



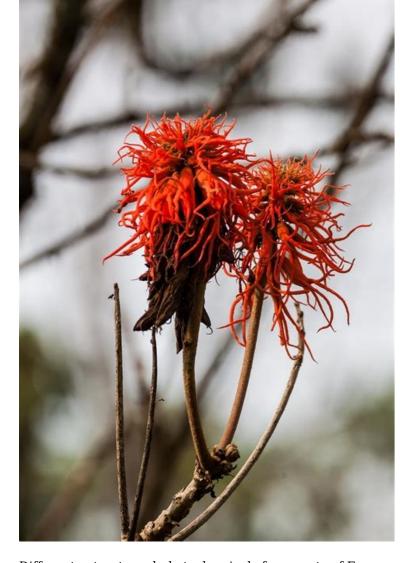
Erythrina abyssinica medicinal uses pdf

Marula tree medicinal uses. Cassia alata medicinal uses. Medicinal uses of ashoka leaves. Rabbitbrush medicinal uses.

Evidence-Based Complementary and Alternative Medicine/2021/Article/Review Article | Open AccessVolume 2021 | Article ID 5513484 | Baker Obakiro, 1,2,6Ambrose Kiprop, 2,6Elizabeth Kigondu, 3Isaac K'Owino, 5,6Mark Peter Odero, 2,6Scolastica Manyim, 2,6Timothy Omara, 2,6,9Jane Namukobe, 8Richard Oriko Owor, 10Yahaya Gavamukulya, 7and Lydia Bunalema4Academic Editor: Riaz UllahBackground. Many studies have been undertaken on the medicinal values of Erythrina abyssinica Lam. ex DC. (Fabaceae). The details, however, are highly fragmented in different journals, libraries, and other publication media. This study was therefore conducted to provide a comprehensive report on its ethnobotany, ethnomedicinal uses, phytochemicals, and the available pharmacological evidence supporting its efficacy and safety in traditional medicinal



Method. We collected data using a PROSPERO registered systematic review protocol on the ethnobotany, phytochemistry, and ethnopharmacology of Erythrina abyssinica from 132 reports that were retrieved from electronic databases. Documented local names, morphology, growth habit and habitat, ethnomedicinal and nonmedicinal uses, diseases treated, parts used, method of preparation and administration, extraction and chemical identity of isolated compounds, and efficacy and toxicity of extracts and isolated compounds were captured. Numerical data were summarized into means, percentages, and frequencies and presented as graphs and tables. Results. Erythrina abyssinica is harvested by traditional herbal medicine practitioners in East, Central, and South African communities to prepare herbal remedies for various human and livestock ailments. These include bacterial and fungal infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, cancer, meningitis, inflammatory diseases, urinary tract infections, tuberculosis, malaria, HIV/AIDS, diarrhea, ca skin and soft tissue injuries.



Different extracts and phytochemicals from parts of E. abyssinica have been scientifically proven to possess anti-inflammatory, antibacterial, antioxidant, antiplasmodial, antiproliferative, antifungal, antimycobacterial, antidiarrheal, anti-HIV 1, antidiabetic, and antiobesity activities.



This versatile pharmacological activity is due to the abundant flavonoids, alkaloids, and terpenoids present in its different parts. Conclusion. Erythrina abyssinica is an important ethnomedicinal plant in Africa harboring useful pharmacologically active phytochemicals against various diseases with significant efficacies and minimal toxicity to mammalian cells. Therefore, this plant should be conserved and its potential to provide novel molecules against diseases be explored further. Clinical trials that evaluate the efficacy and safety of extracts and isolated compounds from E. abyssinica are recommended.1. IntroductionErythrina abyssinica Lam. ex DC. (Fabaceae) is an important medicinal plant as evidenced by the existence of its names in various local languages and high frequency of citation in ethnobotanical surveys [1-4]. The genus Erythrina derives from the Greek word "erythros," translated to mean red (a reflection of the showy red flowers of its various species). The epithet "abyssinica" means "from Ethiopia" [5]. The Erythrina genus houses at least 120 species distributed mainly in tropical and subtropical zones [6].





Plants in this genus are usually referred to as "coral trees" due to their red flowers and branches that resemble the shape of sea coral [7]. Erythrina abyssinica is a deciduous leguminous tree native to East Africa but also found in Central and South Africa [8, 9]. Tropical Asia and Central America have E. abyssinica as an exotic species. The common English names of E. abyssinica are coral tree, Uganda coral, kaffir boom, erythrina, flame tree, red-hot-poker tree, and lucky-bean tree [10]. Some of the local names used across indigenous communities are summarized in Table 1. Medicinal plants have been a veritable source of cure for a number of human and livestock diseases, and thus, they are widely used in many communities. This is because plants house abundant secondary metabolites (phytochemicals) with potential pharmacological activities. These include flavonoids, alkaloids, terpenoids, phenols, chalcones, quinones, and coumarins. It is these phytochemicals that are locally extracted in herbal preparations and used as remedies for the management of several diseases. The World Health Organization (WHO) estimated that 80% of the world's population especially in low- and middle-income countries rely on herbal medicines for primary health care [30]. The use of herbal medicines in the management of several ailments among people continues to gain momentum due to their availability, affordability, perceived effectiveness, and cultural acceptability across ethnic backgrounds [31]. Globally, there has been an increase in natural product research in the last two decades [30, 32].

This has been partly in response to the increasing antimicrobial resistance, emergence of new diseases, and decrease in the chemical diversity of natural product libraries [30, 32-36].

It has also been so in an effort to continue the search for more effective, safer, and cheaper therapeutic agents for existing diseases, to substitute expensive prescription drugs [37-40]. Erythrina abyssinica is among those revered plants [40, 41] that has been widely researched [3]. However, the information on it is highly fragmented in different journals, books, university libraries, and other publication media platforms. This review was therefore undertaken to compile a comprehensive document that describes the ethnobotany, phytochemistry, and ethnopharmacology of E. abyssinica so as to generate integrated and sufficient scientific evidence to support its medicinal use. The study further emphasizes the importance of conserving this medicinal plant amidst the growing destruction of natural resources for settlement, industrialization, construction, and energy production [27, 42-47].2. Methods 2.1. Protocol Registration and Reporting The protocol used in this systematic review was registered with the International Prospective Register of Systematic Reviews (PROSPERO) and can be accessed from their website (with the registration number CRD42020187081. The Preferred Reporting of this study (Figure 1).2.2. Literature SearchElectronic data on ethnobotany, phytochemistry, efficacy, and toxicity of E. abyssinica were retrieved from electronic databases such as Scopus, Web of Science Core Collection, PubMed, American Chemical Society, ScienceDirect, Scientific Electronic Library Online (SciELO), Google Scholar, and NAPRALERT (a comprehensive natural products database with ethnomedical and pharmacological information of extracts and isolated compounds). Sets of keywords such as "ethnobotany," "traditional medicine," "ethnobotany," "traditional medicine," "ethnobotany," "alternative medicine," "ethnobotany," "traditional medicine," "ethnobotany," "traditional medicine," "ethnobotany," "traditional medicine," "ethnobotany," "alternative medicine," "ethnobotany," "alternative medicine," "ethnobotany," "traditional medicine," "ethnobotany," "Erythrina abyssinica." The retrieved articles were downloaded and stored in EndNote X9 (Thomson Reuters, San Francisco, CA, USA) by three independent authors (SBO, TO, and YG).

Duplicate articles were then removed from the file. Further, manual search from the reference lists of screened eligible articles and deposited electronic copies of dissertations and theses in University online libraries were done. The authors continuously received notifications of any new "similar reports" meeting the search criteria from ScienceDirect, Scopus, and Google Scholar.2.3. ScreeningRetrieved articles were first screened based on the titles and abstracts for relevance to the study by three independent reviewers (MPO, SM, and YG). Articles that reported on other species of Erythrina but not abyssinica and also abyssinica but not of genus Erythrina were also excluded. For example, we excluded articles on Entada abyssinica, Erythrina variageta, Erythrina suberosa, Albuca abyssinica, Dregea abyssinica, Arrisonia abyssinica, and Wahlenbergia abyssinica, and Wahlenbergia abyssinica, Erythrina variageta, Erythrina variageta and/or by the principal investigator (SBO). The eligible articles were then assessed further for inclusion in the study using the inclusion/exclusion criteria.2.4. Inclusion and Exclusion criteria.2.4. Inclusion criteria.2.4. Inclusion criteria.2.4. Inclusion criteria.2.4. Inclusion criteria.2.4. translated to English and published in peer-reviewed journals, reports, books, theses, and dissertations dated until January 2021 were considered. All publishing years were included without any geographical restrictions. Articles that reported data not relevant to the study, reviews, and not written in English or French were excluded from the study.2.5. Data ExtractionA data collection tool was designed in Microsoft Excel (Microsoft Corporation, USA) to capture data on different aspects of E. abyssinica. For ethnobotanical data, the diseases or ailments managed, parts used, and mode of preparation and administration were captured. For phytochemistry, the name of isolated pure compounds, chemical class, extraction solvent, and their efficacy and toxicity were captured. For ethnopharmacology, extraction solvent used, bioassay/model used, results of efficacy, and toxicity of extracts were captured. The collected data were checked for completeness and processed independently by two reviewers. 2.6. Data Analysis and SynthesisDescriptive statistical methods were used to analyse the collected data. Results were expressed as percentages and frequencies and subsequently presented as tables and charts. The analyses were performed using SPSS statistical software (version 20, IBM Inc.).3. Results and Discussion3.1. Literature Search and PublicationsA total of 201 reports were retrieved out of which 132 met the inclusion criteria and were retrieved out of these, 78 articles reported only on the ethnobotany, 27 articles on pharmacology only, 15 articles on both pharmacology and phytochemistry, 5 articles on phytochemistry only, and 3 articles on both ethnobotany and pharmacology, and phytochemistry. Most of the articles (56.8%) were published in the 2010-2019 decade, indicating a lot of research is being done as compared to the preceding decades (Figure 2). This could be due to the (1) growing need for more effective and less toxic medicinal products of plant origin, (2) emerging antimicrobial resistance that has rendered most chemotherapeutic agents less effective, (3) new disease outbreaks like Ebola, and (4) increase in noncommunicable diseases such as cancers, hypertension, diabetes mellitus, and sexual dysfunction that require readily available, affordable, effective, and safe therapies. 3.2. Taxonomy, Morphology, Distribution, and PropagationErythrina abyssinica belongs to the kingdom Plantae, phylum Spermatophyta, subphylum Magnoliophyta (flowering plants), class Magnoliopsida (dicotyledons), order Fabales, family Fabaceae (legumes), subfamily Papilionoideae, genus Erythrina (L.), and species abyssinica (Lam ex. DC.). The frequently encountered synonyms of this species include E. kassneri Baker f., Corallodendron suberifera (Welw. ex Baker) Kuntze, E. bequaerti De Wild., E. tomentosa R.

Br., Chirocalyx abyssinicus (Lam.) Hochst., and C. tomentosus Hochst.



[3].Erythrina abyssinica grows as a multibranched deciduous tree or shrub up to a height of 12–15 m tall usually with a rounded spreading crown (Figure 3). The branches have a corky thick deeply fissured bark with prickles (4–8 mm long). The leaves are trifoliate alternately arranged with long (6–20 cm) petiole. The leaflets can be ovate, cordate, and almost circular, rounded at the base and obtuse or notched at the apex, with network venation, dense hair usually at the abaxial surface, and prickles [49, 50]. The inflorescence is raceme, dense, pyramidal, and either terminal or axial with a long peduncle (up to 20 cm) and caducous bracts. Flowers are bisexual and papilionaceous having densely hairy, cylindrical, split at one side calyx, brightly coloured (orange to red) corolla with free keel petals, 10 fused and one free stamen, one carpel with a superior cylindrical oblong ovary, long style, and flat stigma head [51]. The fruits are linear-oblong pods, brown to black in colour, usually hairy, dehisce at two values to release ellipsoid, long (6–12 mm), and bright red seeds [52].

The tree is anchored firmly in the ground by a deep root system [13, 20].(a) (b) (a) (b) Erythrina abyssinica can be propagated either using seeds, wildings [40], or cuttings, but the former has comparatively lower germination rates of 10-30% with propagated either using seeds. grasslands (savannah woodlands, grasslands, and scrublands, secondary scrub vegetation, regions with 500-2000 mm annual rainfall and optimal temperatures of 15-25°C) [11, 54-57]. Thus, it is widespread from Sudan, South Suda Angola, Namibia, Botswana, Central African Republic, Swaziland, Lesotho, Gabon, Zambia, Zimbabwe, and Mozambique (Figure 4) [3, 10, 11, 53]. It has also been introduced as an ornamental in Mauritius and various places in Tropical Asia and Central America, including Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka [10, 53]. In South Sudan for instance, the tree grows at up to 2000 m altitude while in Tanzania, they are found at up to 2300 m. The tree naturally grows on loamy to clay soils, with preference for deep well-drained soils on plateaus and slopes with a pH of 3.5–5.5. The tree is termite- and fire-resistant primarily due to its deep root system but cannot tolerate frost, explaining its limited distribution in cold regions [11, 53].3.3. Ecological, Traditional, and Medicinal UsesErythrina abyssinica being a legume is well known for fixing nitrogen into the soil and thus enhances soil fertility. Because of this, it plays an important role in phytorestoration and forest regeneration in polluted soils [64–66]. Its flowers also secrete nectar that is fed on by pollinating insects especially bees hence being important in both horticulture [67]. Although this plant usually grows naturally in the wild, some communities cultivate it in their homesteads as an ornamental plant, for live fencing purposes due to its brightly coloured flowers and prickles, a material for dye, and craft materials such as curios and necklaces (from seeds) [9, 20, 68, 69]. The stem of this plant is also harvested to obtain timber and charcoal for furniture and energy purposes, respectively [20]. In livestock farming, the plant leaves are used as fodder for animals [5, 70, 71]. The stem bark, seeds, roots, root bark, leaves, and flowers of E. abyssinica and the whole plant either in combination or singly are used to prepare herbal remedies for various human ailments (Table 2). However, the stem bark and roots were the most investigated. This could probably be due to high yield associated with them because of their high potential in concentrating and storing phytochemicals. The seeds were indicated to be poisonous when crushed [11]. The commonest methods of preparation and administration of herbal medicines from this plant are boiling (decoctions) and then drinking, cold infusions (taken orally), pounding fresh samples into powder and then licking, pounding fresh samples into a paste and applying topically, squeezing fresh samples and mixing with bathing water, or direct chewing of the different parts (Table 2). Among the frequently reported ailments for which herbal medicines containing E. abyssinica are used include bacterial and fungal infections, malaria, leprosy, tuberculosis (cough), inflammatory diseases, HIV/AIDS, cancer, and metabolic disorders such as diabetes mellitus, obesity, and anaemia. Other conditions treated using this plant include snake bites, antagonizing poisons, venereal diseases (sexually transmitted diseases, e.g., gonorrhea, syphilis, and urinary tract infections including schistosomiasis), soft tissue and skin infections, diarrhea, infertility and pregnancy-related disorders, vomiting, hepatitis, and helminthiasis. In ethnoveterinary medicine, extracts of E. abyssinica are used in the management of poultry and livestock diseases such as new castle disease, anaplasmosis, and helminthosis [43, 89, 119, 123, 124].3.4. Phytochemical AnalysesOualitative phytochemical screening of medicinal plants is an essential step to their detailed phytochemical and pharmacological investigation [125]. Preliminary phytochemical screening of different solvent extracts of E. abyssinica indicated the presence of tannins, saponins, alkaloids, and flavonoids as the main therapeutic secondary metabolites (Table 3).3.4.2. Structural ElucidationLike in many natural product research studies, chromatography has been used in the isolation of compounds from crude extracts of E. abyssinica. The most widely used techniques included high-performance liquid chromatography (HPLC), and ultraperformance liquid chromatography (UPLC) [129]. Spectroscopic techniques such as mass spectrometry (MS), ultraviolet (UV) spectrophotometry, one-dimensional nuclear magnetic resonance (1D-NMR) spectroscopy, and its complementary techniques (heteronuclear multiple guantum coherence (HMQC) spectroscopy, nuclear multiple guantum coherence (HMQC) spectroscopy, heteronuclear multiple guantum coherence (HMQC) spectroscopy, and its complementary techniques (heteronuclear multiple guantum coherence (HMQC) spectroscopy, and its complementary techniques (heteronuclear multiple guantum coherence (HMQC) spectroscopy, and its complementary techniques (heteronuclear multiple guantum coherence (HMQC) spectroscopy, heteronuclear multiple guantum coherence (HMQC) spectroscopy, and its complementary techniques (heteronuclear multiple guantum coherence (HMQC) spectroscopy, heteronuclear multiple guantum coherence (HM spectroscopy) have been used to elucidate chemical structures of the isolated compounds [130]. Chromatography-spectroscopy hyphenated techniques have become more commonly used in recent decades due to the increased efficiency, sensitivity, and detection limits [1].

These include LC-MS, GC-MS, UPLC-MS, HPTLC-UV, HPLC-photodiode array detection, LC-NMR-MS, GC-NMR-MS, and high-resolution electron spray ionization (ESI)-MS [130]. A total of 122 phytochemicals which are primarily alkaloids, flavonoids, and triterpenoids have been isolated from E. abyssinica (Figure 5; Table 4). Some of the isolated compounds are specific to E. abyssinica while others have been reported to be present in other species of the genus Erythrina [149]. Because genus Erythrina belongs to the family Fabaceae, its members have a rich diversity of secondary metabolites (phytochemicals) amongst themselves due to possession of various biosynthetic pathways [150]. However, some species share common phytochemicals, and hence, these act as biomarkers for nutraceutical, pharmacological, and toxicological potentials in the food and drug industries [130, 151].(a) (b) (c) (d) (e) (f) (g) (1) Alkaloids. In the present study, we retrieved thirteen alkaloids (1-12 and 95) that have been isolated from E. abyssinica (Table 4, Figure 5). The Erythrina alkaloids have a tetracyclic carbon skeleton with three rings (A, B, and C) common to all the alkaloids contain ring D as an unsaturated  $\delta$ -lactone, dienoid alkaloids possess a benzenoid ring D (with two double bonds at C-1 and C-2, and C-6 and C-7), and alkenoid alkaloid possess a benzenoid ring D with a double bond between C-1 and C-6.

Aromatic alkaloids and those containing a double bond at C-16 undergo stereoisomerism to give rise to other alkaloid derivatives [152],(2) Flavonoids. A total of 106 flavonoids have been isolated and identified from E. abyssinica. These include five benzofurans, six isoflavones, six isoflavones and seventy-two flavones, and elven pterocarpans. (i)Benzofurans. Benzofurans are heterocyclic compounds consisting of benzene and furan rings fused to a completely delocalized n-electron system on both benzene rings. Chalcones have been isolated from the synthesis of therapeutic agents [152]. In this study, seven chalcones (15, 28–32, and 47) were retrieved to have been isolated from the roots and stem bark of E. abyssinica. (ii)ICoumestans. Coumestans are oxidized derivatives of pterocarpans consisting of a benzovole fused to a chromen-2-one to form 1-benzovole fused to a chromen-2-one to form 1-benzovole], 2-clothoma-6-one. They are responsible for the 2-phenyichroman flavones and spectra part of the 2-antivity of most medicinal plants of the family Fabaceae [152]. Two coumestans, are used to a chromen from the presence of a chiral enter of substituents on the isoflavones arise from the presence of a chiral center at C-2 position. Members different oxidation states in this skeleton, and the number of substituents [155]. On the other hand, flavonoes are a large group of flavonoes are and hydroxyl substituents [155]. On the other hand, flavonoes flavanones are a chiral center at C-2 position. Members different oxidation states in this skeleton, and the number of substituents [156]. On the other hand, flavonoes are and used to a chromen-5-2-3. and the presence of a chiral center at C-2 position. Members different oxidation states in this skeleton and/or the number of substituents [156]. Unlike isoflavones (25-27-8, 3, 110, and 111) and 72 flavanones (14, 17-22, 24, 3-46, 48-61, 63, 70-75, 77-82, 84, 87-92, 100-013), 108, 109, 111-119, and 122, 11-122) have been isolated from the rosts and roots hysinca centers of the fa

They are the dominant constituents of essential oils and other pharmacologically active oxygenated hydrocarbons occurring in higher plants. They naturally exist as hydrocarbons such as carbonyl compounds, alcohols, lactones, and carboxylic acids [158]. Three sesquiterpenes, 3,6-caryolanediol (115) and clovane-2,9-diol (116) along with caryolane-1,9-diol (96), were isolated from E. abyssinica roots [134]. On the other hand, two new triterpenoids, abyssaponin B (97) along with a triterpenoid saponin, soyasapogenol B (99), were isolated from E. abyssinica stem bark [147].3.5. Pharmacology of E. abyssinica and Isolated CompoundsIn this section, we report investigations which evaluated the pharmacological potential of both extracts and isolated pure compounds from E. abyssinica. Indeed, phytochemicals in this species possess antibacterial, antifungal, antiviral, anticancer, antioxidant, anti-inflammatory, antimycobacterial, anti-HIV/AIDS, antiplasmodial, antihelmintic, antibesity, antipyretic, antidiabetic, antianemic, and hepatoprotective bioactivities (Tables 4 and 5).3.5.1. Anti-Inflammatory ActivityThe aqueous root bark of E.

abyssinica at doses less than 100 mg/kg showed considerable in vivo anti-inflammatory activity against Trypanosoma brucei-induced inflammation in mice [50]. The extract-treated group had a lower number of astrocyte reactivity and reduced perivascular cuffing than the nontreated mice. It was suggested that the extracts reduced the infiltration of the inflammatory cells into the cerebrum of the brain. The anti-inflammatory activity was attributed to the alkaloids and flavonoids present in the extracts although the pure compounds responsible were not identified [50]. Interestingly, other crude extracts and pure compounds isolated from members of the genus Erythrina have been validated to possess good anti-inflammatory activities via different mechanisms. For example, the ethyl acetate and ethanol extracts of E. latissimi, E. caffra, and E. lysistemon showed good anti-inflammatory activity through reduction in the synthesis of prostaglandins as a result of inhibition of cyclooxygenase activity [168]. Erycristagallin isolated from E. mildbraedii inhibited leukotriene synthesis via the 5-lipoxygenase pathway, thereby demonstrating in vitro anti-inflammatory activity (IC50 = 23.4 µM) in polymorphonuclear leukocytes [169].

Three flavonoids (abyssinone V, erycrystagallin, and 4'-hydroxy-6,3',5'-triprenylisoflavonone) isolated from the methanolic stem bark extract E. variegate had strong phospholipase A2 (PLA2) inhibitory activity with IC50 values of 6, 3, and 10 µM, respectively [170]. This implied that these compounds can significantly reduce the synthesis of arachidonic acid and consequently diminish the synthesis of prostaglandins and leukotrienes. Two prenylated flavanones (sigmoidin B) isolated from E.

sigmoidea were reported to selectively inhibit 5-lipoxygenase but had no effect on cyclooxygenase-1 activity. Sigmoidin A had a dose-response inhibitory potency (IC50 = 31 mM). In the PLA2-induced mouse paw oedema assay, only the sigmoidin B inhibited oedema formation with a percentage inhibition of 59% compared to cyproheptadine (positive control) which had 74% after 60 minutes. In the TPA test, both compounds reduced the induced oedema by 89% and 83%, respectively.

It was suggested that the compounds had different mechanisms of action depending on whether one or two prenyl groups were present in ring B of the flavonoid [83]. Since these same compounds have been isolated from E. abyssinica, it is highly probable that the reported anti-inflammatory activity of this plant is due to one or a combination of these mechanisms. 3.5.2. Antioxidant ActivityThe in vitro 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay has been widely used to evaluate the antioxidant activity of various phytochemicals and extracts. The ethanolic extract of E.

abyssinica (10-320  $\mu$ g/mL) showed dose-dependent DPPH radical scavenging that was comparable to that of ascorbic acid (a known antioxidant) [159]. Abyssinone VII, sigmoidin B, eryvarin L, and 3-methylbutein isolated from the stem bark and root wood of E. abyssinica showed considerable DPPH radical scavenging potency (IC50 = 12-52  $\mu$ g/mL) although the standard antioxidants (ascorbic acid, gallic acid, and quercetin) had superior activity (IC50 = 4-18  $\mu$ g/mL) [134]. The acetone crude extract of the root bark of E. abyssinica (IC50 = 7.7  $\mu$ g/mL) and two isolated pterocarpenes, erycristagallin (IC50 = 8.2  $\mu$ g/mL) and 3-hydroxy-9-methoxy-10-(3,3-dimethylallyl) pterocarpene (IC50 = 10.8  $\mu$ g/mL), showed DPPH radical scavenging activity in a dose-dependent manner similar to that of quercetin (IC50 = 5.4  $\mu$ g/mL) [133].

The radical scavenging activity of these compounds is due to their free phenolic groups which can donate electrons to the radicals [171].

For flavonoids, the O-dihydroxyl structure in the B ring, the 2,3-double bond in conjunction with the 4-oxo function in the C ring, and the 3- and 5-hydroxyl groups with hydrogen bonding to the keto group are responsible for the antioxidant activity. In pterocarpans, the 3,3-dimethylallyl groups enhance the radical scavenging activities and also increase the lipophilicity of these compounds making them better antioxidants than polar flavonoids [133].3.5.3. Anticancer Activity The chloroform, methanol, and breast) and strongly inhibited protein tyrosine phosphatase (PTP1B) activity with IC50 ranging between 1 and 100 µg/mL. Using the dimethylthiazol-2,5-diphenyl-tetrazolium bromide (MTT) assay, the abyssinones A-D and abyssaponins (A and B) isolated from E. abyssinica stem bark exhibited considerable cytotoxicity against MCF-7 and MDA-MB-231 breast adenocarcinoma cell lines with IC50 ranging between 12.9 and 74 µM as compared to resveratrol (IC50 = 13.9-19.3 µM) [147]. The mechanisms by which these phytochemicals isolated from E. suberosa showed to induce apoptosis through the inhibition of NF-kB factor and via an increase in cytosolic cytochrome C that stimulates caspases 9 and 3 which further activity at a dose of 500 mg/kg in rats using the oral glucose tolerance test (OGTT) with a hyperglycemia inhibition factor of 38.5% as compared to glibenclamide (49.6%). It was suggested that probably the inhibition of the SLGT-1 and GLUT-2 transporters along with α-glucosidase were the possible mechanisms for the antidiabetic activity [114]. In an acute OGTT, the ethanolic extract of E. abyssinica significantly decreased blood glucose levels in both normal and streptozotocin- (STZ-) induced diabetic rats in a dose-dependent manner (100, 200, and 400 mg/kg) when compared with negative (normal saline) and positive control (glibenclamide) [159]. In a subchronic antidiabetic test, daily oral administration of the same doses of extract for six weeks significantly lowered blood glucose levels in STZ-induced diabetic rats in a dosedependent manner when compared with the diabetic control group. In this study, glibenclamide (5 mg/kg) significantly lowered blood glucose in nondiabetic rats only but not in diabetic rats [159]. Benzofurans, coumestans, and flavanones isolated from the stem bark of E. abyssinica had marked stimulation of the AMP-activated protein kinase (AMPK) activity with varying potencies at 10 µM concentrations with coumestans and benzofurans showing the highest potency. The prenyl groups in coumestans and benzofurans were suggested to be responsible for the enhanced stimulatory activity while their substitution with a methoxy group in the B ring could be responsible for the decreased activation of the AMPK. Activated AMPK plays a critical role in glucose and lipid metabolism such as enhancing insulin sensitivity, stimulating glucose uptake in the muscles, suppressing gluconeogenesis in the liver, increased oxidation, and diminished fatty acid synthesis. All these mechanisms are responsible for the antidiabetic activity of the isolated phytochemicals [144]. Further, prenylated flavanones from the stem bark of E. abyssinica inhibited protein tyrosine phosphate 1B (PTP1B) activity in an in vitro assay with IC50 = 4.7 µM). Since PTP1B regulates the insulin and leptin signaling pathways, its inhibition has been reported to result in hypoglycemic effect, and hence, its inhibitory compounds have a great potential in acting as antidiabetic and antiobesity agents [135, 142, 160]. Sigmoidin A, a flavanone isolated from the stem bark of E. abyssinica showed a considerable in vitro inhibitory activity on pancreatic lipase (IC50 = 4.5 μM) and α-glucosidase enzyme (IC50 = 62.5 μM). Although orlistat (an antiobesity drug) exhibited a superior inhibitory activity against pancreatic lipase (IC50 = 0.3 µM), the observed activity suggested that prenylated flavonoids have potential antilipase activity against pancreatic lipase (IC50 = 190.6 µM), a standard antidiabetic agent [146].3.5.5. Antiparasitic Activity The antiplasmodial activity of E. abyssinica has been evaluated using the nonradioactive antiplasmodial (in vitro) and four-day Plasmodial activity against chloroquine-resistant and chloroguine-sensitive Plasmodium strains with IC50 values of 5.3 and 7.9 µg/mL, respectively [49, 163]. Subsequently, isolated chalcones, flavanones, and isoflavonoids had promising antiplasmodial activity against chloroguine-sensitive had superior activity [49]. Another earlier in vitro study by Kebenei et al. [143] assessed the possible use of artemisinin in combination with a potential antimalarial drug from ethyl acetate extract of E. abyssinica stem bark reported that abyssinone V isolated from the extract was effective against chloroquine-sensitive (D6) P. falciparum parasites with IC50 value of 3.19 µg/mL. The interaction of artemisinin and abyssinone V analyzed using combination ratios of 10:90 to 90:10, respectively, against P. falciparum led to the identification of an antimalarial combination therapy of artemisinin and abyssinone V with sum of fraction inhibiting concentration (FIC) of 0.79 at a ratio of 2:3, respectively [143]. In an in vivo study, the root extracts of this plant suppressed P. berghei infection by 77%, 71%, and 48% in mice treated with a higher dose (50 mg/kg) had a significantly longer survival time than those treated with lower doses and even chloroguine [164]. The crude leaf extracts of E. abyssinica had weak activity against P. falciparum chloroquine-sensitive Sierra Leone I (D6) and multidrug-resistant Indochicha I (W2) strains with IC50 ranging from 165 to 468 µg/mL [145]. Conversely, erythinasinate A and 7-hydroxy-4'-methoxy-3-prenylisoflavone isolated from E. abyssinica methanolic leaf extract had moderate antiplasmodial activity against W2 and D6 with IC50 between 120 and 150 µg/mL [145]. Isolated compounds had a much higher antiplasmodial activity than the crude extract. Isolation removes matrix interference and increases the concentration of the active ingredient at the drug target [173]. In another study, the ethyl acetate extract of this plant at 10 µg/mL inhibited the growth of P. falciparum by 83.6% as compared to chloroquine (98.1%) [73].

This antiplasmodial activity was also confirmed in E. burttii, a related species.

The acetone root bark extract of E. burttii had good in vitro antiplasmodial activity against the chloroquine-resistant and chloroquine-sensitive P.

falciparum strains with IC50 of 1.73 and 0.97 µg/mL, respectively [163]. The methanolic leaf extract of E. abyssinica also exhibited moderate mosquitocidal and larvicidal activities with 65.5% and 65.1% mortality and corresponding IC50 values of 231.90 and 218.90 mg/mL, respectively. However, the activities were host identified, it methalolic leaf extract of E. abyssinica also exhibited moderate mosquitocidal and larvicidal activity of E. abyssinica also exhibited moters target by 69.90 %) [49, 145]. The antihelminitic activity of E. abyssinica has been validated using the worm motility assessment assay on Ascaridia galli. The ethanolic leaf extract of E. abyssinica has been validated using the worm motility assessment assay on Ascaridia galli. The ethanolic leaf extract of this plant cactivity of E. abyssinica has been validated using the worm motility assessment assay on Ascaridia galli. The ethanolic leaf extract of E. abyssinica has been validated using the active phytochemicals were not identified, it was suggested that the antihelminitic activity of this plant could be due to tranna dalaloids present in the crude extracts. This is because tannins are polyphenolic compounds if e. abyssinica have been widely evaluated using the microbroth dilution assay against various pathogens. The bacteria tested against tincluded Escherichia coli, Staphylococcus aureus, Bacillus subtilis, methicillin-resistant Staphylococcus aureus, Pseudotidia albicans, Mucor mucedo, Saccharomyces cerevisiae, Penicillium crustosum, Microsporum gypseum, Trichophyton mentagrophytes, and Cryptococcus neoformas. The bacteria tested against cliftence in the word antibacteria and antifungal activities with minimum inhibitory concentrations (MICs) between 3 and 10,000 µg/mL against different pathogens. Generally, the extracts had strong activity against Gram-negative bacteria it level and moderate to eval adard moderate to eval adard moderate to eval adard moderate (SIG) and SIG adard adar

utils, R. chinensis, and M. mucedo [136]. In a recent study, Schultz et al. [176] reported that ethyl acetate and ethanolic extracts of E. abyssinica bark did inhihit Enterococcus facum EU-4d (ICSD = 64 µg/mL), Acinetobacter Jaumannii CDC-0033 (ICSD = > 256 µg/mL), but had no activity against Klebsiella pneumoniae CDC-004, Pseudomonas aeruginosa AH-71, and Enterobacter cloacea CDC-0032. Further, the extracts or isolated compounds. Therefore, it remains to be determined whether the phytochemicals are microbiostatic or microbiotidal.3.5.7. Antimycobacterial ActivityThe crude methanolic root bark of this plant inhibited the growth of four Mycobacterial activity on the extracts or isolated compounds. Therefore, it remains to be determined whether the phytochemical, a standard and a growt inhibited the growth of four Mycobacterial Growth Indicator Tube (MGIT) 960 TB system, the methanolic root bark of this plant inhibited the growth of four Mycobacterial Growth Indicator Tube (MGIT) 960 TB system, the methanolic activity of each other or isolated compounds. Thereaties at the same tested concentration of 2.5 mg/mL, and terpenoids present in the extracts interacts (0.49 µg/mL) when combined with either rifampicin or isonaizid (0.01 µg/mL) had a complete inhibitory effect on the growth indicator Tube (MGIT) 960 TB system; the management of susceptible and resistant tuberculosis. We addity and the growth of M. tuberculosis (H37Rv). The standard drugs at methanol and ethanol extracts at the same tested concentration of 2.5 mg/mL had a complete inhibitory effect on the growth of M. tuberculosis, W. tawassinica and the growth indicator interaction anagement of tuberculosis. We addit at the same tested concentration of 2.5 mg/mL had 0.5 mg/mL and 0.

The extract was hepatoprotective against steatosis, inflammation, and hepatic ballooning. The extracts also significantly altered other hepatic-related biochemical indices as compared to standard drug pioglitazone [162]. This hepatoprotective activity was attributed to the coumestans, benzofurans, and pterocarpans present in the water extracts that regulate the activity of AMP kinases and protein tyrosine phosphatase 1B.3.5.10.

Antipyretic and Estrogenic ActivityThe estrogenic activity of this plant was studied using the smart button data loggers' model in ovariectomized rats. The methanol extract (200 mg/kg) and estrogen (1 mg/kg) reduced the number and frequency of hot flushes (171) as compared to those ovariectomized rats that did not receive the extract (264). Also, the rats treated with extract and estrogen had significantly reduced durations (683 and 869 minutes, respectively) of hot flashes than the untreated rats (1935 minutes). Thus, the methanol extract seemed to offer protection against small temperature rises which trigger hot flashes in the ovariectomized untreated rats. Although the real chemicals in the extract responsible for the antipyretic activity were not identified, it was postulated that the chemicals mimic estrogen by increasing the sweating threshold and thermoneutral zone size [161].

In a related study, the estrogenic activity of the erythroidines isolated from E. poeppigiana was evaluated using various estrogen receptor (ER-) dependent reporter gene assays. It was found out that both  $\alpha$ -erythroidine and  $\beta$ -erythroidine showed significant binding affinity values for ER $\alpha$  of 0.015% respectively, whereas only  $\beta$ -erythroidine showed a significant binding affinity values for ER $\alpha$  of 0.015% respectively, whereas only  $\beta$ -erythroidine showed a significant ergonic stimulation of ER-dependent reporter gene assays, both erythroidines showed a significant binding affinity values for ER $\alpha$  of 0.015% respectively, whereas only  $\beta$ -erythroidine showed a significant ergonic stimulation of ER-dependent reporter gene assays. It was found out that both  $\alpha$ -erythroidine showed a significant binding affinity values for ER $\alpha$  of 0.015% respectively, whereas only  $\beta$ -erythroidines showed a significant binding affinity values for ER $\alpha$  of 0.015% respectively, whereas only  $\beta$ -erythroidines showed a significant ergonic stimulation of ER-dependent reporter gene assays. It was found out that both  $\alpha$ -erythroidine showed a significant binding affinity values for ER $\alpha$  of 0.015% respectively, whereas only  $\beta$ -erythroidines showed a significant ergonic stimulation of ER-dependent reporter gene assays. It was found out that both  $\alpha$ -erythroidines showed a significant binding affinity values for ER $\alpha$  of 0.015% respectively, whereas only  $\beta$ -erythroidines showed a significant ergonic stimulation of ER-dependent reporter gene activity of this plant. As found out that both  $\alpha$ -erythroidines showed a significant ergonic activity of this plant. As found out that both  $\alpha$ -erythroidines showed a significant ergonic activity of this plant. As found out that both  $\alpha$ -erythroidines showed a significant ergonic activity of this plant. As found out that both  $\alpha$ -erythroidines showed a significant ergonic activity of this plant. As found out first of the ergonic activity of this plant. As found out first or and ergonic activi

On the other hand, some may be immediate while others delayed. Although no substance can be declared to be completely devoid of toxicity, toxicity tests (acute, subchronic, and chronic) are used to determine the relative toxicity of potential therapeutic agents. Despite the huge data regarding its toxicity. The seeds are traditionally known to be poisonous [11]. In an in vitro acute toxicity assay using the brine shrimp lethality model, the methanolic and ethanic extracts of E. abyssinica had LC50  $\geq$  1000 µg/mL [127] and 997 µg/mL, respectively. A related in vitro study using the haemolytic assay reported that the extracts were (62.5 µg/mL), ethyl acetate (62.5 µg/mL), and methanol (125 µg/mL), and methanol (125 µg/mL), and methanol extracts from this plant, it was found out lhat the median lethal dose clls [175]. The higher percentage haemolysis (15.5, 9.1, 15.4, and 39.7%) of red blood cells [175]. The higher percentage haemolysis (15.5, 9.1, 15.4, and 39.7%) of red blood cells [175]. The higher percentage haemolysis (15.5, 9.1, 15.4, and 39.7%) of red blood cells [175]. The higher percentage haemolysis (15.5, 9.1, 15.4, and 39.7%) of red blood cells [175]. The higher percentage haemolysis (15.5, 9.1, 15.4, and 39.7%) of red blood cells [175]. The higher percentage haemolysis (15.5, 9.1, 15.4, and 39.7%) of red blood cells [175]. The higher percentage haemolysis (15.5, 9.1, 15.4, and 39.7%) of red blood cells [175]. The higher percentage haemolysis (15.5, 9.1, 15.4, and 39.7%) of red blood cells [175]. The higher percentage haemolysis (15.5, 9.1, 15.4, and 39.7%) of red blood cells [175]. The higher percentage haemolysis (15.5, 9.1, 15.4, and 39.7%) of red blood cells [175]. The higher percentage haemolysis (15.5, 9.1, 15.4, and 39.7%) of red blood cells [175]. The higher percentage haemolysis (15.5, 9.1, 15.4, and 39.7%) of red blood cells [175]. The higher percentage haemolysis (15.5, 9.1, 15.4, and 39.7%) of red blood cells [175]. The higher percentage haemolysis (15.5, 9.1, 15.4, and 39.7%) of red blood

This could probably suggest possible liver insufficiency or interference with bile flow. However, this finding was inconclusive as it could be due to other contributing factors other than the liver. Another study reported that the E.

abyssinica (1000 mg/kg) significantly increased the levels of urea and creatinine and level of serum diagnostic enzymes particularly alkaline phosphatase, and alpha-amylase in treated mice after 28 days of daily oral administration [128]. This probably indicated some degree of impairment of renal, liver, and heart functions. Histopathological evaluation of the tissues of the liver revealed necrotic foci, dilated and congested blood vessels, numerous hepatocytes with double nuclei in view, and infiltration of inflammatory cell, while the kidney tissues showed necrotic foci in the papillary region, loss of tubules in necrotic foci, and vacuolated cells in place of original cells.

The liver being the primary detoxifying organ of the body while the kidney being the excretory organ are highly susceptible to damage by phytochemicals present in the extracts/herbal medicines. The haematological parameters were also slightly altered by extract administration, suggesting an effect on the hematopoietic tissue [183]. As with the biochemical parameters, the assays did not conclusively show haemolysis or other blood-related toxicity of the extracts. In contrast, another study found out that the stem extract (1000 mg/kg) did not significantly alter the haematological indices of the treated rats as compared to the nontreated after 28 days of daily oral administration [128]. It can therefore be inferred that extracts of this plant have minimal toxicity effect on the hematopoietic tissue. Since this plant have memory by conduct or an herbal product from te subject is sufely expectives. An orall medicine use 4. Conclusion and Future PerspectivesE. abyssinica has been proven to harbor useful pharmacologically active phytochemicals against various diseases with significant efficacies although with some minimal toxicity profiles. There is therefore a need to generate sufficient evidence as regards their safety for human use. Once proven safe, the plant could provide a cheap and sustainable source of novel molecules for the development. There is also a need to standardize and promote rational herbal medicine use through encouraging registration and licensing of products with proven efficacy and sustainable source of not is subscince are required. Due to its ethony development. There is also a need to standardize and promote rational herbal medicine use through encouraging registration and licensing of products with proven efficacy and encouraged to conserve this plant species. Abbreviations.AMPK:Adenosine monophosphate-activated protein kinaseCNS:Central nervous systemE. abyssinica:Erythrina abyssinica

ex. DC.HIV:Human immunodeficiency virusLD50:Median lethal doseMIC/IC50:Minimum inhibitory concentrationPLA2:Phospholipase A2WHO:World Health Organization.Data AvailabilityThis is a review article and no raw experimental data were collected. All data generated or analyzed during this study are included in this published

article.DisclosureThis work was initially presented at Natural Products Research Network for Eastern and Central Africa Uganda Chapter (NAPRECA-U) in its virtual seminar held on 24 September 2020.Conflicts of InterestThe authors declare that there are no conflicts of interest regarding the publication of this paper.AcknowledgmentsThe authors are grateful to the World Bank and the Inter-University Council of East Africa (IUCEA) for the scholarship awarded to SBO, SM, MPO, and TO through the Africa Centre of Excellence II in Phytochemicals, Textiles and Renewable Energy (ACE II PTRE) at Moi University, Kenya, which made this communication possible. Our sincere appreciation goes to the preceding authors for their efforts in sharing their research findings on the medicinal values of E. abyssinica. This research was supported by the International Foundation for Science (IFS), Stockholm, Sweden, and Organisation for the Prohibition of Chemical Weapons (OPCW) through a grant to Samuel Baker Obakiro (Grant no. I-1-F-6451-1).D. F. Rambo, R. Biegelmeyer, N. S. B. Toson et al., "The genus Erythrina L.: a review on its alkaloids, preclinical, and clinical studies," Phytherapy Research, vol. 5, no. 33, pp. 1258–1276, 2019.View at: Publisher Site | Google ScholarA. Nyamukuru, J.

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