records, regional pharmacopoeias and modern databases. The main phytochemical ingredients in different portions of the plant are a number of iridoids (for example, verminoside and catalpol), flavonoids (luteolin and kigelin derivatives), coumarins, naphthoquinones, phenolic acids (ferulic and chlorogenic acid), and important terpenoids. The traditional uses are supported by documented pharmacological actions with potent antibacterial, antioxidant, anti-inflammatory, wound-healing, anticancer and antidiabetic activities. Significant research shortcomings persist despite an abundance of documentation, including the absence of rigorous randomised clinical trials to confirm traditional claims, standardised methodologies for extraction to maximise yields of actives, comprehensive toxicological and pharmacokinetic profiling of unrefined fruit extracts, and sustainable conservation strategies to minimise habitat degradation from over-extraction. Filling these gaps will enable translation of *Kigelia africana* metabolites into standardised safe and efficacious modern pharmaceutical and cosmetic preparations.

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INTRODUCTION

Highlight

- Medicinal plants are essential botanical components of traditional medicinal formulations; however, numerous species are currently endangered due to unsustainable harvesting, habitat degradation, and land-use change.
- Kigelia africana*, commonly known as the cucumber tree, has long been associated with therapeutic properties, and these have been scientifically substantiated.

- It exhibits antimicrobial activity; promotes wound healing; provides skin-soothing benefits; rejuvenates and nourishes; and possesses antioxidant and anti-inflammatory properties that help manage reactive oxygen species and anxiety-induced inflammatory disorders, including cancers, as well as anti-diabetic effects, highlighting its prospective application in modern medicine by facilitating the development of novel pharmaceuticals that tackle microbial resistance, an escalating global health concern.

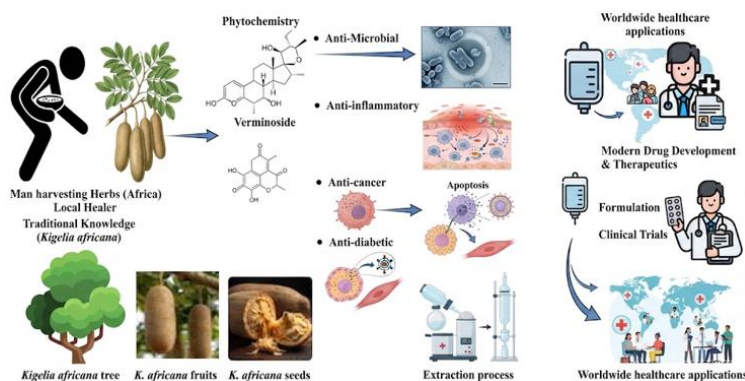


Figure 1: *K. africana*: From Ethnobotany to modern therapeutics

Context of Traditional and Modern Medicine

Since prehistoric times, humans have used natural products, such as plants, animals, microorganisms, and marine organisms, in medicines to alleviate and treat diseases. According to fossil records, the human use of plants as medicines may be traced back at least 60,000 years (Yuan *et al.*, 2016; Shi *et al.*, 2010), relying on cultural beliefs, natural products, and intergenerational knowledge. Traditional medicines (TMs) make use of natural products and are of great importance. Such forms of medicine as traditional Chinese medicine (TCM), Ayurveda, Kampo, traditional Korean medicine (TKM), and Unani employ natural products and have been practiced all over the world for hundreds or even thousands of years, and they have blossomed into orderly-regulated systems of medicine. In their various forms, they may have certain defects, but they are still a valuable repository of human knowledge (Shi *et al.*, 2010; Gao *et al.*, 2007). Therefore, traditional medicine is understood as a culturally rooted practice that embraces a holistic approach to health by treating the whole person—mind, body, and spirit—rather than just isolating specific symptoms. It includes many modalities such as herbal medicine, acupuncture, spiritual treatments, manual therapies, and traditional food habits. Traditional medicine is an important source of primary health care for millions of people worldwide and is used as a complementary medication in developed countries. Increasingly, traditional medicine is being exposed to modern scientific validation to assess its pharmacology, active ingredients, safety and efficacy (Fabricant and Farnsworth, 2001). Modern medicine is an 18th and 19th century phenomenon, with its emphasis on science, clinical evidence and targeted testing. Modern medicine is better and more effective because it has particular ways of diagnosing and treating diseases that have been scientifically verified. This makes the process easier and saves time and resources. There is no formal proof in science for TM, and it may take longer to demonstrate results. In modern medicine, sickness is defined primarily in biological terms. Traditional medicine takes a comprehensive approach, including spiritual, psychological and social dimensions. Traditional and modern medicine are not in competition with each other, but complementary to each other. While contemporary medicine is excellent in clinical therapy, traditional medicine fills the gap since it caters to human and holistic needs to promote wellness generally. Conventional medicine encompasses specific methodologies that utilize flora, fauna, and inorganic substances, alongside intuitive practices that require offerings to deities (Tabuti *et al.*, 2012). Medicinal flora constitute the fundamental botanical constituents in conventional medicinal preparations; however, the species that yield these elements are currently at risk due to unsustainable extraction, habitat modification, and conversion, endangering most plant species (Nabatanzi *et al.*, 2020). Conventional medicine is based on a

reductionist biology paradigm that can overlook the holistic, lifestyle and psychosocial aspects of health. It is sometimes costly and has risks of synthetic adverse pharmaceutical reactions. Clinical trial validation is not consistent, active dosages and regulatory control may result in unequal treatment efficacy and potential herb-drug interactions or toxicity in traditional therapy.

Kigelia africana (Lam.) Benth is a species commonly found in central, western, and southern regions of Africa, Synonym: *K. pinnata* (Jacq.) DC. It is part of the Bignoniaceae family, a genus derived from the Mozambican term "*kigeli-keia*," meaning "sausage tree." *Kigelia africana*, a species indigenous to Africa, exhibits unique characteristics that inform its designation "*africana* (Smithies, 2003). The substantial fruits (approximately 0.6 m long and weighing 4 kg) of *Kigelia africana*, referred to as the cucumber or sausage, hang from elongated, fibrous stalks. It is brought into Southeast Asian nations, including India (mainly in West Bengal), Pakistan, China, the Philippines, Assam, Ecuador, South-western Mexico, (Onyambu *et al.*, 2019) and Iraq. These nations primarily grow it for its ornamental value, frequently found in parks and botanical gardens due to its striking red blossoms and unique pomegranates. The lively tree is a popular decorative variety in Miami and South Florida landscapes (Austin, 1978), providing shade to inhabitants from the intense sun (Kaur *et al.*, 2011; Austin, 1978). In various regions of Southeast Asia (Lal and Yadav, 1983; Lim, 2012), *K. africana* was among the first equatorial agricultural products introduced to the Americas by James L. Nugent (Henry, 1949), the vast pergolas of this grove provide a beneficial refuge in extensive grassy areas.

While the individual pharmacological activities or traditional uses of *Kigelia africana* have been reported in previous studies, there is no comprehensive synthesis available that correlates traditional knowledge with the present industrial, ecological and clinical needs. Hence, the present work makes a unique contribution to the field by providing an integrated framework for linking the ethnomedicinal heritage with modern green extraction techniques, critically evaluating translational and regulatory challenges, and proposing sustainable conservation strategies that are vital for its future global application.

K. Africana Habitat

This plant typically thrives in damp environments, showing a broad distribution across moist savannah and riverbank habitats (Singh *et al.*, 2018). It primarily favors humid habitats and is usually found along the banks of rivers, streams, savannahs, and alluvial prairies in countries such as Cameroon, Senegal, Nigeria, Guinea, and Kenya. Additionally, it is located within extensive woodlands that extend from Chad, Namibia, and KwaZulu-Natal in South Africa to Tanzania.

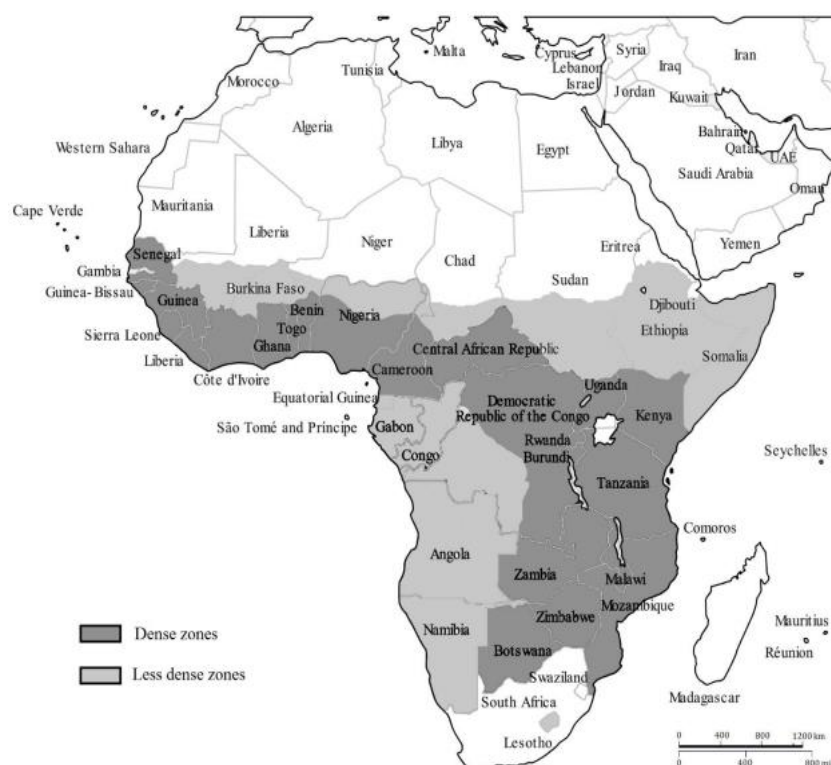


Figure 2: A cartographic representation of *Kigelia africana* illustrating its indigenous geographical distribution (Modified from FAO, 1986)

Worldwide Common Names for *K. Africana*

Across the African continent, *K. africana* is commonly known as the sausage tree (Bello *et al.*, 2016; Fagbohun *et al.*, 2020a; Imran *et al.*, 2021). This name, often referred to as the "banger plant" (Imran *et al.*, 2021; Farah *et al.*, 2017) originates from its elongated shape and large fruit. The *Kigelia* species native to Africa has various local names, including balam kheera and hathi bailan (Hindi, India); yago (Luo); shiva kundalam (Malayalam); yaanai pudukan (Tamil, India) (Beidelman, 1964; Smith, 1966; Sofowora, 1980); nufuten and nufutsen (Twi, Ghana); worsboom (Afrikaans, South Africa); pandoro, orara, orora, and uyan (Yoruba, Nigeria); muratina (Kikuyu, Kenya); mbungati, mwegea, mnyegea, and mvongonya (Swahili, Southeast Africa); dobale, dabal, diambal, dabole, and dombale (Wolof, Senegal); yago (Luo, Kenya); jago (Luo, Uganda); and limbi, lamban, and didon (Malinke, Guinea) (Bello *et al.*, 2016). Additional names include "muatine" (Kamba), "murati" (Kikuyu), "ratuinet" (Kipsigis), "kumufunga" (Luhya), "yago" (Luo), "oldarpo" (Maasai), "muratina" (Meru), "rotio" (Marakwet), "ratinuet" (Nandi), "bogh" (Orma), "mbwoka" (Pokomo), "muun" (Rendile), "imombi" (Samburu), "bukuraal" (Somali), "mwengea" (Swahili), "mwasina" (Taita), "mukish" (Taveta), and "muthigu" (Tharaka) (VanWyk, 2002; Singh, *et al.*, 2018; Halder, 2017).

The traditional medicinal use of *K. africana* has sparked significant academic interest regarding the pharmacological properties of this species (Focho, *et al.*, 2009; Halder, 2017; Singh, *et al.*, 2018). This examination merges traditional African healing practices with contemporary international healthcare by exploring *K. africana*'s biological applications

as a resource for innovative medicines and treatments. It encompasses ethnobotany and modern medical practices, alongside its traditional uses, pharmacological value, and commercial significance, as well as its potential applications in other fields

The Conventional Medicinal uses of *Kigelia Africana*

Members of the Bignoniaceae family are vital to traditional medicine, with *K. africana* exemplifying this significance. The utilisation and application of *K. africana* plant parts in traditional medicine vary across ethnic communities. Notwithstanding discrepancies in preparation and application, a notable convergence in their use is evident across many locations and nations. The sausage pome has intrigued botanical scholars and cultural historians worldwide, who have methodically documented its uses across many societies. Ethnoveterinary medicine uses fruits to address enhanced gastrointestinal ailments, limb swelling, skin conditions, udder infections, Newcastle disease, brucellosis, and retained placenta.

Applications Beyond Pharmaceuticals

The plant serves various functions in African societies. In addition to its traditional medicinal uses, African societies utilise it as fodder for animals. Primates, hippopotamuses, and baboons consume the fruit seedlings, whereas elephants and giraffes feed on the foliage, despite the fact that the unrefined pome is poisonous and, in essence, unsuitable for ingestion by individuals due to its propensity to induce skin blisters and a laxative impact on the intestines (Neuwinger, 1997; Watt, *et al.*, 1962).

Table 1: Non-pharmaceutical Applications, Cultural Significance, and Material Utilization of *Kigelia Africana*

Category / Application	Plant Part Used	Specific Use / Functional Context	Cultural, Ecological, or Traditional Significance	Reference
Animal Fodder and Wildlife Consumption	Fruit seedlings, foliage, flowers, and decayed fruits	Utilized as fodder for domestic and wild animals; primates, hippopotamuses, and baboons consume fruit seedlings, while elephants and giraffes feed on foliage. Fauna and wildlife also partake in consuming decayed fruits and flowers.	Supports regional wildlife ecology, though unrefined pomes remain unsuitable for human ingestion due to blistering and laxative properties.	Neuwinger (1997); Watt et al. (1962); Nsubuga (2018)
Spiritual and Ritual Practices	Bark and fruit	Utilized to manufacture drinkable witch-concession potions; employed in witch-hunting rituals and to thwart witchcraft.	Ascribed spiritual significance in Zimbabwe for protection and ceremonial confessions.	Beidelman (1964); Campbell et al. (1991)
Cultural Symbolism and Rites	Fruit	Represents the body of a relative who has perished violently in an inaccessible area where body retrieval is impractical.	Serves as a symbolic proxy in the Luo community of western Kenya.	Raintree and Hoskins (1988)
Agricultural and Environmental Utility	Plant structure / Fruit	Regarded as a plant that enhances soil fertility for agricultural use and acts as a talisman or emblem to augment agricultural yield and protect against tempests.	Integrated into local farming traditions to boost harvest success and land productivity.	McGregor et al. (1989)
Traditional Brewing and Fermentation	Bark and fruit	Incorporated into conventional beers and customary alcoholic drinks (such as the Pare tribe's 'dengelua') during the brewing process.	Used to augment metabolism, refine taste, and produce traditional beverages.	Wendelin et al. (1997)
Woodcraft and Material Culture	Trunk, timber, and twigs	Fabricated into dredging vessels, wooden planks, fencing supports, packaging, percussion instruments, mortars, seating, weapon grips, large animal troughs, and weapon bows from twigs. Also used to shape contours for administering children's enemas.	Provides durable timber and structural materials for community tools, transport, and weaponry.	Venter and Venter (1996); Weiss (1979); Burkill (1985)
Storage and Domestic Utility	Trunk	Serves as storage space and functions as a receptacle for fruit and a framework for fishing canoes.	Utilized for domestic storage and aquatic navigation.	Venter and Venter (1996); Weiss (1979)
Famine Food Source	Tough pods / Fruit pulp	Roasted and ingested as a nutritious sustenance during periods of famine, despite raw pulp being hazardous/laxative.	Serves as an emergency food reserve when properly processed during scarcity.	Neuwinger (1997); Watt et al. (1962)
Artisanal Craft and Pigment Production	Wood, fruit, and apple residue	Carved into rodent lures, figurines, utensils, and silver items; tannin-laden apple residue produces a dark pigment; wood functions as fuel.	Demonstrates multi-purpose craftsmanship, artistic expression, and utility as a dye source and energy resource.	Burkill (1985)
Socio-Economic and Protective Talismans	Fruits	Marketed as emblems to signify affluence and achievement, bestowed fortitude and bravery onto warriors, and serve as talismans for fertility or defence against tempests.	Acts as a cultural emblem of status, protection, and psychological strength within community markets.	Burkill (1985)

Importance of *K. Africana***Possibilities for Contemporary Healthcare and Manufacturing**

K. africana displays antibacterial properties that inhibit microbial proliferation, indicating its potential utility in contemporary healthcare. It has also enabled the creation of innovative medications that combat drug resistance, a growing global health issue. Its capacity to heal injuries and diminish scarring has motivated researchers to explore the fundamental processes and validate prevalent assertions, perhaps paving the way for the development of novel pharmaceuticals for wound repair. The importance of antioxidants and anti-inflammatory agents in addressing anxiety-related inflammatory diseases caused by various reactive oxygen species, including cancers and diabetes, has a considerable detrimental effect on human health. Nevertheless, the production of cosmetics employs *K. africana* products to achieve their skin-calming, revitalising, and nourishing qualities. A multitude of cosmetic items, such as soaps, lotions, ointments, and oils, include these extracts. Numerous African cultures employ traditional medicine to address a range of ailments, rendering it an essential component of African folklore and healing practices.

Tackling Worldwide Health Issues

The diminishing efficacy of current pharmaceuticals elevates the rates of illness and death, establishing the rise of antibiotic-resistant pathogens as a significant threat to worldwide health. The development of innovative treatments to address microbial resistance to pharmaceuticals may stem from the antibacterial properties of *K. africana*, which inhibit microbial proliferation and dissemination. Non-communicable diseases (NCDs), such as cardiovascular disorders, elevated glucose levels, and cancers, are becoming more widespread globally and are associated with an increased risk of morbidity and mortality.

We observe an imbalance in the generation of unstable oxygen species and oedema (soreness). The application of *K. africana* as a therapeutic measure for multiple ailments seeks to reduce oxidative stress and inflammation. *K. africana* is effective in healing wounds, particularly in diabetic patients who often face challenges that impede this process, leading to amputations due to elevated blood sugar levels. Its use has markedly expedited the healing of wounds in these individuals. Due to the lack of contemporary medical facilities, individuals in developing nations rely exclusively on traditional medicine. *K. africana* provides affordable and readily available healthcare solutions for communities with limited access to modern medical facilities.

Overview of the Flora and its Geographical Distribution

Taxonomy of *Kigelia Africana*

Kingdom	Plantae
Phylum	Streptophyta
Class	Equisetopsida
Subclass	Magnoliidae
Order	Lamiales
Family	Bignoniaceae
Genus	<i>Kigelia</i>
species	<i>Kigelia africana</i>

Figure 3: Taxonomy of *Kigelia Africana*

K. africana is a moderately large to substantial semi-evergreen species, attaining elevations of up to 25 meters, distinguished by a stout, round deciduous trunk and an elliptical canopy, exhibiting a range of hues from greyish to pale brown. Its configuration is characterized by low branching and features sprawling, lenticellate branches and twigs. Vegetation can reach heights of 24 meters with leaves that have a pinnate arrangement.

The primary veins of *K. africana* blossoms display hermaphroditic, zygomorphic, and pentamerous traits. The external section of the calyx has a bell-shaped form and is partitioned into five segments, with the lower lobes typically elongating as they mature. The pome is a non-opening, fibrous structure, exhibiting a brownish-grey hue, elongated in shape, and typically weighs around 10 kg. The tree yields mature fruits throughout the year, and its distinctive fruits and sizable, appealing blossoms render it a remarkable ornamental species. It serves as a demarcation tool and is proficient in reducing erosion and stabilizing riverbanks.

According to Dhungana *et al.*, (2017) the terminal leaflet and three to five pairs of leaflets form a contrasting extension that is densely packed toward the branch ends; the terminal leaflet pair is devoid of petioles, whereas the lower leaflets possess small petiolates. The blossoms display a unique deep crimson colorization and a cup-shaped structure, flowering at night on extended, vine-like stems that hang from the branches and detach before sunrise. The fragrant and nectar-rich blossoms are pollinated by sunbirds, insects, and bats in their native habitats (Harris and Baker, 1958). The fruits are elongated and fibrous, like sausages, and are connected to the branch by a lengthy, cord-like stem. A pome can attain significant dimensions, reaching one meter in length and sixteen cm in diameter, with a mass of up to 12 kg. Consequently, vigilance is essential to avert accidents and property destruction resulting from fruit falling off the tree. Upon maturation, the fruits display a brownish-gray hue and possess a robust, distasteful fibre composed of several seeds (Gabriel, and Olubunmi, 2009).



Figure 4: Depicts images of the *Kigelia africana* tree featuring its suspended fruits, the tree itself, and its blossoms

MATERIALS AND METHODS

Review Approach and Scope

The manuscript is prepared as a thorough narrative evaluation. The synthesis is qualitative and thematic, not quantitative statistical meta-analysis. The strategy to gathering literature is transparent and structured to assure comprehensiveness and reproducibility across leading academic databases. The main goal is to provide an exhaustive synthesis of historical ethnobotanical records, regional pharmacopoeias and modern pre-clinical studies on *Kigelia africana* (Lam.) Benth. (Bignoniaceae) as a bridge between a customary uses and current medical applications.

Search Strategy for Literature and Sources of Information

A thorough literature search was conducted to uncover peer-reviewed research publications, review papers, ethnobotanical field surveys and monographs on the traditional usage, phytochemistry and pharmacological profile of *Kigelia africana*. The search was conducted in various major electronic databases including: PubMed /

MEDLINE, ScienceDirect, Scopus, Google Scholar and Web of Science

The search covers literature from database inception until date. The search approach included a combination of Boolean operators (AND, OR) and specific keywords to thoroughly retrieve relevant records: (*Kigelia africana* OR sausage tree) and (ethnobotany OR traditional medicine OR phytochemistry OR pharmacology OR antibacterial OR antidiabetic OR anticancer OR clinical applications)

Selection Procedures and Eligibility Criteria

The screening of the retrieved records was conducted in two steps: titles and abstracts were screened, followed by a detailed screening of the complete text against the pre-defined eligibility criteria:

Eligibility Criteria

- Original research publications, review papers and ethnobotanical field studies, peer-reviewed, published in English.
- Literature on botanical authenticity, verifiable phytochemical isolation, qualitative and quantitative

characterisation of extracts or compounds obtained from *K. africana*.

- iii. Preclinical (*in vitro* and *in vivo*) and clinical research of pharmacological properties and mechanisms (e.g. antibacterial, antioxidant, anti-inflammatory, wound-healing and cytotoxic activities)

Criteria for Exclusion

- i. Duplicate publications, abstracts without full text, non-peer-reviewed conference proceedings, and non-English papers without verifiable translations.
- ii. Studies that lacked proper botanical identification or did not mention specific characteristics about the plant portion studied (fruits, stem bark, root, or leaves).

Handling of Divergent Results and Experimental Variation

In instances where contradictory experimental evidence was found in the literature (e.g. potency of antibacterial activity, % yields of phytochemicals from different geographical strains or *in vitro* and *in vivo* toxicity outcomes), a critical evaluation approach was used. Rather than averaging or ignoring these contradictions, disagreements were contextualised and clarified through fundamental methodological differences, namely, evaluating:

Plant Part and Geographical Source

Differences were found depending on the source of the material, i.e., whether it was collected from African native

habitats or from introduced ornamental ranges in Asia or the Americas, and the specific plant tissue employed (fruit pulp, stem bark, leaves, or roots).

Extraction Solvents and Parameters

The differences related to the types of extraction (e.g. aqueous decoctions traditionally used by indigenous tribes as opposed to laboratory-based organic solvent extracts such as methanol, ethanol or chloroform). The emphasis was on studies with strong botanical authenticity and uniform experimental designs, whereas unresolved conflicts and gaps in the literature were expressly identified as areas needing further standardisation and clinical validation.

RESULTS AND DISCUSSION

Phytochemical Analysis of *K. Africana*

Principal Constituents

The banger tree exhibits numerous health advantages linked to its varied extracellular metabolites. Iridoids constitute the paramount phytochemical finding in *K. africana*. Additional significant components comprise terpenes, terpenoids, flavonoids, coumarins, and naphthoquinones (Houghton, 2002; *African Herbal Pharmacopoeia*, 2010; Bello, *et al.*, 2016; Imran *et al.*, 2021). Moreover, non-terpene substances including hexadecanoic acid and the monoterpenes α -pinene ethyllimonene are prevalent in the oils of *K. africana* flowers and leaves (Asekun *et al.*, 2007), among an array of fragrant chemicals.

Table 2: Phytochemical Constituents, Extraction Methods, and Pharmacological Activities of *Kigelia Africana*

Plant Part Used	Extraction Solvent Used	Bioactive Compound Identified	Experimental Modern Assay / Method	Scientific Findings	Country / Region	Reference
Stem bark	Aqueous infusion	Combined polyphenols and polysaccharides	Exploratory organ-protective and anti-inflammatory screening	Exhibits synergistic reduction of visceral inflammatory markers.	Uganda	FAO (1986)
Fruit	Soxhlet / Maceration extracts	Naphthoquinones (pinnatal, isopinnatal, dehydro-alpha-lapachone), iridoids	LC-MS/MS profiling coupled with <i>in vitro</i> anti-neoplastic and antimicrobial assays	Confirms broad-spectrum antimicrobial efficacy and cytotoxic activity against aberrant cell growths, validating traditional poultice uses.	India and Global Compendiums	Olubunmi <i>et al.</i> (2019); Nabatanzi <i>et al.</i> (2020)
Fruit	Lipophilic vehicles / Palm wine maceration	Steroid saponins and active plant growth regulators	Dermal permeation and ex-vivo topical matrix absorption tests	Lipophilic extraction matrices promote enhanced localized transdermal delivery of active constituents.	South Africa	Moll <i>et al.</i> (1994); Nabatanzi <i>et al.</i> (2020)
Stem bark	Alcoholic / Palm wine vehicle	Lipophilic quinones and complex secondary metabolites	Synergistic micro-dilution antimicrobial assays against sexually transmitted pathogens (<i>Neisseria gonorrhoeae</i>)	Demonstrates that alcohol/palm wine matrices significantly enhance the solubility and bioavailability of active quinones against STIs.	Central and West Africa	Eldeen and Van Staden (2007); Cunningham (1993)
Stem bark	Aqueous (decoction)	Iridoids (verminoside), flavonoids, and phenolic derivatives	Phytochemical screening and <i>in vitro</i> DPPH/ABTS antioxidant assays	Confirms free radical scavenging capabilities and validates traditional tissue-protective and anti-inflammatory uses.	Cameroon	Focho <i>et al.</i> (2009); Neuwinger (1997)
Stem bark	Aqueous / Hydro-alcoholic	Naphthoquinones (e.g., lapachol) and iridoids	<i>In vitro</i> antimicrobial susceptibility testing and cyclooxygenase (COX) inhibition assays	Demonstrates direct inhibitory action against microbial strains and moderates inflammatory pathways relevant to rheumatism.	Ivory Coast / West Africa	Neuwinger (1997); Maregesi <i>et al.</i> (2007)
Stem bark	Aqueous infusion	Tannins and polyphenolic complexes	Qualitative phytochemical profiling and tannin precipitation evaluations	High tannin content accounts for strong astringent effects, supporting traditional use against dysentery and mucosal discharges.	Nigeria and Ghana	Neuwinger (1997)
Stem bark	Aqueous / Hydro-alcoholic	Iridoid glycosides (verminoside) and phenylpropanoids (verbascoside)	<i>In vitro</i> anti-plasmodial assays against <i>Plasmodium falciparum</i>	Validates antipyretic and anti-malarial properties, substantiating traditional reductions in fever and headache.	Tanzania	Gessler <i>et al.</i> (1995); Moshi <i>et al.</i> (2009)
Leaves and stem	Hydro-alcoholic	Naphthoquinones (lapachol, kigelone) and flavonoids	Cytotoxicity screening and anti-proliferative assays on skin cell lines	Validates traditional topical application for managing abnormal skin lesions, boils, and localized skin neoplasia.	South Africa and Namibia	Chinsebu <i>et al.</i> (2015); Van Wyk (2011)

Plant Part Used	Extraction Solvent Used	Bioactive Compound Identified	Experimental Modern Assay / Method	Scientific Findings	Country / Region	Reference
Fruit (Pome)	Hot water / Aqueous infusion	Iridoids, caffeic acid derivatives, and sterols	Lipid peroxidation inhibition and ferric reducing antioxidant power (FRAP) assays	High phenolic content counters oxidative stress mechanisms involved in chronic systemic fatigue and reproductive strains.	South Africa and Central Africa	De Wet and Ngubane (2014); Van Wyk (2011); Carey <i>et al.</i> , 2010; Kumawat <i>et al.</i> , 2018; Lal and Yadav, 1983; Burkill, 1985; Olubunmi <i>et al.</i> , 2019

Universal Solvent Extraction Techniques for Phytochemical Components of Plants

A vital phase in the pharmaceutical discovery process is the extraction of secondary metabolites, necessitating the disruption of plant cell walls to obtain chemical constituents from a complex plant material matrix (Luque *et al.*, 1998). The extraction of desired components can be accomplished by many methods, typically commencing with a blend of both active and passive elements, which are subsequently isolated to discern individual molecules. Illustrations include basic: Soxhlet and steam distillation methods or extraction procedures utilizing methanol. A multitude of these strategies have been utilized for ages and are frequently categorized as traditional methods. While these extraction methods are often simple and effective, they possess certain drawbacks, such as being cumbersome to implement, employing hazardous solvents that require additional removal processes, and often utilizing heat, which can deteriorate heat-sensitive organic compounds. Furthermore, particular methods demonstrate an undue preference for a narrow range of substances; nonetheless, the selection of solvent might lead to a significant production of a specific class of compounds. Fat separation has traditionally been achieved using Soxhlet extraction, which is regarded as the benchmark method for assessing the efficacy of other techniques. Furthermore, separation processes demonstrate markedly insufficient yield, a scant amount of advantageous material in comparison to the substantial energy expenditure demanded, and entail elevated expenses linked to the disposal of considerable organic waste, which presents potential ecological hazards (Anastas *et al.*, 2010; Harbourne, *et al.*, 2013).

During the 1990s, eco-friendly materials started to emerge in separation process applications, with the objective of reducing energy usage and substituting traditional solvents with less harmful alternatives (Rombaut *et al.*, 2014; Pourmortazavi and Hajimirsadeghi, 2007). Contemporary eco-friendly technologies for herbal extraction, noted for their decreased reliance on natural solvents or reduced energy use through efficient disintegration or abbreviated processing durations, encompass:

- Mechanical compaction
- Supercritical fluid extraction technique
- Extraction facilitated by ultrasound:
- Microwave-assisted extraction and decreased energy consumption via efficient dissolution or abbreviated processing times.
- Controlled Instantaneous Relaxation (CID) (Pourmortazavi and Hajimirsadeghi, 2007)

Among these techniques, supercritical fluid extraction (SFE) offers reduced energy usage during processing and an alternative solvent approach. Furthermore, the reclamation of gaseous solvents occurs upon depressurization through a supercritical fluid phase. Depressurization through a supercritical fluid phase, leading to a transition back to gas, facilitates the separation of phases between the supercritical

fluid and refined molecules, which can be in either liquid or solid form. Employing phase separation can facilitate the acquisition of a more refined CO₂ solvent (gas), which can subsequently be stored and reused. This reduces the overall energy expenditure as diminished CO₂ capture is required, rendering SCF-based extractions more ecologically sustainable. The method eradicates the requirement for solvent waste, which necessitates incineration, a procedure that is both environmentally harmful and costly. It is crucial to highlight that only SFE solvent-based methods employ minimal or no natural solvents. Hypercritical fluids have proven effective as solvents in extraction methods due to their unique adjustable physical properties, such as varying density, viscosity akin to those of liquids or gases, and enhanced dispersion. The utilization of SFE methodologies in the extraction of organic substances has been thoroughly investigated (King, 2014; Kibirige *et al.*, 2019), alongside environmentally sustainable extraction methods, ultrasonic-enhanced SFE processes, and critical considerations for scaling operations.

Medicinal Properties

Biomedical Utilisation of Kigali Africana Antidiabetic Effects of K. Africana

The worldwide incidence of diabetes: Economically deprived countries experience a higher worldwide incidence of diabetes, in economically deprived countries. Three-quarters of those afflicted by the illness live in nations with poor or moderate income levels (International Diabetes Federation., 2021; Kibiti and Afolayan, 2015). Diabetes is a chronic metabolic disorder that occurs when the pancreas fails to produce sufficient insulin, either due to improper synthesis or a hereditary or acquired dysfunction (Wild *et al.*, 2004). In the year 2000, the incidence was projected to be 2.8 % over the entire demographic; by 2030, it is forecasted to increase to 4.4 % (World Health Organization, 2002). The population of individuals with elevated blood glucose levels is projected to increase to 171 million by 2000 and to 366 million by 2030 (World Health Organization, 2002; Hillary *et al.*, 1996).

In 2010, approximately 12.1 million people in Africa received a diabetes diagnosis, and forecasts indicate that this number will rise to 23.9 million by 2030 (Kibiti and Afolayan, 2015). The estimation for Kenya was 1.06 % in the year 2000, with an anticipated increase to 1.32 % by 2025 (Mwila *et al.*, 2019). Roughly 726,300 people in Zambia have been diagnosed with diabetes. Many of these individuals also experience issues such as vision problems, achieving or maintaining an erection, and fatigue. Individuals may also be classified as overweight or obese, with factors such as population expansion, ageing, stress, and dietary changes all associated (World Health Organization, 2002); cerebrovascular incidents and hypertension are included as well (Nutakki *et al.*, 2021; Stephen *et al.*, 2018). Stephen *et al.* (2018) report that both water-based and ethyl acetate solvent extracts from sausage tree leaves demonstrated antidiabetic

effects when administered intraperitoneally in specified doses. The herbal extract lowered blood glucose levels in a dose-independent manner with both methods of delivery. The reduced glucose levels observed may be associated with several phytochemicals, plant-derived nutrients, and trace elements present in *K. africana*. Babbar *et al.* (2014) attribute the mechanism of action to the presence of flavonoids, kigelone, vernolic acid, kigelone, iridoids, luteolin, 6-hydroxyluteolin, and several other phenolic chemicals. These substances are capable of neutralising free radicals. The alleged antioxidant properties of *Kigali africana* contribute to its anti-diabetic advantages by mitigating cellular oxidation, alleviating stress-related symptoms, protecting pancreatic beta cells, and enhancing insulin secretion. Furthermore, the study conducted by D'souza *et al.* (2012), revealed that flavonoids correlate with a decrease in alpha-glucosidase activity. The diminished activity of enzymes leads to reduced postprandial glucose levels in diabetic people. AL-Ishaq *et al.* (2019) revealed that different flavonoids had a beneficial effect on diabetes mellitus through multiple mechanisms.

The Antioxidant and Free Radical Neutralising Characteristics of *K. Africana*

Radiation exposure, cigar smoking, excessive alcohol use, and the intake of oxidised fatty acids produce reactive oxygen species. Excessive production leads to harmful oxidative effects on molecules such as amino acids, carboxylic acids, genetic material, and cellular membranes. The generation of reactive oxygen species (ROS) is associated with severe conditions, including cancer, hyperglycaemia, and neurological ailments (Dumitrascu, *et al.*, 2013; Shim *et al.*, 2013). A free radical is defined as an element possessing an unpaired electron or a particle that harbours several unpaired electrons in its outer shell. Nitrogen compounds and reactive oxygen, characterised by free electrons, are vital elements in the normal physiological processes of living organisms. Under typical physiological circumstances, organelles such as microsomes and the cell's powerhouse produce free electrons (ROS). Antioxidants, which are intrinsic molecules that may counteract free radicals, possess considerable promise for alleviating diseases induced by reactive oxygen species (Shim *et al.*, 2013; National Toxicology Program, 2002). The overproduction of reactive oxygen species (ROS) leads to the reduction of domestically produced protective proteins, such as superoxide dismutase and catalase, diminishing the efficacy of dismutase, glutathione, and related proteins. Synthetic antioxidants in dietary supplements may have serious side effects that make them less useful, owing to their considerable negative effects (Umamaheswari, *et al.*, 2008). The antioxidant properties reduce free radicals, therefore safeguarding against conditions associated with cellular oxidation, including cardiovascular and neurological ailments. Oxidative stress is pivotal in the pathological development of diseases by either neutralising reactive oxygen species (ROS) or offering defence against them (Oboh *et al.*, 2007). Antioxidants operate by binding to and neutralising transition metals, thereby preventing their involvement in initiating metal catalysis that leads to oxidative stress and lipid peroxidation (Moreira da Silva *et al.*, 2010). An overabundance of reactive oxygen species (ROS) directly affects omega-3 fatty acids within the organelle, resulting in rancidity (Moreira da Silva *et al.*, 2010). The detrimental consequences of iron arise when it engages with hydrogen peroxide, resulting in the production of hydroxyl radicals (OH) via the Fenton reaction. Hydroxyl radicals are highly reactive oxygen species that inflict cellular

harm on living organisms. They engage with polyunsaturated fatty acids in the phospholipids that form the membrane, potentially resulting in mutations, cytotoxicity, and cancer. Superoxide can engage with Fe^{3+} to regenerate Fe^{2+} , which plays a role in the Fenton reaction. Research by Olubukola *et al.* (2014) indicates that *K. africana* has a very low ability to scavenge hydrogen peroxide at minimal dosages. At high concentrations and alongside other flora such as *Artocarpus altilis* and *Ficus exasperata*, it demonstrates improved hydroxyl and DPPH radical scavenging capacity, in addition to inhibitory effects on lipid peroxidation. The heightened antioxidant efficacy is probably attributable to their significant phenolic composition, which may arise from the plentiful presence of phenolic compounds. Replacing synthetic antioxidants with natural substitutes is advantageous for human well-being. As a result, the pharmaceutical industry might employ these extracts as natural antioxidants or dietary supplements for health maintenance. Owolabi and Nworgu (2009) performed an *ex vivo* investigation on the neutralisation of free radical activities by *K. africana* extract in rat liver homogenate. The introduction of several pro-oxidants, such as 10 μM iron (II) sulphate (FeSO_4), 5 μM sodium nitroprusside (SNP), and 2 mM 3-nitropropionic acid, led to an increased generation of reactive thiobarbituric acid substances (TBARS), signifying intensified oxidative lipid degradation in the liver. *K. africana* markedly ($p < 0.05$) diminishes TBARS production in a manner contingent upon the specific prooxidant-induced oxidative damage model employed during administration. This implies that the medicinal efficacy of the herb, particularly for hepatic disorders, could be associated with its antioxidant characteristics (Owolabi and Nworgu, 2009). Saini *et al.* (2009) identified a relationship between the antioxidant properties of the sausage tree and the presence of caffeic acid along with other unique substances in the plant.

Therapeutic Attributes of *K. Africana* in Wound Management

Worldwide, skin infections are common, with most exhibiting minimal mortality rates and resolving spontaneously. Previously, these disorders had increased mortality rates, as they were associated with conditions like human immunodeficiency status, primarily AIDS or HIV. Consequently, dermatological and pulmonary infections affect over 90 % of individuals diagnosed with HIV (Quave *et al.*, 2008). Quave *et al.* (2008), assert that robust bacteria further boosted lethality. Roughly 20 to 80% of individuals in developing countries suffer from fungal and bacterial infections. As per Al-Hoqail (2012), dermatophytes affect merely 25% of the global population, mostly in African countries. Some herbal extracts address various skin ailments externally, such as burns, psoriasis, dermatitis, inflammation, and infections. When the skin is compromised, it typically loses its barrier function, which increases permeability for water and nutrients, thereby altering the efficacy of topical medicines (Baert, *et al.*, 2007). Superficial dermatological medications predominantly employ therapeutic agents that focus on the skin's outside layer, particularly for addressing infections impacting the skin's surface.

Baert *et al.* (2007) assert that they can operate on superficial and cutaneous layers, accessing the outer layer without entering the bloodstream, to address issues impacting those layers, or they can target the transdermal layer to penetrate the bloodstream. The permeability of the stratum corneum generally affects these bioactive substances (Andrews *et al.*, 2013; Sibongile, *et al.*, 2016). The research conducted by Nicki *et al.* (2016) demonstrated that *K. africana*, when

combined with several plant species, is commonly used to treat burns, ulcers, infections, and other minor dermatological conditions. The permeability findings indicated that these extracts could potentially address this dermatological issue. These findings corroborated their ethnobotanical application and the recognition of their use in addressing dermatological issues in Maputa Land (Beckley-Kartey, *et al.*, 1997). The phytochemicals exhibit an advantageous synergistic effect, and their lack of antagonism further supports their combined use in therapeutic applications. The eradication of bacteria by the organic extract provides researchers with greater insight into the mechanisms of the compounds in these plant extracts when applied to pristine skin (Wang *et al.*, 1987; Oyelami *et al.*, 2012). Phytochemical substances penetrating the injured skin more rapidly would accelerate the healing process.

Composition for Cosmetic and Pharmaceutical Applications

As noted by Oyelami *et al.* (2012), *Kigelia africana* has traditionally been used as a beauty enhancement. Some treatments consist of extracts derived from various plant parts, predominantly the bark of a stem, fruit, or peduncle. The formulation typically consists of 50 % extract mixed with a vehicle, components, and colourants (Sumobrain™). Neither hydrophilics nor extracts with alcohol are ideal for water-based formulations in cosmetic products, such as gels (Dampeirou, 2002). The formulation includes hydrating agents, liquids or oils, softening substances, and pharmaceuticals. Components are employed in the creation of anti-ageing and restorative skincare products, as well as skin-firming cosmetics, including bust-enhancing items. The *kigelia* plant encompasses two flavonoids, luteolin and quercetin, in addition to steroidal saponins. The extraction from the fruit is beneficial for enhancing bust growth and fortifying the strength and firmness of female collagen structures. Sunlight spots, referred to as "solar keratosis", are eliminated with a lotion derived from fruit extract, especially on the face and hands. Numerous skin creams, hair follicle treatments, and cleansers are derived from the pulp of the fruit. Some cosmetics using *kigelia* as an active ingredient diminish wrinkle depth and enhance the appearance of fine lines. The product refines the skin's texture, improves tone, boosts elasticity, naturally brightens pigmentation, reduces imperfections, thoroughly cleanses, and eliminates impurities (Dampeirou, 2002). Strengthens the delicate skin around the periorbital area. Improves the dermal texture and stimulates circulation. The pulp derived from fruits and their juices is employed in nutraceuticals, nutritional and botanical supplements, pharmaceuticals, cosmeceuticals, and various products (Makado, 2003; Ferlay *et al.*, 2001) possible products could include medications to treat skin cancer and reduce inflammation after sun exposure, as well as antioxidants and ingredients that help firm the skin. In the United Kingdom, Melvita Gel Cream, included in a 50 ml vessel, features argan nut extract and enhances the remarkable firming attributes of *Kigelia africana*. This product works best by mixing the shaping effects of bellis oil with the skin-rejuvenating benefits of orange essential oils, geranium, and vitamin C, along with the nutrients from orange peel extract. Additional details can be obtained at this link: <http://www.mondebio.co.uk/organicbrand/melvita/gel-cream-for-the-bust-with-kigeliabellis-et-argan5250ml/930.html>. The 30-millilitre container of *Kigelia* Booster Serum available in the US addresses drooping skin, age spots, irregular pigmentation, and parched, lacklustre skin that has lost its vitality. Effectively counters photoaging by improving skin clarity, luminosity, and complexion for a

more youthful and vibrant appearance. John Penders' Firmer Curves' *Kigelia* Lipo (40g) serves as a completely natural alternative to surgical interventions offered in the UK. It includes an extract derived from the *Kigelia africana* tree. The 50 ml Sausage tree cream is a completely natural treatment for sun keratoses, a type of skin cancer. Additionally, it is used in Zambia to alleviate skin ailments such as eczema and psoriasis. This very moisturising formulation was created to restore and enhance skin, and it is offered in the US under the name Sausage Tree Cream (75 ml). Sausage Tree Cream (*africana* sausage) effectively moisturises parched or mature skin, alleviates inflammation, and prevents infections.

Oncological Potential

Impaired biological signals governing cell division and proliferation lead to cancer, which manifests as abnormal cell division and growth (Ferlay *et al.*, 2001). In the year 2000, the predominant malignancies worldwide were colorectal (9.4%), breast (10.4%), and lung (12.3%) (World Health Organisation, 2018).

In 2015, cancer was responsible for 8.8 million deaths worldwide, making it the second foremost cause of mortality (Boyle and Levin, 2008). Cancer is the leading cause of mortality worldwide, accounting for 70% of deaths in low- and middle-income countries. Occurrences in these countries represent more than fifty per cent of all new cancer diagnoses globally and are anticipated to comprise over eighty per cent of the worldwide cancer burden by 2030 (Farmer *et al.*, 2010; Aung *et al.*, 2017). Eighty per cent of individuals depend on flora for their fundamental healthcare requirements (Shaikh *et al.*, 2016). Around thirty-five thousand plant varieties have been assessed for their potential anti-cancer properties, leading to the discovery of significant therapeutic agents such as vinblastine, indicine-N-oxide, camptothecin, etoposides, vincristine, and Taxol, which inhibit the growth of cancerous cells by influencing autophagy and apoptosis mechanisms (Kanase and Singh, 2018). Nevertheless, due to the emergence of drug resistance and the harmful effects of current chemotherapeutic agents on non-target cells, it is crucial to identify novel bioactive compounds that exhibit reduced side effects and enhanced efficacy (Olatunji and Atolani, 2009). *Kigelia africana* encompasses compounds, notably naphthoquinones, which exhibit lethal effects on several cancer-immortalised cells, suggesting potential antineoplastic properties. It induces apoptosis in melanoma, colon, and breast cancer cells.

A preclinical study conducted by Olatunji and Atolani (2009), Jackson *et al.* (2000), and Chivandi *et al.* (2012) indicates that extracts could suppress cancer proliferation. Numerous studies in the literature indicate the application of *Kigelia africana* for cancer prevention or therapy.

Human embryonic kidney (HEK 293) and human colorectal carcinoma (Caco-2) cell lines were cultivated under varying concentrations of *Kigelia africana* seed oil in milligrams per millilitre (mg/ml) to evaluate the oil's effect on cellular proliferation. The trypan blue dye exclusion method was employed to assess cell growth 48 hours post-oil treatment. The oil derived from the seed exhibited a dose-dependent suppression of cell growth in HEK-293 and Caco-2 cell lines. The application of oil derived from *Kigelia* seeds did not increase the rate of cellular mortality. *Africana*, as the quantity of the deceased biological entity is constant in both the treatment and placebo scenarios. Caco-2 cell proliferation significantly decreased due to the seed oil as compared to the proliferation of HEK-293 biological units across all tested concentrations.

Houghton *et al.* (1994) suggest that *Kigelia africana* seed oil could suppress the growth of Caco-2 and HEK-293 cells, indicating an anti-proliferative influence on these cell lines. *Kigelia Africana* root extract (methanol) contains lapachol (Grace and Davis, 2010), which is thought to aid in the treatment of Kaposi sarcoma, skin cancer, and sun keratosis (Houghton *et al.* 1994). The effects of standardised sequential dilutions of dichloromethane, ethanol, and water extracts from the stem bark and fruit of *Kigelia africana* on the proliferation and inhibition of four melanoma biological units and the Caki-2 renal cell carcinoma line were assessed using two distinct assays: MTT and SRB. The dichloromethane extract from the stem bark, when used alongside recognised medicinal anti-cancer drugs, exhibited considerable inhibitory efficacy in a concentration- and time-dependent fashion. In the research conducted by Grace and Davis (2010), the renal adenocarcinoma line exhibited diminished sensitivity to chemotherapy compared to the melanoma cell culture's reaction to the bark of the stem. Nonetheless, all five cell lines showed comparable sensitivity to lapachol, suggesting that lapachol is an active compound with anti-cancer properties. Mukavi *et al.* (2020), demonstrated that a 14.85 % extract of *Kigelia africana*, was obtained using a dichloromethane and methanol (1:1) mixture. *Africana* markedly inhibited the growth of HCC 1937 breast cancer cells. The inhibition of cellular proliferation exhibited a concentration-dependent correlation for both extracts, with less suppressive effects noted at lower doses. The findings align with the research conducted by Atawodi and Olowonyi (2015) and Arkhipov *et al.* (2014), which indicated substantial anticancer advantages from *K. Africana* extracts in relation to several cell lines. GraphPad Prism was employed for the assessment of non-linear regression to ascertain the half-maximal inhibitory concentrations (IC₅₀) of the two extracts.

Effects on Inflammation Reduction

Activated macrophages generate reactive oxygen species (ROS), leading to oxidative stress (OS), which instigates inflammation and promotes the release of nitric oxide (NO) alongside pro-inflammatory cytokines (Nworu and Akah, 2015). Cuzzocrea *et al.* (2002), assert that nitric oxide stimulates cyclooxygenase-2 (COX-2) to generate prostaglandins (PGs), suppresses mitochondrial enzymes, and intensifies inflammatory conditions. Consequently, the inhibition of cyclooxygenase (COX-2), lipoxygenase (LOX), and nitric oxide (NO), together with reactive oxygen species (ROS), is expected to be beneficial in both the prevention and treatment of inflammatory conditions. The conventional treatment for inflammation includes non-steroidal anti-inflammatory drugs (NSAIDs) (Cuzzocrea *et al.* 2002); however, prolonged use of these treatments results in detrimental effects. Inflammation serves as the body's principal defence mechanism, promoting tissue restoration in response to harmful stimuli (Newton, 2000). Cyclooxygenase-2 (COX-2) subsequently generates prostaglandins (PGs) that promote inflammation, swelling, and pain perception (Punchard *et al.*, 2004). Lipoxygenase (LOX) transforms arachidonic acids into leukotrienes, which are a class of inflammatory mediators (Brand-Williams *et al.*, 1995). As per disseminated accounts, *K. Africana* has been conventionally employed across numerous cultures for diverse applications, including its role as an anti-inflammatory substance. Upon sustaining an injury, the body's initial defence mechanism to facilitate tissue healing involves responding to inflammation by releasing proinflammatory cytokines such as interleukins (IL-1 β and

IL-6), interferons (IFN), and tumour necrosis factor-alpha (TNF- α), among others. This is followed by the stimulation of cyclooxygenase-2 (COX-2), which then produces prostaglandins (PGs) that promote inflammation, swelling, and pain (Punchard *et al.*, 2004). Lipoxygenase (LOX) facilitates the transformation of arachidonic acid into leukotrienes, which are a category of inflammatory mediators. Investigation of the anti-inflammatory characteristics of various constituents of *K. africana* has proven its effectiveness, historically employed alone alongside numerous herbs to augment its therapeutic impact on inflammation.

Nigerians employ the bark of *K. Africana* to alleviate inflammation (Rådmark and Samuelsson, 2009; Adam and Alhameed, 2013), and the Embu community in Kenya uses its fruits as a remedy for inflammation (Newton, 2000). The anti-inflammatory properties of cucumber trees are believed to suppress inflammatory mediators (Chih-Cheng *et al.*, 2012).

Nabatanzi *et al.* (2020) documented the anti-inflammatory effects of cucumber tree extracts in suppressing COX-2, 15-LOX, reactive oxygen species, pro-inflammatory cytokines, and anti-inflammatory cytokines, thereby clarifying the possible mechanisms of action against inflammation. It has been indicated that the flavonoids and phenolic compounds present in *Kigelia africana* inhibit pro-inflammatory cytokines, hence diminishing inflammation. Eldeen and Van Staden (2008) reported the inhibitory effects of *K. africana* ethanol (leaf) and dichloromethane (bark) juice on COX-2 and COX-1.

Antimicrobial Activity

Numerous indigenous African healthcare providers have employed the *K. Africana* crop to remedy several diseases and disorders, including diarrhoea and gastrointestinal problems. Cock (2013) and Setzer *et al.* (2001) demonstrated that *K. Africana* fruit extracts impede the proliferation of both gram-positive and gram-negative bacteria.

Cock (2008), Sautron and Cock (2014), along with Mohanty and Cock ((2010), revealed that plant extracts in conjunction with cucumber trees show enhanced effectiveness against monoderm bacteria relative to diderm bacteria. *K. Africana* fruit extracts exhibited notable inhibitory effects on *P. mirabilis*, a bacterium associated with bladder infections (or UTIs) and the onset of rheumatoid arthritis (RA) (Mohanty and Cock, 2010). The application of cucumber fruit extract could avert the development of rheumatoid arthritis by suppressing inflammation and immune system impairment. This treatment would avert both the advanced symptoms of rheumatoid arthritis and the related tissue damage (Cock and Van-Vuuren, 2014).

Owolabi *et al.*, (2004), Jeyachandran and Mahesh (2007), Akinyili *et al.* (1991), and Grace *et al.* (2002) discovered that extracts of *K. Africana* derived from different plant components demonstrated notable antibacterial characteristics.

Arkhipov *et al.* (2014a), discovered that solvent extracts from cucumber trees had a broad range of efficacy against fungal infections, supporting the claim made by Owolabi *et al.* (2007) that the stem bark extracts of *K. Africana* exhibit considerable antifungal characteristics. Arkhipov *et al.*, (2014a) illustrated that *K. Africana* extracts have significant antibacterial and antifungal properties. Extracts from African fruits significantly suppressed the proliferation of *Giardia duodenal* is a parasite found in water and food. The resurgence of giardiasis, a gastrointestinal parasitic infection impacting a considerable population worldwide, especially in

areas marked by economic deprivation, inadequate sanitation, untreated drinking water, and poor nutrition. Rayan *et al.*, (2005). Giardiasis, although typically non-fatal, manifests significant symptoms such as abdominal pain, diarrhoea, excessive flatulence, reduced appetite, abdominal distress, and haematuria (Rayan *et al.*, 2005; Higgins *et al.*, 2010). Currently, the pharmaceutical alternatives for giardiasis are restricted, mostly consisting of imidazole derivatives and quinolones. These therapies are linked to negative side effects, including nausea, dizziness, emesis, diarrhoea, and hallucinations. Recent results suggest an issue of medication resistance in therapies for *Giardia* species (Higgins *et al.*, 2010), while earlier research has demonstrated that vermonoside can inhibit the proliferation of amoebic protozoans.

Properties against Protozoa

Kigelia africana possesses several uses, particularly in addressing Plasmodium parasite infections (Moideen *et al.*, 1999). Dichloromethane, hexane, ethanol, and ethyl acetate, together with bark of root extracts, exhibited effectiveness against *Trypanosoma brucei brucei*, *Plasmodium falciparum* (Bharti *et al.*, 2006), and *T. b. Rhodesiense* (Halder and Sharma, 2017), the aetiological agents of sleeping sickness and malaria, respectively, in in vitro studies. Bharti *et al.* (2006) indicated that butanol extract from the stem bark inhibited the growth of *Entamoeba histolytica*. Halder and Sharma (2017) discovered four compounds from *Kigelia africana* exhibiting notable anti-plasmodial activity, isolated by ethyl acetate. Three out of the four drugs showed significant efficacy against all tested leech varieties, encompassing two field isolates of *Plasmodium falciparum*, with IC₅₀ values under 5 µM and chloroquine-resistant W-2. Specioside demonstrated the greatest potency against W-2 (IC₅₀=1.5µM), succeeded by 2β, 3β, 19α-trihydroxyurs-12-en-28-oic acid (IC₅₀=1.60µM) and atranorin (IC₅₀=4.41µM), while p-hydroxycinnamic acid exhibited the least efficacy (IC₅₀=53.84µM) (Quave *et al.*, 2011). Lapachol, found in the methanol extract of the root, in conjunction with another element (a-quinone) derived from the wood, exhibits anti-malarial characteristics. Specioside, minicoside, three iridoids, and verminiside, extracted from the stem bark utilising butanol solvent, exhibit anti-amoebic properties (Moideen *et al.*, 1999). 2-(1-hydroxyethyl)-naphtho [2,3-b]-furan-4,9-quinone and three naphthoquinones: isokigelinol, kigelinol, and isopinnatal is responsible for the stem bark and root bark extracts anti-trypanosome efficacy (Halder and Sharma, 2017).

Intracellular Communication among Bacteria

Given its existence in habitats with considerable microbial intrusion, vegetation has evolved novel strategies to safeguard itself against bacterial infections (Packiavathy *et al.*, 2012). Flora must synthesise and release extracellular metabolites into their environment to survive. This not only aids in their defence against pathogens, but it also serves as a mechanism for attacking competing species. They are designed to generate antibiotics that inhibit microorganisms from synthesising compounds essential for their infectiousness and effective colonisation (Singh *et al.*, 2009). Botanical species contain various phytochemicals that may help treat infectious diseases. This phenomenon is because of the extensive variety of supplementary chemicals present in their extracts, which include terpenoids, polyacetylenes, quinones, alkaloids, flavonoids, and phenols. The interactive system referred to as quorum sensing (QS) allows microorganisms to monitor their population density

through the production of autoinducers, which are small signalling molecules. Instances of autoinducers produced by the LuxI homologue family of autoinducer synthases include acyl-homoserine lactones (AHLs). Gram-negative bacteria exhibit anti-virulence or anti-pathogenic properties due to the efficacy of certain phytochemicals as antimicrobial agents. These actions are neither lethal to bacteria nor inhibitive to bacterial growth. These chemicals diminish the transcription of genes linked to diseases and their severity by interfering with quorum signalling (QS) and associated processes (Adonizio *et al.*, 2006). The synthesised signalling molecules are expelled from the cell and bind to specific receptor proteins (LuxR homologues) located on the surfaces of adjacent bacterial cells. Quorum signalling regulates numerous cellular functions and biological processes, such as bioluminescence, adhesion, biofilm development, antimicrobial production, expression of virulence factors, pigment synthesis, motility, exopolysaccharide production, and the proliferative effects of various degradative enzymes in pathogens that impact animals, aquatic organisms, and plants. Given the significance of quorum sensing (QS) in bacterial growth and pathogenicity, it is crucial to create therapeutic agents that can inhibit bacterial QS to mitigate the impact of bacterial diseases.

Both manufactured and natural substances can disrupt the behaviours of bacteria governed by quorum sensing. Synthetic agents that inhibit QS synthesis encompass methylthio-adenosine and halogenated furanone, whereas natural agents comprise phytochemicals sourced from food items, such as vegetables, botanical substances, and flavourings, represented by cinnamaldehyde, garlic cloves, and vanilla extracts, along with constituents from medicinal plant extracts (Packiavathy *et al.*, 2011).

Singh *et al.* (2009) demonstrated that furanones containing halogens possess significant reactivity and toxicity, making them inappropriate for the therapeutic treatment of microbial infections in patients and harmful to rainbow trout. Natural goods provide alternatives for quorum sensing inhibition (QSI) agents that can impede the regulation of microbial colonisation and associated severe factors. Natural compounds have been identified from various origins, such as botanical treatments, consumable herbs, fruits, and vegetables (Packiavathy *et al.*, 2012; Packiavathy *et al.*, 2011; Truchado *et al.*, 2012) as well as flavourings (Packiavathy *et al.*, 2012). The antibacterial characteristics of plant-derived chemicals may stem from QS inhibition, which might be unrelated to microbial growth and diminishment (Packiavathy *et al.*, 2012). Unlike antimicrobial treatments, anti-pathogenic substances do not eradicate microorganisms or inhibit their growth. Furthermore, they diminish the probability of resistance development (Truchado *et al.*, 2012). QS Suppressing drugs that fail to eradicate or inhibit microbial growth may exert a greater selective pressure for the development of antibiotic-resistant bacteria in comparison to traditional antibiotic treatments. Phytochemicals demonstrate a range of medicinal properties, chiefly through the inhibition or modulation of quorum sensing (QS). This activity reduces the expression of genes associated with disease progression and successful infection by disrupting microbial networks (Packiavathy *et al.*, 2012; Truchado *et al.*, 2012). Their broad utilisation in both conventional and contemporary medicine for treating infectious diseases makes them appealing for pharmaceutical development.

Truchado *et al.*, (2012), delineated areas of quorum sensing suppression utilising the agent's furanone, cinnamaldehyde, and vanillin. All examined cucumber extracts from the tree exhibited inhibitory effects on violacein, suggesting anti-

quorum sensing properties. The anti-QS activity demonstrated a concentration-dependent relationship, suggesting that higher extract concentrations resulted in enhanced anti-QS activity. The suppressive impacts of the four unrefined extracts (0.33 mg/mL–8.2 mg/mL) on the production of violacein pigments were evaluated spectrophotometrically and quantified. Three *K. Africana* crude extracts exhibited a concentration-dependent decrease in violacein synthesis by *C. violaceum* ATCC 12472, without influencing bacterial proliferation.

Packiavathy *et al.* (2012) and Singh *et al.* (2009) discovered that extracts from *Cuminum cyminum* and aqueous extracts of *Moringa oleifera* leaves and fruits did not impede bacterial growth.

The agar diffusion bioassay assessed dosages of 0.5, 2, and 4 mg/mL of *Kigelia africana* methanol extract (EX 3) against *Chromobacterium violaceum* ATCC 12742, revealing both anti-quorum sensing (non-pigmented zones) and antibacterial effects (translucent zones) (Chenia, 2013). The methanol extract of *K. Africana* demonstrated many active compounds in a manner dependent on concentration. The inner transparent ring signified antibacterial efficacy, whereas the outside uncoloured ring implied suppression of quorum sensing. Furanone and oxo-dodecanoyl AHL were used as controls, located in the bottom right and bottom left corners, respectively. *K. Africana* fruit extracts have a rich historical use in African nations for many medicinal ailments and beauty purposes (Steenkamp *et al.*, 2007). The *K. Africana* fruit extract utilises a phytochemical-driven anti-virulence approach that bypasses the resistance linked to traditional antimicrobial agents by focusing on the modulation of QS-related virulence characteristics instead of eradicating bacteria. The suppression of quorum sensing presents encouraging opportunities for addressing multidrug-resistant bacteria, with possible uses in diverse fields such as aquaculture, healthcare, agriculture, and food science. QS Inhibitors are crucial as they improve the effectiveness of existing antimicrobial drugs and prevent biofilm development. This suggests that they can interfere with the infection mechanism by obstructing the progression of bacterial pathogenesis. The influence of QSI and the successful eradication of transmissible diseases may stem from the collaborative effects of many bioactive phytochemicals found in *K. African* fruit extracts (Vattem *et al.*, 2007).

The Obstacles and Prospective Pathways

Discrepancy / Declaration of Issue

Numerous preliminary scientific studies have thoroughly investigated *Kigelia africana*; however, there is a deficiency of clinical trials assessing its safety and efficacy in human subjects for therapeutic purposes. There is a lack of standardisation, quality assurance, and the formulation of drugs into tablet and syrup forms. How comprehensively do we grasp the ecosystem of this potent medicinal plant? Furthermore regulatory bodies like the FDA (USA) and EMA (EUROPE) should mandate a comprehensive review and approval process for natural products marketed as medicines. The preponderance of African countries is grappling with issues related to deforestation and afforestation. Nonetheless, unsustainable harvesting, habitat modification, and conversion are currently threatening the plant species that provide these elements.

Closing the Gaps

Investigations into pre-clinical and clinical trials assessing the safety and effectiveness of the extract or isolated chemicals for treating diverse ailments should be pursued.

Researchers are currently working on a new way to deliver *K. Africana*-derived drugs that will make them more available and effective. These drugs are currently made in cream form in the UK and the US.

The phytochemical composition may vary significantly in *K. Africana* and may be elucidated by its geographical positioning, farming methodologies, and ecological factors that can alter the consistency and predictability of its therapeutic outcomes.

Approaches to Conservation for K. Africana: Tackling Risks and Promoting Sustainable Use

We must modify the habitat of this Indigenous avalanche plant to align with contemporary circumstances in order to sustain its medicinal applications. This is essential due to the issues arising from deforestation and the destruction of natural habitats. Let us adhere to sustainable harvesting methods. Rather than downing the entire tree, we might concentrate on extracting particular components, such as stem bark, fruit, and leaves, while minimising harm to the organism.

The legislation should promote or facilitate natural regeneration. We ought to adhere to the practice of coppicing to maintain the vitality of plant populations. Designated harvest periods ought to be instituted to facilitate plant recuperation and foster new growth; local populations should participate in conservation initiatives, including the creation and oversight of protected regions. We ought to promote global collaboration to tackle the issues related to African conservation and sustainable use.

Community and educational awareness must be immediate; such initiatives will inform the residents about the significance of the preservation of *K. africana* is essential. Through the examination and advancement of methodologies for *K. africana*, scientists can alleviate the pressure on the wild population of *Africana*. This is due to their capacity to discover bioactive chemicals via tissue culture and synthetic manufacturing. This approach will furthermore establish a financial motivation for preservation through the use of *K. africana* in beauty products, medicinal formulations, and dietary supplements. Legislators and regulations will facilitate the realisation of all these benefits. Neglecting to maintain the significance and viability of this plant and its yield will unavoidably lead to obstacles in industrial and pharmaceutical advancement.

CONCLUSION

To summarise, *Kigelia africana* is an abundant source of bioactive secondary metabolites such as naphthoquinones, iridoids, flavonoids and phenylpropanoids that rationalise its widespread use in traditional systems of medicine in Africa, Asia and global phytotherapy. Its usefulness in treating infectious diseases, inflammatory and rheumatic diseases, dermatological issues and reproductive or systemic disorders are constantly highlighted in ethnomedicinal documents. These ancient assertions generally corroborate contemporary scientific evaluations including in vitro antibacterial, antioxidant and anti-neoplastic assays revealing promising pharmacological potential.

But there are still some major research gaps in the present literature. Most notably, the lack of standardised techniques for extraction and quantitative marker profiling results in considerable variability in the composition and efficacy of

crude extracts. Furthermore, overall toxicological information, including long-term safety, chronic administration, and herb-drug interactions, is not well studied. Although the present data underscore the significant pharmacological potential, no concrete conclusions about established therapeutic efficacy can be made yet. Future research should focus on rigorous standardisation of plant preparations, comprehensive toxicological evaluation and well-designed controlled clinical trials for safe translation of the traditional value of *Kigelia africana* into approved modern medicinal formulations.

REFERENCES

- Adonizio, A. L., Downum, K., Bennet, B. C., & Mathee, K. (2006). Anti-quorum sensing activity of medicinal plants in southern Florida. *Journal of Ethnopharmacology*, 15(3), 427–435.
- African Herbal Pharmacopoeia. (2010). In T. Brendler, J. N. Eloff, A. Gurib-Fakim, & L. D. Phillips (Eds.), *Association for African Medicinal Plants Standards (AAMPS)* (p. 289). Republic of Mauritius.
- Akunyili, D. N., Houghton, P. J., & Roman, A. (1991). Antimicrobial activities of the stem of *Kigelia pinnata*. *Journal of Ethnopharmacology*, 35(2), 173–177.
- AL-Ishaq, R. K., Abotaleb, M., Kubatka, P., Kajo, K., & Büsselberg, D. (2019). Flavonoids and their anti-diabetic effects: Cellular mechanisms and effects to improve blood sugar level. *Biomolecules*, 9(9), Article 403.
- Anastas, P., & Eghbali, N. (2010). Green chemistry: Principles and practice. *Chemical Society Reviews*, 39(1), 301–312.
- Andrews, S. N., Jeong, E., & Prausnitz, M. R. (2013). Transdermal delivery of molecules is limited by full epidermis, not just the stratum corneum. *Pharmaceutical Research*, 30(4), 1099–1109.
- Arkipov, A., Rayan, P., McDonnell, A., & Cock, I. E. (2014a). An examination of the antibacterial, antifungal, anti-giardial and anticancer properties of *Kigelia africana* fruit extracts. *Pharmacognosy Communications*, 4(2), 1–9.
- Arkipov, A., Sirdaarta, J., Matthews, B., Cock, I. E., & Ighere, D. A. (2014b). Metabolomic profiling of *Kigelia africana* extracts with anti-cancer activity by high-resolution tandem mass spectroscopy. *Pharmacognosy Communications*, 4(1), 33–42.
- Asekun, O. T., Olusegun, E., & Adebola, O. (2007). The volatile constituents of the leaves and flowers of *Kigelia africana* Benth. *Flavour and Fragrance Journal*, 22(1), 21–23.
- Atawodi, O., & Olowoniya, F. (2015). Pharmacological and therapeutic activities of *Kigelia africana* (Lam.) Benth. *Annual Research & Review in Biology*, 5(1), 1–17.
- Atolani, O., Fabiyi, O. A., & Olatunji, G. A. (2014a). Isovitexin from *Kigelia pinnata*, a potential ecofriendly nematicidal agent. *Tropical Agriculture*, 41(2), 020067–020008.
- Atolani, O., Olatunji, G. A., Fabiyi, O. A., Adeniji, A. J., & Ogbole, O. O. (2013). Phytochemicals from *Kigelia pinnata* leaves show antioxidant and anticancer potential on human cancer cell lines. *Journal of Medicinal Food*, 16(10), 878–885.
- Aung, T., Qu, Z., Kortschak, R., & Adelson, D. (2017). Understanding the effectiveness of natural compound mixtures in cancer through their molecular mode of action. *International Journal of Molecular Sciences*, 18(3), Article 656.
- Austin, D. F. (1978). Exotic plants and their effects in south-eastern Florida. *Environmental Conservation*, 5(1), 25–34.
- Babbar, N., Oberoi, H. S., Sandhu, S. K., & Bhargav, V. K. (2014). Influence of different solvents in the extraction of phenolic compounds from vegetable residues and their evaluation as natural sources of antioxidants. *Journal of Food Science and Technology*, 51(10), 2568–2575.
- Baert, B., Deconinck, E., Van Gele, M., Slodicka, M., Stoppie, P., Bode, S., Slegers, G., Vander Heyden, Y., Lambert, J., Beetens, J., & De Spiegeleer, B. (2007). Transdermal penetration behaviour of drugs: CART-clustering, QSPR and selection of model compounds. *Bioorganic & Medicinal Chemistry*, 15(22), 6943–6955.
- Beckley-Kartey, S. A. J., Hotchkiss, S. A. M., & Capel, M. (1997). Comparative in vitro skin absorption and metabolism of coumarin (1,2-benzopyrone) in human, rat, and mouse. *Toxicology and Applied Pharmacology*, 145(1), 34–42.
- Beidelman, T. O. (1964). Some Kaguru plants: Terms, names and uses. *Man*, 64, 79–82.
- Bello, I., Shehu, M. W., Musa, M., Zaini Asmawi, M., & Mahmud, R. (2016). *Kigelia africana* (Lam.) Benth. (Sausage tree): Phytochemistry and pharmacological review of a quintessential African traditional medicinal plant. *Journal of Ethnopharmacology*, 189, 253–276. <https://doi.org/10.1016/j.jep.2016.05.049>
- Bharti, N., Singh, S., Fermida, N., & Amir, A. (2006). Isolation and in vitro antiamebic activity of iridoids isolated from *Kigelia pinnata*. *Arkivoc*, 2006(10), 69–76.
- Boyle, P., & Levin, B. (2008). *World Cancer Report 2008*. International Agency for Research on Cancer.
- Brand-Williams, W., Cuvelier, M. E., & Berset, C. (1995). Use of a free radical method to evaluate antioxidant activity. *LWT - Food Science and Technology*, 28(1), 25–30.
- Burkill, H. M. (1985). *The Useful Plants of West Tropical Africa*. Royal Botanic Gardens.
- Butler, M. S., Fontaine, F., & Cooper, M. A. (2014). Natural product libraries: Assembly, maintenance, and screening. *Planta Medica*, 80(12), 1161–1170.
- Campbell, B. M., Clarke, J. M., & Gumbo, D. J. (1991). Traditional agroforestry practices in Zimbabwe. *Agroforestry Systems*, 14(2), 99–111.
- Carey, M. W., Rao, N. V., Kumar, B. R., & Mohan, G. K. (2010). Anti-inflammatory and analgesic activities of

- methanolic extract of *Kigelia pinnata* DC flower. *Journal of Ethnopharmacology*, 130(1), 179–182.
- Chenia, H. Y. (2013). Anti-quorum sensing potential of crude *Kigelia africana* fruit extracts. *Sensors*, 13(3), 2802–2817. <https://doi.org/10.3390/s130302802>
- Chih-Cheng, L., Lu-Te, C., Yuan-Chen, W., Yan-Hong, T., Jia-Shang, L., Boakye, A., Glew, R. H., & Glew, R. S. (2012). Polyphenol and antioxidant content of *Kigelia africana* leaves from Ghana. *Food*, 6(1), 1–5.
- Chinsembu, K. C., Hedimbi, M., & Mukaru, W. C. (2011). Putative medicinal properties of plants from the Kavango region, Namibia. *Journal of Medicinal Plants Research*, 5(28), 6787–6797.
- Chinsembu, K., Hjarunguru, A., & Mbangu, A. (2015). Ethnomedicinal plants used by traditional healers in the management of HIV/AIDS opportunistic diseases in Rundu, Kavango East Region, and Namibia. *South African Journal of Botany*, 100, 33–42.
- Chivandi, E., Cave, E., Davidson, B. C., Erlwanger, K. H., Mayo, D., & Madziva, M. T. (2012). Suppression of Caco-2 and HEK-293 cell proliferation by *Kigelia africana*, *Mimusops zeyheri* and *Ximenia caffra* seed oils. *In Vivo*, 26(1), 99–105.
- Cock, I. E. (2008). Antibacterial activity of selected Australian native plant extracts. *The Internet Journal of Microbiology*, 4(1), 1–12.
- Cock, I. E. (2013). Antimicrobial activity of *Leptospermum bracteata* and *Leptospermum juniperium* methanolic extracts. *Pharmacognosy Communications*, 3(3), 45–52.
- Cock, I. E., & Van-Vuuren, S. F. (2014). Anti-Proteus activity of some South African medicinal plants: Their potential for the treatment and prevention of rheumatoid arthritis. *Inflammopharmacology*, 22(1), 23–36. <https://doi.org/10.1007/s10787-013-0179-3>
- Cunningham, A. B. (1993). *African medicinal plants: Setting priorities at the interface between conservation and primary health care*. UNESCO.
- Cuzzocrea, S., Riley, D. P., Caputi, A. P., & Salvemini, D. (2001). Antioxidant therapy: A new pharmacological approach in shock, inflammation, and ischemia/reperfusion injury. *Pharmacological Reviews*, 53(1), 135–159.
- D'souza, D., Subhas, B. G., Shetty, S. R., & Balan, P. (2012). Estimation of serum malondialdehyde in potentially malignant disorders and post antioxidant treated patients: A biochemical study. *Contemporary Clinical Dentistry*, 3(4), 448–451.
- Dampeirou, C. (2002). *National Center for Biotechnology Information (2025). PubChem Patent Summary for US-2002176874-A1, Cosmetic compositions with high viscosity for female breast care containing kigelia extract*. U.S. Patent No. US-2002176874-A1. <https://pubchem.ncbi.nlm.nih.gov/patent/US-2002176874-A1>
- Ddhindsa, K. S. (2005). *Chemical Investigation and Antimicrobial Activity of Kigelia Pinnata Dc* [Doctoral dissertation, Chaudhary Charan Singh Haryana Agricultural University].
- De Wet, H., & Ngubane, S. C. (2014). Traditional herbal remedies used by women in a rural community in northern Maputaland (South Africa) for the treatment of gynaecology and obstetrics complaints. *South African Journal of Botany*, 94, 129–139.
- Dhungana, B. R., Jyothi, Y., & Das, K. (2017). *Kigelia pinnata*: Exploration of potential medicinal usage in human ailments. *Journal of Pharmacy Research*, 11(2), 138–142.
- Eldeen, I. M. S., & Van Staden, J. (2007). *In vitro* pharmacological investigation of extracts from some trees used in Sudanese traditional medicine. *South African Journal of Botany*, 73(3), 435–440.
- Eldeen, I. M. S., & Van Staden, J. (2008). Cyclooxygenase inhibition and antimycobacterial effects of extracts from Sudanese medicinal plants. *South African Journal of Botany*, 74(2), 225–229.
- El-Sayyad, S. M. (1981). Flavonoids of the leaves and fruits of *Kigelia pinnata*. *Fitoterapia*, 52(4), 189–191.
- Eyong, K. O., Ambassa, P., Yimdjo, M. C., Sidjui, L. S., & Folefoc, G. L. (2012). A new source of kojic acid isolated from *Kigelia africana*: A possible precursor for quinine biosynthesis. *Rasayan Journal of Chemistry*, 5(4), 477–480.
- Fabricant, D. S., & Farnsworth, N. R. (2001). The value of plants used in traditional medicine for drug discovery. *Environmental Health Perspectives*, 109(Suppl 1), 69–75. <https://doi.org/10.1289/ehp.01109s169>
- Fagbohun, O. F., Babalola, O. O., Agboola, F. K., Joseph, J. S., Malindisa, S., & Msagati, T. A. M. (2020a). Evaluation of phytochemicals, antioxidants, trace elements in *Kigelia africana* fruit extracts and chemical profiling analysis using UHPLC-qTOF-MS2 spectrometry. *Biological Trace Element Research*, 195(2), 679–695.
- FAO. (1986). *Some medicinal forest plants of Africa and Latin America*. Food and Agriculture Organization.
- Farah, H. M., Hussein, A. M., Khalid, H. E., & Osman, H. M. (2017). Toxicity of *Kigelia africana* fruit in rats. *Advances in Research*, 12(6), 1–9.
- Farmer, F., Knaul, F. M., Shulman, L. N., Alleyne, G., Armstrong, L., & Gospodarowicz, M. (2010). Expansion of cancer care and control in countries of low and middle income: A call to action. *Lancet*, 376(9747), 1186–1193.
- Ferlay, J., Bray, F., Pisani, P., & Parkin, D. M. (2001). *Globocan 2000: Cancer incidence, prevalence and mortality worldwide, Version 1.0*. IARC CancerBase.
- Focho, D. A., Newu, M. C., Anjah, M. G., Nwana, F. A., & Ambo, F. B. (2009). Ethnobotanical survey of trees in Fundong, Northwest Region, Cameroon. *Journal of Ethnobiology and Ethnomedicine*, 5, Article 1.

- Gabriel, O. A., & Olubunmi, A. (2009). Comprehensive scientific demystification of *Kigelia africana*: A review. *African Journal of Pure and Applied Chemistry*, 3(9), 158–164.
- Gao, X. M., Zhang, T. M., Zhang, J. R., Guo, J. S., & Zhong, G. S. (2007). *Chinese Materia Medica*. China Press of Traditional Chinese Medicine.
- Gessler, M. C., Msuya, D. E., Nkunya, M. H. H., Mwasumbi, L. B., Schär, A., Heinrich, M., & Tanner, M. (1995). Traditional healers in Tanzania: The treatment of malaria with plant remedies. *Journal of Ethnopharmacology*, 48(3), 131–144.
- Gouda, Y. G., Abdel-Baky, A. M., Mohamed, K. M., Darwish, F. M., Kasai, R., & Yamasaki, K. (2006). Phenylpropanoid and phenylethanoid derivatives from *Kigelia pinnata* DC. fruits. *Natural Product Research*, 20(10), 935–939.
- Govindachari, T. R., Patankar, S. J., & Viswanathan, N. (1971). Isolation and structure of two new dihydroisocoumarins from *Kigelia pinnata*. *Phytochemistry*, 10(7), 1603–1606.
- Grace, O. M., & Davis, S. D. (2010). *Kigelia africana* (Lam.) Benth. In L. P. A. Oyen & R. H. M. J. Lemmens (Eds.), *Plant resources of tropical Africa* (Vol. 1, p. 13). PROTA.
- Grace, O. M., Light, M. E., Lindsey, K. L., Mulholland, D. A., Van Staden, J., & Jäger, A. K. (2002). Antibacterial activity and isolation of active compounds from fruit of the traditional African medicinal tree *Kigelia africana*. *South African Journal of Botany*, 68(1), 220–222.
- Grace, O. M., Prendergast, H. D. V., Jäger, A. K., van Staden, J., & van Wyk, A. E. (2003). Bark medicines used in traditional healthcare in KwaZulu-Natal, South Africa: An inventory. *South African Journal of Botany*, 69(3), 301–363.
- Halder, S. (2017). A review on *Kigelia africana*. *World Journal of Pharmaceutical Research*, 6(8), 389–411.
- Halder, S., & Sharma, A. (2017). A review on *Kigelia africana*. *World Journal of Pharmaceutical Research*, 6(11), 1–15. <https://doi.org/10.20959/wjpr201711-9633>
- Harbourne, N., Marete, E., Jacquier, J. C., & O’Riordan, D. (2013). Conventional extraction techniques for phytochemicals. In *Handbook of plant food phytochemicals* (pp. 397–411). John Wiley & Sons.
- Harris, B., & Baker, H. (1958). Pollination in *Kigelia africana* Benth. *Journal of the West African Science Association*, 4(1), 25–30.
- Henry, J. (1949). Early pioneers of South Florida. *Tequesta*, 9, 61–72.
- Higgins, C., Bell, T., Delbederi, Z., Feutren-Burton, S., McClean, B., O’Dowd, C., Watters, W., Armstrong, P., Waugh, D., & van den Berg, H. (2010). Growth inhibitory activity of extracted material and isolated compounds from the fruits of *Kigelia pinnata*. *Planta Medica*, 76(15), 1840–1846.
- Hillary, K., Ronald, E. A., & William, H. H. (1998). Global burden of diabetes 1995–2025: Prevalence, numerical estimates and projections. *Diabetes Care*, 21(9), 1414–1441.
- Houghton, P. J. (2002). The sausage tree (*Kigelia pinnata*): Ethnobotany and recent scientific work. *South African Journal of Botany*, 68(1), 14–20.
- Houghton, P. J., Photiou, A., Uddin, S., Shah, P., Browning, M., Jackson, S. J., & Retsas, S. (1994). Activity of extracts of *Kigelia pinnata* against melanoma and renal carcinoma cell lines. *Planta Medica*, 60(5), 430–433.
- Imran, I. Z., Elusiyan, C. A., Agbedahunsi, J. M., & Omisore, N. O. (2021). Bioactivity-directed evaluation of fruit of *Kigelia africana* (Lam.) Benth. used in the treatment of malaria in Iwo, Nigeria. *Journal of Ethnopharmacology*, 268, Article 113680. <https://doi.org/10.1016/j.jep.2020.113680>
- Inoue, K., Inouye, H., & Chen, C. C. (1981). A naphthoquinone and a lignan from the wood of *Kigelia pinnata*. *Phytochemistry*, 20(9), 2271–2276.
- International Diabetes Federation. (2021). *IDF diabetes atlas* (10th ed.). <https://www.diabetesatlas.org>
- Jabeen, B., & Riaz, N. (2013). Isolation and characterization of limonoids from *Kigelia africana*. *Zeitschrift für Naturforschung B*, 68(9), 1041–1048.
- Jackson, S. J., Houghton, P. J., Retsas, S., & Photiou, A. (2000). Cytotoxicity of norviburtinal and isopinnatal from *Kigelia pinnata* against cancer cell lines. *Planta Medica*, 66(8), 758–761.
- Jeyachandran, R., & Mahesh, A. (2007). Antimicrobial evaluation of *Kigelia africana* (Lam). *Research Journal of Microbiology*, 2(8), 645–649.
- Kanase, H. R., & Singh, K. N. M. (2018). Marine pharmacology: Potential, challenges, and future in India. *Journal of Medical Sciences*, 38(2), 49–53.
- Kaur, H., Shyam, R., & Amutha, R. (2011). *Kigelia africana* fruit carbon as a low-cost adsorbent for removal of copper (II) ions from aqueous solution. *Nature, Environment and Pollution Technology*, 10(3), 419–422.
- Khan, M. F., Dixit, P., Jaiswal, N., Tamrakar, A. K., Srivastava, A. K., & Maurya, R. (2012). Chemical constituents of *Kigelia pinnata* twigs and their GLUT4 translocation modulatory effect in skeletal muscle cells. *Fitoterapia*, 83(1), 125–129.
- Kibirige, D., Lumu, W., Jones, A. G., Smeeth, L., Hattersley, A. T., & Nyirenda, M. J. (2019). Understanding the manifestation of diabetes in sub-Saharan Africa to inform therapeutic approaches and preventive strategies: A narrative review. *Clinical Diabetes and Endocrinology*, 5(1), Article 2. <https://doi.org/10.1186/s40842-019-0077-8>
- Kibiti, C. M., & Afolayan, A. J. (2015). Herbal therapy: A review of emerging pharmacological tools in the management of diabetes mellitus in Africa. *Pharmacognosy Magazine*, 11(Suppl 2), S258–S274.

- King, J. W. (2014). Modern supercritical fluid technology for food applications. *Annual Review of Food Science and Technology*, 5, 215–238.
- Kumawat, R. B., Mali, P. C., & Sharma, R. A. (2018). Ethnomedicine and pharmacological activities of five traditionally used Indian medicinal plants: A review. *Advances in Pharmacology and Toxicology*, 19(3), 45–56.
- Lal, S. D., & Yadav, B. K. (1983). Folk medicines of Kurukshetra district (Haryana), India. *Economic Botany*, 37(3), 299–305. <https://doi.org/10.1007/BF02858885>
- Lim, T. K. (2012). *Kigelia africana*. In *Edible medicinal and non-medicinal plants*. Springer. https://doi.org/10.1007/978-90-481-8661-7_65
- Luque de Castro, M. D., & García-Ayuso, L. E. (1998). Soxhlet extraction of solid materials: An outdated technique with a promising innovative future. *Analytica Chimica Acta*, 369(1–2), 1–10.
- MaClean, C. U. M. (1969). Traditional healers and their female clients: An aspect of Nigerian sickness behavior. *Journal of Health and Social Behavior*, 10(3), 172–186.
- Maheshwari, S., & Rajagopal, K. (2013). Biodiversity of endophytic fungi in *Kigelia pinnata* during two different seasons. *Current Science*, 104(4), 515–518.
- Makado, I. (2003). *Skincare preparation*. Japanese Patent No. JP2003137763.
- Maregesi, S. M., Ngassapa, O. D., Pieters, L., & Vlietinck, A. J. (2007). Ethnopharmacological survey of the Bunda district, Tanzania: Plants used to treat infectious diseases. *Journal of Ethnopharmacology*, 113(3), 457–470.
- McGregor, J., Maruzane, D., & Mukwekwerere, M. (1989). *Deforestation in Zimbabwe's communal lands: Perceptions of forest resource scarcity and value* (Geographical Paper No. 135). University of Reading.
- Mohanty, S., & Cock, I. E. (2010). Bioactivity of *Syzygium jambos* methanolic extracts: Antibacterial activity and toxicity. *Pharmacognosy Communications*, 2(1), 4–9.
- Moideen, S. V. K., Houghton, P. J., Rock, P., Croft, S. L., & Aboagye-Nyame, F. (1999). Activity of extracts and naphthoquinones from *Kigelia pinnata* against *Trypanosoma brucei brucei* and *Trypanosoma brucei rhodesiense*. *Planta Medica*, 65(6), 536–540.
- Moll, E. J., Moll, G., & Page, N. (1994). *Common trees of southern Africa*. Zimbabwe Publishing House.
- Moreira da Silva, F., Marques, A., & Chaveiro, A. (2010). Reactive oxygen species: A double-edged sword in reproduction. *Veterinary Science Journal*, 4(2), 127–133.
- Moshi, M. J., Otieno, D. F., Mbabazi, P. K., & Weisheit, A. (2009). The ethnomedicine of the Haya people of Bugabo ward, Kagera Region, north-western Tanzania. *Journal of Ethnobiology and Ethnomedicine*, 5, Article 24. <https://doi.org/10.1186/1746-4269-5-24>
- Mukavi, J. W., Mayeku, P. W., Nyaga, J. M., & Kituyi, S. N. (2020). *In vitro* anti-cancer efficacy and phytochemical screening of solvent extracts of *Kigelia africana* (Lam.) Benth. *Heliyon*, 6(7), Article e04481. <https://doi.org/10.1016/j.heliyon.2020.e04481>
- Mwila, K. F., Bwembya, P. A., & Jacobs, C. (2019). Experiences and challenges of adults living with type 2 diabetes mellitus presenting at the University Teaching Hospital in Lusaka, Zambia. *BMJ Open Diabetes Research & Care*, 7(1), Article e000497.
- Nabatanzi, A., Nkadameng, S. M., Lall, N., Kabasa, J. D., & McGaw, L. J. (2020). Antioxidant and anti-inflammatory activities of *Kigelia africana* (Lam.) Benth. *Evidence-Based Complementary and Alternative Medicine*, 2020, Article 4352084. <https://doi.org/10.1155/2020/4352084>
- Nabatanzi, A., Nkadameng, S., Lall, N., Kabasa, J. D., & McGaw, L. J. (2020). Ethnobotany, phytochemistry and pharmacological activity of *Kigelia africana* (Lam.) Benth. (Bignoniaceae). *Plants*, 9(6), Article 753. <https://doi.org/10.3390/plants9060753>
- National Toxicology Program. (2002). Butylated hydroxyanisole (BHA). *Report on Carcinogens: Carcinogen Profiles*, 10, 40–42.
- Neuwinger, H. D. (1997). African ethnobotany: Poisons and drugs: Chemistry, pharmacology, and toxicology. *Journal of Natural Products*, 60(8), 864–865.
- Newton, R. (2000). Molecular mechanisms of glucocorticoid action: What is important? *Thorax*, 55(7), 603–613.
- Nsubuga, U. (2018, August 14). The fruit that cures syphilis. *New Vision*. https://www.newvision.co.ug/new_vision/news/1475477/fru-it-cures-syphilis
- Nutakki, A., Chomba, M., Chishimba, L., Zimba, S., Gottesman, R. F., Bahouth, M. N., & Saylor, D. (2021). Risk factors and outcomes of hospitalized stroke patients in Lusaka, Zambia. *Journal of the Neurological Sciences*, 424, Article 117404. <https://doi.org/10.1016/j.jns.2021.117404>
- Nworu, V., & Akah, V. (2015). Anti-inflammatory medicinal plants and the molecular mechanisms underlying their activities. *African Journal of Traditional, Complementary and Alternative Medicines*, 12(6), 52–61.
- Oboh, G., Puntel, R. L., & Rocha, J. B. T. (2007). Hot pepper (*Capsicum annum*, Tepin and *Capsicum chinense*, Habanero) prevents Fe^{2+} -induced lipid peroxidation in the brain *in vitro*. *Food Chemistry*, 102(1), 178–185.
- Olatunji, A. G., & Atolani, O. (2009). Comprehensive scientific demystification of *Kigelia africana*: A review. *African Journal of Pure and Applied Chemistry*, 3(9), 158–164.
- Olubukola Oyebimpe Akanni, Solomon Eduviere Owumi, & Oluwatosin Adekunle Adaramoye. (2014). *In vitro* studies to assess the antioxidative, radical scavenging and arginase inhibitory potentials of extracts from *Artocarpus altilis*, *Ficus exasperata* and *Kigelia africana*. *Asian Pacific Journal of*

Tropical Biomedicine, 4(Suppl 1), S492–S499. <https://doi.org/10.12980/APJTB.4.2014C581>

Onyambu, M. O., Gikonyo, N. K., Nyambaka, H. N., & Thoithi, G. N. (2019). A review of trends in herbal drugs standardization, regulation and integration to the national healthcare systems in Kenya and the globe. *International Journal of Pharmacognosy and Chinese Medicine*, 3(3), Article 000168.

Owolabi, O. J., Omogbai, K. I., & Obasuyi, O. (2007). Antifungal and antibacterial activities of the ethanolic and aqueous extract of *Kigelia africana* (Bignoniaceae) stem bark. *African Journal of Biotechnology*, 6(14), 1677–1680.

Owolabi, O., & Nworgu, Z. (2009). Antiulcer effect of the ethanol extract of *Kigelia africana* (Lam.) Benth (Bignoniaceae). *The Internet Journal of Pharmacology*, 7(1), 1–6.

Oyelami, O. A., Yusuf, K. O., & Oyelami, A. O. (2012). The use of *Kigelia africana* in the management of polycystic ovary syndrome (PCOS). *Chinese Medicine*, 3(1), 1–3.

Packiavathy, I. A. S. V., Agilandeswari, P., Babu, R. R., Karutha, P. S., & Ravi, A. V. (2011). Anti-quorum sensing and antibiofilm potential of *Capparis spinosa*. *Archives of Medical Research*, 42(8), 658–668.

Packiavathy, I. A. S. V., Agilandeswari, P., Syed Musthafa, K., Pandian, S. K., & Ravi, A. V. (2012). Antibiofilm and quorum sensing inhibitory potential of *Cuminum cyminum* and its secondary metabolite methyl eugenol against Gram-negative bacterial pathogens. *Food Research International*, 45(1), 85–92.

Picerno, P., Autore, G., Marzocco, S., Meloni, M., Sanogo, R., & Aquino, R. P. (2005). Anti-inflammatory activity of verminoside from *Kigelia africana* and evaluation of cutaneous irritation in cell cultures and reconstituted human epidermis. *Journal of Natural Products*, 68(11), 1610–1614.

Pourmortazavi, S. M., & Hajimirsadeghi, S. S. (2007). Supercritical fluid extraction in plant essential and volatile oil analysis. *Journal of Chromatography A*, 1163(1–2), 2–24.

Punchard, N. A., Whelan, C. J., & Adcock, I. (2004). The Journal of Inflammation. *Journal of Inflammation*, 1(1), Article 1.

Quave, C. L., Pieroni, A., & Bennett, B. C. (2008). Dermatological remedies in the traditional pharmacopoeia of Vulture-Alto Bradano, inland southern Italy. *Journal of Ethnobiology and Ethnomedicine*, 4, Article 5.

Quave, C. L., Plano, L. R. W., & Bennett, B. C. (2011). Quorum sensing inhibitors of *Staphylococcus aureus* from Italian medicinal plants. *Planta Medica*, 77(2), 188–195.

Rådmark, O., & Samuelsson, B. (2009). 5-Lipoxygenase: Mechanisms of regulation. *Journal of Lipid Research*, 50(Suppl), S40–S45. <https://doi.org/10.1194/jlr.R800062-JLR200>

Raintree, J. B., & Hoskins, M. W. (1988). Appropriate research and development (R&D) support for forestry

extension. In *Planning forestry extension: Proceedings of an international symposium* (pp. 24–48). FAO.

Rayan, P., Stenzel, D., & McDonnell, P. A. (2005). The effects of saturated fatty acids on *Giardia duodenalis* trophozoites *in vitro*. *Parasitology Research*, 97(3), 191–200.

Rombaut, N., Tixier, A. S., Bily, A., & Chemat, F. (2014). Green extraction processes of natural products as tools for biorefinery. *Biofuels, Bioproducts and Biorefining*, 8(4), 530–544.

Saini, S., Kaur, H., Verma, B., Ripudaman, & Singh, S. K. (2009). *Kigelia africana* (Lam.) Benth - An overview. *Natural Product Radiance*, 8(2), 190–197.

Sautron, C., & Cock, I. E. (2014). Antimicrobial activity and toxicity of *Syzygium australe* and *Syzygium leuhamii* fruit extracts. *Pharmacognosy Communications*, 4(1), 53–60.

Setzer, M. C., Setzer, W. N., Jackes, B. R., Gentry, G. A., & Moriarity, D. M. (2001). The medicinal value of tropical rainforest plants from Paluma, North Queensland, Australia. *Pharmaceutical Biology*, 39(1), 67–78.

Shaikh, A. M., Shrivastava, B., Apte, K. G., & Navale, S. D. (2016). Medicinal plants as a potential source of anticancer agents: A review. *Journal of Pharmacognosy and Phytochemistry*, 5(2), 291–295.

Shi, Q. W., Li, L. G., Huo, C. H., Zhang, M. L., & Wang, Y. F. (2010). Study on natural medicinal chemistry and new drug development. *Chinese Traditional and Herbal Drugs*, 41(10), 1583–1589.

Shim, H., Jang, J. Y., Lee, S. H., & Lee, J. G. (2013). Correlation of the oxygen radical activity, antioxidants, and severity in the critically ill surgical patients-study protocol. *World Journal of Emergency Surgery*, 8, Article 18.

Sibongile, N., Sandy, V., Armored, V. E., & de Wet, H. (2016). Plants used to treat skin diseases in northern Maputland, South Africa: Antimicrobial activity and *in-vitro* permeability studies. *Pharmaceutical Biology*, 54(11), 2420–2436. <https://doi.org/10.3109/13880209.2016.1158287>

Sidjui, L. S., Melong, R., Mahiou-Leddé, V., Herbette, G., Tchinda, A. T., Ollivier, E., & Folefoc, G. N. (2015). Triterpenes and lignans from *Kigelia africana*. *Journal of Applied Pharmaceutical Science*, 5(1), 1–6.

Singh, A., Kumari, S., Singh, A. K., & Singh, N. K. (2018). Ethnopharmacology and pharmacology of *Kigelia africana* (Lam.) Benth. *International Journal of Green Pharmacy*, 11(4), S23–S31.

Singh, B. N., Singh, B. R., Singh, R. L., Prakash, D., Dhakarey, R., Upadhyay, G., & Singh, H. B. (2009). Quorum-sensing inhibitors and biofilms. *Anti-Infective Agents in Medicinal Chemistry*, 8(4), 315–326.

Smith, C. A. (1966). *Common names of South African plants* (Memoirs of the Botanical Survey of South Africa No. 35). Government Printer.

- Smithies, S. I. (2003). Bignoniaceae. In *Plants of southern Africa: An annotated checklist* (Strelitzia 14, pp. 312–313). National Botanical Institute.
- Sofowora, A. (1980). The present status of knowledge of the plants used in traditional medicine in Western Africa: A medical approach and chemical evaluation. *Journal of Ethnopharmacology*, 2(2), 109–118.
- Steenkamp, V., Fernandes, A., & Van Rensburg, C. (2007). Screening of Venda medicinal plants for antifungal activity against *Candida albicans*. *South African Journal of Botany*, 73(2), 256–258. <https://doi.org/10.1016/j.sajb.2006.11.003>
- Stephen, M., Njogu, S. M., Arika, W. M., Machocho, A. K., Ngeranwa, J. J. N., & Njagi, E. N. M. (2018). *In vivo* hypoglycemic effect of *Kigelia africana* (Lam): Studies with alloxan-induced diabetic mice. *Journal of Evidence-Based Integrative Medicine*, 23, 1–10.
- Tabuti, J. R. S., Kukunda, C. B., Kaweesi, D., & Kasilo, O. M. (2012). Herbal medicine used in the districts of Nakapiripirit, Pallisa, Kanungu, and Mukono in Uganda. *Journal of Ethnobiology and Ethnomedicine*, 8, Article 35.
- Truchado, P., Tomás-Barberán, F. A., Larrosa, M., & Allende, A. (2012). Food phytochemicals act as quorum-sensing inhibitors, reducing production and/or degrading *Yersinia enterocolitica* and *Erwinia carotovora* autoinducers. *Food Control*, 24(1–2), 78–85.
- Umamaheswari, M., & Chatterjee, T. K. (2008). *In vitro* antioxidant activities of the fractions of *Coccinia grandis* L. leaf extract. *African Journal of Traditional, Complementary and Alternative Medicines*, 5(1), 61–73.
- Van Wyk, B. E. (2011). The potential of South African plants in the development of new medicinal products. *South African Journal of Botany*, 77(4), 812–829.
- Vattem, D. A., Mihalik, K., Crixell, S. H., & McLean, R. J. C. (2007). Dietary phytochemicals as quorum sensing inhibitors. *Fitoterapia*, 78(4), 302–310.
- Venter, F., & Venter, J. A. (1996). *Making the most of indigenous trees*. Briza Publications.
- Wang, J. C., Patel, B. G., Ehmann, C. W., & Lowe, N. (1987). The release and percutaneous permeation of anthralin products, using clinically involved and uninvolved psoriatic skin. *Journal of the American Academy of Dermatology*, 16(4), 812–821.
- Watt, J. M., & Breyer-Brandwijk, M. G. (1962). *The medicinal and poisonous plants of southern and eastern Africa: Being an account of their medicinal and other uses, chemical compositions, pharmacological effects and toxicology in man and animal*. Livingstone.
- Weiss, E. A. (1979). Some indigenous plants are used domestically by East African coastal fishermen. *Economic Botany*, 33(1), 35–51.
- Wendelin, A. M., Kitabatake, N., & Mosha, T. C. E. (1997). The under-exploited indigenous alcoholic beverages of Tanzania: Production, consumption and quality of the undocumented "Denge". *African Study Monographs*, 18(1), 29–44.
- Wild, S., Roglic, G., Green, A., Sicree, R., & King, H. (2004). Global prevalence of diabetes: Estimates for the year 2000 and projections for 2030. *Diabetes Care*, 27(5), 1047–1053.
- World Health Organisation. (2010). *World malaria report*. World Health Organization.
- World Health Organization. (2002). *Traditional Medicine Strategy 2002–2005*. World Health Organization.
- Yuan, H., Ma, Q., Ye, L., & Piao, G. (2016). The Traditional Medicine and Modern Medicine from Natural Products. *Molecules (Basel, Switzerland)*, 21(5), 559. <https://doi.org/10.3390/molecules21050559>
- Zofou, D., Kengne, A. B., Tene, M., Ngemenya, M. N., Tane, P., & Titanji, V. P. (2011). *In vitro* antiplasmodial activity and cytotoxicity of crude extracts and compounds from the stem bark of *Kigelia africana* (Lam.) Benth (Bignoniaceae). *Parasitology Research*, 108(6), 1383–1390.

