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Full Length Research Paper

Botany, Botany, Medicinal Applications, Phytochemistry, and Pharmacological Characteristics of Albizia Adianthifolia

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In tropical Africa, the bark, leaves, and roots of Albizia adianthifolia are highly prized for their use as herbal remedies. In order to offer baseline data needed for assessing the species' therapeutic potential, the purpose of this study was to analyze the botany, medicinal applications, phytochemistry, and pharmacological characteristics of A. adianthifolia. Databases including ScienceDirect, SciFinder, Pubmed, Google Scholar, Medline, SCOPUS, EThOS, ProQuest, OATD, and Open-thesis were used to gather data on the botanical profile, medicinal applications, phytochemistry, and pharmacological characteristics of A. adianthifolia. The University library conducted a preelectronic literature search of books, dissertations, theses, scientific articles, conference papers, and book chapters. According to a literature search, A. adianthifolia is used as a herbal remedy and purgative for diabetes, eye, gastrointestinal, hemorrhoidal, headache, neurodegenerative, female reproductive, respiratory, wound, and pain conditions, skin diseases, STDs, and ethnoveterinary medicine. Apocarotenoids, chalcone, dipeptide, elliptosides, essential oils, fatty acids, flavonoids, histamine, imidazolyl carboxylic acid, prosapogenins, steroids, triterpene saponins, and triterpenoids are among the phytochemical components found in the species. Acetylcholinesterase enzyme inhibitory, anthelmintic, antiamoebic, antibacterial, antimycobacterial, anti-sexually transmitted infection, antifungal, anti-inflammatory, antioxidant, anxiolytic, and antidepressant, as well as cognitive-enhancing, hemolytic, hypoglycemic and antihyperglycemic, immunomodulatory, and cytotoxic properties, were found in pharmacological investigations of A. adianthifolia extracts and compounds. It is necessary to conduct thorough investigations into the pharmacokinetics, in vivo, and clinical trials of chemicals that have been identified from A. adianthifolia and its extracts.

INTRODUCTION

Albizia adianthifolia (Schumach.) W. Wight is a medium-sized to large tree (Figure 1) that is a member of the Mimosoideae subfamily of the Fabaceae family of plants. The plant belongs to the genus Albizia Durazz., which is well-known around the world for its excellent ecological, economic, and therapeutic importance [1]. Folk medicine has utilized Albizia species to treat wounds, rheumatism, stomachaches, diarrhea, coughing, sleeplessness, irritability, and TB [2]. Several types of secondary metabolites, including flavonoids, alkaloids, terpenes, and saponins, have been isolated as a result of phytochemical investigations conducted on various Albizia species [2, 3]. In addition to their pharmacological characteristics, which include analgesic, anthelmintic, antidysenteric, antihistaminic, anti-inflammatory, antimicrobial, antimutagenic, antiseptic, antispermatogenic, antitumor,

anxiolytic, cytotoxic, immunomodulatory, nootropic, and apoptosis inducing qualities, the saponin compounds isolated from the genus Albizia have been reported to have cancer-related activities [3]. A. adianthifolia is one of 13 Albizia species that are considered socially and economically significant in tropical Africa as sources of high-quality lumber, gum, fodder, and herbal remedies (Louppe et al., 2008 [1]). Therefore, it is not unexpected that Iwu [4] ranked A. adianthifolia as one of the most significant African medicinal plants, and Van Wyk [5] recently recognized the species' bark as a medicinal and aromatic ingredient that is commercially useful in herbal medicines in South Africa and Kenya. The book "Medicinal Plants of South Africa," which is a photographic guide to the most widely used plant remedies in the nation and covers their botany, primary traditional applications, and active components, also features Albizia adianthifolia. A. adianthifolia is one of the most sought-after medicinal herbs in KwaZulu-Natal region, South Africa, according to research by Mander [6]. In a similar vein, Williams et al. (2000, 2001) [7, 8] demonstrated that the species' bark is frequently sold in Johannesburg, Gauteng province, South Africa's informal medical markets.

FIGURE 1: *Albizia adianthifolia*, a branch showing leaves and flowers (photo: MA Hyde).

A. adianthifolia was found in almost two-thirds (66%) of Johannesburg's informal herbal medicine markets, according Williams et al. (2000) [7]. In 2001, in Gauteng province alone, between 9050 and 10400 kg of A. adianthifolia bark were traded annually as herbal medicine [9], and in KwaZulu-Natal region, South Africa, between 21 and 200 kg were trafficked annually [10–12]. Urban herbalists have identified A. adianthifolia bark as one of the 15 species that are becoming increasingly scarce in KwaZulu-Natal province, South Africa, due to overcollection of the bark for herbal medicine and the trade of the bark in the country's informal herbal medicine markets [10,13]. In order to offer baseline data necessary for assessing the species' therapeutic potential, the current study was conducted with the goal of studying the botany, medicinal applications, phytochemical, and pharmacological properties of A. adianthifolia.

2. Research Methodology

From October 2017 to May 2018, a search was conducted for information about the pharmacological, phytochemical, medicinal, and botanical characteristics of A. adianthifolia. Relevant literature was found using online electronic resources such as Google Scholar, SciFinder, ScienceDirect, Medline, Pubmed, SCO-PUS, EThOS, ProQuest, OATD, and Open-thesis. The University of Fort Hare library conducted preelectronic literature research on conference papers, scientific articles, books, book chapters, dissertations, and theses. "Albizia adianthifolia," synonyms of the plant species "A. chirindensis (Swynn. ex Baker f.) Swynn. ex Steedman, A. ealaensis De Wild., A. fastigiata (E. Mey.) Oliv., A. gummifera auct. non (J. F. Gmel.) C.A. Sm., A. intermedia De Wild. & T. Durand, Inga fastigiata (E. Mey.), Mimosa adianthifolia Schumach., and Zygia fastigiata E. Mey., and English common names "flat-crown albizia, rough-bark flat-crown flat-crown albizia, and West African albizia" were used in the electronic search criteria. In order to find pertinent information, the following keywords were combined with the species name, synonyms, and English common names: "biological properties," "ethnobotany," "ethnomedicinal uses," "ethnopharmacological properties," "medicinal uses," "pharmacological properties," and "phytochemistry." 60 articles published in international journals, books (13), conferences, working papers, and other scientific publications (eight), book chapters (three), dissertations, and websites (one each) were among the publications included in this study, which was published between 1939 and 2018. While four of the research articles were published between 1970 and 1979, 1980 and 1989 (seven articles), 1990 and 1999 (10 articles), 2000 and 2009 (32 articles), and 2010 and 2010 (30 articles), three of the publications were published prior to 1970.

3. Botanical Profile and Description of Albizia adianthifolia

About 120 to 140 species make up the vast genus Albizia, which is found throughout tropical Africa (including Madagascar), central South America, south-east Asia, and Malaysia [14]. Based on a description of A. julibrissin Durazzin cultivated from seeds brought from Constantinople to Tuscany, Florence, Italy, by Fillippo Degli Albizzi in 1749, Durazzini first published the genus name Albizia in 1772 [15]. The species is called "adianthifolia" because its leaves resemble those of the maidenhair fern, which belongs to the genus Adiantum L. and family Pteridaceae [16, 17]. Two recognized infraspecifics, A. adianthifolia var. adianthifolia [18, 19] and A. adianthifolia var. intermedia (De Wild. & T. Durand) Villiers [19, 20], have been identified by literature studies; however, no effort has been made to provide an infraspecific description and geographic distribution of the two varieties. Thus, throughout this manuscript, A. adianthifolia sensu lato shall be used. A. chirindensis, A. ealaensis, A. fastigiata, A. gummifera, A. intermedia, Inga fastigiata, Mimosa adianthifolia, and Zygia fastigiata are synonyms for A. adianthifolia.

The medium- to big deciduous tree Albizia adianthifolia can reach a height of 35 meters [16, 21]. Up to 95 cm in diameter, the bole is straight and cylindrical in confined

forest but frequently crooked and/or twisted in more open savannah and bushland areas. In forest areas, it typically has modest, thick buttresses, but in savannah and bushland areas, it frequently has none [16]. The inner bark is granular, creamy to yellowish in color, with transparent gum, and the outside bark is smooth or rough, ranging from yellowish brown to grey. The crown of Albizia adianthifolia is flattened, and its wide, spreading branches are thickly pubescent in yellow or red. Three to ten pairs of pinnae with ovate to lanceolate stipules and five to seventeen pairs of leaflets per pinna make up the alternating, bipinnately complex leaves [16, 21]. The axillary head of the inflorescence is adorned with small, bisexual, reddish-to-greenish-white flowers.

The fruit is a flat, rectangular pod that is transversely veined, thickly but delicately hairy, and pale brown when ripe. The seeds are brown in color, globose in shape, inflated, and flattened [21]. Forests, woodlands, and regions that are transitional to woodland have all been found to support Albizia adianthifolia. The species is found from South Africa to Senegal in the north, via Madagascar in central and east Africa (Figure 2).

FIGURE 2: Distribution of *Albizia adianthifolia* in tropical Africa.

One of the most widely available herbal medicine products in South Africa's unofficial herbal medicine marketplaces is the bark of A. adianthifolia [7–13]. Grace et al. (2003) [22] attempted to verify the dried bark of the species using thin layer chromatography (TLC). According to this study, the dried bark of A. adianthifolia is frequently mistaken for the dried bark of three other plant species that are sold as herbal medicines in South Africa's unofficial herbal medicine markets: Acacia sieberiana DC., Acacia xanthophloea Benth. (family Fabaceae), and Croton sylvaticus Hochst. ex C. Krauss (family Euphorbiaceae). The significant similarities between the phytochemical fingerprints of Acacia sieberiana, Acacia xanthophloea, A. adianthifolia, and Croton sylvaticus, according to Grace et al. [22], may be a sign of close usage relationships because TLC chromatogram similarities can occasionally explain the phytochemical characteristics shared by bark products that are intentionally substituted for one another, especially when taxonomically unrelated species are used [23].

4. Medicinal Uses of Albizia adianthifolia

Both human and animal ailments are treated with A. adianthifolia's bark, sap, leaves, roots, and stem bark (Table 1). In 51.6% of the countries where the species is native, Burundi, Cameroon, Guinea, Madagascar, Guinea-Bissau, Mozambique, Nigeria, Sierra Leone, Rwanda, Swaziland, South Africa, Tanzania, Uganda, Zimbabwe, and Togo have documented ethnomedical uses of the species (Figure 3). Diabetes, eye issues, gastrointestinal issues, hemorrhoids, headaches, neurodegenerative disorders, purgative, reproductive issues in women, respiratory issues, wounds and pain, skin conditions, STDs, and ethnomedical medicine are among the major diseases and ailments reported in at least two countries (Figure 3). Lower respiratory infections, diarrheal illnesses, and ischemic heart disease are the top three conditions and diseases that the World Health Organization [24] has identified as the main causes of death in low-income nations. Albizia adianthifolia is used to control and cure these conditions. In Cameroon, Mozambique, Nigeria, and South Africa, the bark, leaves, and stem bark of A. adianthifolia are utilized as herbal medicines for lower respiratory infections, such as bronchitis, cough, respiratory issues, and sinusitis [25–29]. In the DRC, Madagascar, Mozambique, South Africa, and Tanzania, the bark, leaves, and roots of A. adianthifolia are used as natural medicines for stomachaches, diarrhea, and dysentery [26, 30–36]. In Togo [37], the leaves of A. adianthifolia are utilized as herbal treatments to treat hypertension, one of the most prevalent chronic illnesses in contemporary countries. Therefore, more research is required to link some of the ethnomedicinal uses of A. adianthifolia to the biological and phytochemical activities of the chemical compounds and crude extracts that have been obtained from the species. Furthermore, the World Health Organization has acknowledged the critical role that traditional medicines play in basic healthcare delivery in areas with limited resources, such as tropical and subtropical Africa [38]. Furthermore, a number of research have shown the value and effectiveness of medicinal plants in the creation of novel pharmaceutical medications and health products [39, 40].

Herbal remedies made from A. adianthifolia are used in multitherapeutic applications to treat sexually transmitted diseases. For instance, in Sierra Leone, a herbal remedy for gonorrhea is made by combining the stem bark of A. adianthifolia with the fruits of Citrus aurantiifolia (Christm.) Swingle and taking the mixture orally [41]. The bark of Trichilia dregeana Sond. is combined with the leaves of A. adianthi-folia and used orally as a natural remedy for syphilis in South Africa [42]. A. adianthifolia leaves are combined with those of Gynura scandens O. Hoffm. and Musa paradisiaca L. fruits and applied topically as a natural remedy for livestock blisters that are apparent in the Democratic Republic of the Congo [43].

5. Phytochemistry

About 90 secondary metabolites have been identified so far from A. adianthifolia's heartwood, leaves, roots, and stem bark. Using nuclear magnetic resonance (NMR) techniques, high performance liquid chromatography (HPLC), high-resolution electrospray ionization mass spectroscopy (HRESIMS), gas chromatography-mass spectrometry (GC-MS), fast atom bombardment mass spectroscopy (FABMS), dipeptide, elliptosides, essential oils, fatty acids, flavonoids, histamines, imidazolyl carboxylic acids, steroids, triterpene saponins, and triterpenoids were among the isolated phytochemical compounds (Table 2). The most common family of phytochemical substances found in A. adianthifolia are thought to be the essential oils, fatty acids, triterpene saponins, flavonoids, and phenolics [27, 28, 63–71].

According to research by Akande et al. (2018) [70], the main constituents of the leaf oil were β-caryophyllene 54 (23.0%), E-geranyl acetone 7 (7.4%), acorenone 38 (6.4%), viridiflorol 48 (6.4%), α-zingiberene 52 (6.3%), and ar-curcumene 51 (4.6%), while the main constituents of the stem bark oil and essential oils were 54 (39.3%), selin-11-en-4-α-ol 44 (10.4%), 53 (9.6%), 51 (7.2%), caryophyllene oxide 40 (6.4%), and α-humulene 50 (5.6%). Pentadecanal 28 (6.1%), 50 (4.4%), 41 (8.4%), 54 (32.1%), and 44 (13.1%) were the main components of A. adianthifolia root bark oil. N-hexadecanoic acid 66 (34.9%), stigmasterol 75 (28.6%), oleic acid 68 (6.3%), 24S,5α stigmast-7-en-3β-ol 76 (4.4%), and chondrillasterol 74 (18.2%) were identified from the gas chromatography-mass spectrometry analyses of the n-hexane heartwood extract of A. adianthifolia. Meanwhile, 9,12-octadecadienoic acid (Z,Z), methyl ester 64 (17.6%), and trans-13-octadecanoic acid, methyl ester 69 (37.2%) were identified from the chloroform extract [68]. Flavonoids 3-methoxyflavanone 70, apigenin 71, and melanoxetin 72 were discovered from the heartwood and leaves of A. adianthifolia by Candy et al. (1978) [64] and Beppe et al. (2014) [28]. The total phenolics in the leaves and stem bark of A. adianthifolia were calculated to be 1.5 to 30.2 μg gallic acid equivalents/g dry weight [27, 28, 69], whereas the total flavonoids in the leaves were assessed by Beppe et al. (2014) [28] to be 0.53 ± 0.001 mg rutoside/g lyophilized powder. Roques et al. (1977) [63] and Haddad et al. (2003, 2004) [66, 67] identified triterpene saponins as major phytochemical compounds in the roots and root bark of A. adianthifolia, and these included 16α-hydroxy-21β-[(2-hydroxybenzoyl)oxy]-3β-[(O-β-D-xylopyranosyl-(12)-O-β-D-fucopyranosyl-(16)-2-(acetylamino)-2-deoxy-β-D-glucopyranosyl)oxy]olean-12-en-28-oic acid 28-O-α-L-arabi-nofuranosyl-(14)-O-[β-D-glucopyranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)-β-D-glucopyranosyl ester 77, 16α-hydroxy-21β-[(2-hydroxybenzoyl)-oxy]-3β-[(O-β-D-glucopyranosyl-(1→2)-O-[O-β-D-xylopyranosyl-(1→2)- O-β-D-fucopyranosyl-(1→6)]-β-D-glucopyranosyl)oxy]-olean-12-en-28-oic acid 28-O-α-L-arabinofuranosyl-(1→ 4)O-[β-D-glucopyranosyl-(1→3)]-O-α-L-rhamnopyrano- syl-(1→2)β-D-glucopyranosyl ester 78, 3-O-{O-α-L-arabi- nopyranosyl-(1→2)-O-β-d-fucopyranosyl-(1→6)-O-[β-d- glucopyranosyl-(1→2)]-β-d-glucopyranosyl}-21-O-{(2E, 6S)-6-{{4-O-[(2E,6S)-2,6-dimethyl-6-(β-D-quinovopyrano- syloxy)octa-2,7-dienoyl]-β-d-quinovopyranosyl}oxy}-2-(hydroxymethyl)-6-methylocta-2,7-dienoyl} acacic acid 28-{O-α-L-arabinofuranosyl-(14)-O-[β-d-glucopyranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)-β-d-glucopyranosyl} ester 79, 21-O-{(2E,6S)-6-{{4-O-[(2E,6S)-2,6-dimethyl-6-(β-d-quinovopyranosyloxy)octa-2,7-dienoyl]-β-d-quinovopyr- anosyl}oxy}-2-(hydroxymethyl)-6-methylocta-2,7-dienoyl}-3-O-{O-β-D-xylopyranosyl-(12)-O-β-d-fucopyranosyl-(16)-2-(acetylamino)-2-deoxy-β-d-glucopyranosyl}acacic acid 28-{O-α-L-arabinofuranosyl-(14)-O-[β-d-glucopyranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)-β-d-glucopyranosyl} ester 80, 21-O-{(2E,6S)-6-{{3-O-[(2E,6S)-2,6-dimethyl-6-(β-d-quinovopyranosyloxy)octa-2,7-dienoyl]-β-d-quinovopyranosyl}oxy}-2,6-dimethylocta-2,7-dienoyl}-3-O-{O-β-D-xylopyranosyl-(12)-O-β-d-fucopyranosyl-(16)-2-(acetylamino)-2-deoxy-β-d-glucopyranosyl}acacic acid 28-{O-α-L-arabinofuranosyl-(14)-O-[β-d- glucopyranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)-β-d-glucopyranosyl} ester 81, and 3-O-{O-α-L-arabinopyranosyl-(12)-O-β-d-fucopyranosyl-(16)-O-[β-d-glucopyranosyl-(12)]-β-d-glucopyranosyl}-21-O-{(2E,6S)-2,6-dimethyl-6-(β-d-quinovopyranosyloxy)octa-2,7-dienoyl}acacic acid 28-{O-α-L-arabinofuranosyl-(14)-O-[β-d-glucopyranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)-β-d-glucopyranosyl} ester 82 which have been shown to be cytotoxic against a large panel of cancer cells [3, 66].

Further comprehensive studies focusing on chemical constituents of A. adianthifolia and their pharmacological activities are required. Chemical structures of aurantiamide acetate 9, docosanoic acid 65, n-hexadecanoic acid 66, octadecanoic acid 67, oleic acid 68, 16α-hydroxy-21β-[(2-hydroxybenzoyl)oxy]-3β-[(O-β-D-xylopyranosyl-(12)-O-β-D-fucopyranosyl-(16)-2-(acetylamino)-2-deoxy-β-D-glucopyranosyl)oxy]olean-12-en-28-oic acid 28-O-α-L-arabino-furanosyl-(14)-O-[β-D-glucopyranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)-β-D-glucopyranosyl ester 77, 16α-hydroxy-21β-[(2-hydroxybenzoyl)-oxy]-3β-[(O-β-D-glucopyranosyl-(12)-O-[O-β-D-xylopyranosyl-(12)-O-β- D-fucopyranosyl-(16)]-β-D-glucopyranosyl)oxy]-olean- 12-en-28-oic acid 28-O-α-L-arabinofuranosyl-(14)O-[β- D-glucopyranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)β-D-glucopyranosyl ester 78, 3-O-{O-α-L-arabinopyrano- syl-(12)-O-β-d-fucopyranosyl-(16)-O-[β-d-glucopy-ranosyl-(12)]-β-d-glucopyranosyl}-21-O-{(2E,6S)-6-{{4-O-[(2E,6S)-2,6-dimethyl-6-(β-D-quinovopyranosyloxy)octa-2,7-dienoyl]-β-d-quinovopyranosyl}oxy}-2-(hydroxymethyl)-6-methylocta-2,7-dienoyl}acacic acid 28-{O-α-L-ara-binofuranosyl-(14)-O-[β-d-glucopyranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)-β-d-glucopyranosyl} ester 79, 21-O-{(2E,6S)-6-{{4-O-[(2E,6S)-2,6-dimethyl-6-(β-d-quin-ovopyranosyloxy)octa-2,7-dienoyl]-β-d-quinovopyranosyl} oxy}-2-(hydroxymethyl)-6-methylocta-2,7-dienoyl}-3-O-{O-β-D-xylopyranosyl-(12)-O-β-d-fucopyranosyl-(16)-2-(acetylamino)-2-deoxy-β-d-glucopyranosyl}acacic acid 28-{O-α-L-arabinofuranosyl-(14)-O-[β-d-glucopyranosyl- (13)]-O-α-L-rhamnopyranosyl-(12)-β-d-glucopyranosyl} ester 80, 21-O-{(2E,6S)-6-{{3-O-[(2E,6S)-2,6-dimethyl6-(β-d-quinovopyranosyloxy)octa-,7-

dienoyl]-β-d-quino- vopyranosyl}oxy}-2,6-dimethylocta-2,7-dienoyl}-3-O-{O-β-D-xylopyranosyl-(12)-O-β-d-fucopyranosyl-(16)-2-(acetylamino)-2-deoxy-β-d-glucopyranosyl}acacic acid 28-{O-α-L-arabinofuranosyl-(14)-O-[β-d-glucopyranosyl- (13)]-O-α-L-rhamnopyranosyl-(12)-β-d-glucopyranosyl} ester 81 and 3-O-{O-α-L-arabinopyranosyl-(12)-O-β-d-fucopyranosyl-(16)-O-[β-d-glucopyranosyl-(12)]-β-d-glucopyranosyl}-21-O-{(2E,6S)-2,6-dimethyl-6-(β- d-quinovopyranosyloxy)octa-2,7-dienoyl}acacic acid 28-{O-α-L-arabinofuranosyl-(14)-O-[β-d-glucopyranosyl-(1 3)]-O-α-L-rhamnopyranosyl-(12)-β-d-glucopyranosyl} ester 82, acacic acid 3-O-beta-D-xylopyranosyl-(1–>2)-beta- D-fucopyranosyl-(1–>6)-2-acetylamino-2-deoxy-beta-D-glucopyranoside 84, acacic acid 3-O-(beta-D-xylopyranosyl- (1–>2)-beta-D-fucopyranosyl-(1–>6)-[beta-D-glucopyrano- syl-(1–>2)]-beta-D-glucopyranosyl)-21-O-(6(S)-2-hydroxym-ethyl-6-methyl-6-O-(beta-D-quinovopyranosyl)-2,7-octadienoyl) ester 85, and lupeol 86 which exhibited pharmac- ological properties [27, 65–68] are shown in Figure 4.

6. Pharmacological Activities

Acetylcholinesterase enzyme inhibitory [69, 72, 73], anthelmintic [70, 74], antiamoebic [74], antibacterial [27, 53, 68, 73, 75], antimycobacterial [76], anti-sexually transmitted infections [77], antifungal [27, 68], anti-inflammatory [73, 78], antioxidant [27, 28, 69, 79, 80], anxiolytic and antidepressant [79], cognitive-enhancing [28], hemolytic [66, 81], hypoglycemic and antihyperglycemic [45], immunomodulatory [66], and cytotoxic [77, 80–84] are just a few of the powerful in vitro and in vivo pharmacological activities that have been demonstrated in pharmacological studies on A. adianthifolia extracts and compounds extracted from the species.

7. Acetylcholinesterase Enzyme Inhibitory Activities

Thin layer chromatography (TLC) and microtitre plate assays were used by Risa et al. (2004) [72] to assess the acetylcholinesterase inhibitory properties of aqueous and ethanol stem bark extracts of A. adianthifolia. In the microplate assay, the ethanol extract showed a mild inhibitory zone in the TLC assay, while the aqueous and ethanol extracts produced 14% and 8% inhibition at 0.1 mg/ml, respectively [72]. Eldeen et al. (2005) [73] used thin layer chromatography (TLC) and microplate assays with galanthamine as the positive control to assess the acetylcholinesterase enzyme inhibitory activities of ethanol and ethyl acetate bark and root extracts of A. adianthifolia.

With half maximal inhibitory concentration (IC50) values ranging from 0.4 mg/ml to 1.2 mg/ml and percentage inhibition ranging from 45% to 61%, the extracts demonstrated moderate activities; these values were lower than the 93% percentage inhibition and IC50 value of 2μM displayed by the control, galanthamine, at a concentration of 2μM [73].

The acetylcholinesterase inhibitory properties of A. adianthifolia leaf extracts in methanol, ethyl acetate, chloroform, and n-hexane were assessed by Sonibare et al. (2017) [69]. With IC50 values ranging from 10.0 μg/mL to 124.4 μg/mL, all extracts demonstrated activity [69]. The traditional usage of A. adianthifolia in the treatment of memory loss and neurodegenerative diseases in South Africa and Nigeria is supported by the extracts' capacity to inhibit acetylcholinesterase [32, 51].

8. Anthelmintic Activities

In two separate tests, McGaw et al. (2000) [74] assessed the anthelmintic effects of A. adianthifolia leaf extracts in hexane, ethanol, and water on the mortality and capacity to reproduce of the free-living worm Caenorhabditis elegans. Following two-hour and seven-day incubation periods, all extracts demonstrated activity at both doses of 1 mg/ml and 2 mg/ml [74]. Using adult Eudrilus eugeniae earthworms and albendazole as the standard, Akande et al. (2018) [70] assessed the anthelmintic properties of essential oils extracted from the leaves, root bark, and stem bark of A. adianthifolia. As concentration was raised, the duration of paralysis and Eudrilus eugeniae worm death reduced. With paralysis and death times of 12.6 and 60.2 minutes, respectively, the leaf essential oil had the highest activity compared to the anthelmintic medication albendazole, which showed times of 82.8 and 154.6 minutes [70].

9. Antiamoebic Activities

With metronidazole serving as the positive control, McGaw et al. (2000) [74] assessed the antiamoebic properties of ethanol and water leaf extracts of A. adianthifolia using the microdilution technique against the enteropathogenic Entamoeba histolytica.
With an IC50 value of >5.0 mg/ml, the extracts demonstrated mild actions that were superior to the 0.20 μg/ml that metronidazole displayed [74].

10. Antibacterial Activities

Using the disk diffusion method, Van Puyvelde et al. (1983) [53] assessed the antibacterial properties of A. adianthifolia leaf extracts against Streptococcus pyogenes, Neisseria gonorrhoeae, Neisseria meningitidis, and Staphylococcus aureus. With a zone of inhibition spanning from 10 mm to 12 mm, the extracts demonstrated activity against Neisseria gonorrhoeae and Neisseria meningitidis [53]. Eldeen et al. (2005) [73] used the disc-diffusion and microdilution assays with neomycin (0.2 mg/ml) as the positive control to assess the antibacterial properties of A. adianthifolia bark and root extracts in aqueous, ethanol, and ethyl acetate against Bacillus subtilis, Staphylococcus aureus, Micrococcus luteus, Escherichia coli, and Klebsiella pneumoniae. With minimum inhibitory concentrations (MIC) ranging from 3.13 mg/ml to 6.25 mg/ml, ethanol bark extracts demonstrated efficacy against every tested bacterium. Conversely, ethyl acetate bark extract demonstrated efficacy against every pathogen except Klebsiella pneumoniae, with MIC values ranging from 6.25 mg/ml to 12.5 mg/ml [73]. Using the

modified agar overlay method and chloramphenicol as the positive control, Abubakar and Majinda [68] assessed the antibacterial properties of chloroform and n-hexane extracts of A. adianthifolia heartwood against Escherichia coli, Pseudomonas aeruginosa, Bacillus subtilis, and Staphylococcus aureus. With minimum inhibition quantities (MIQ) of 1 g each, n-hexane and chloroform extracts demonstrated the best activity against Escherichia coli, whereas other extracts showed moderate activity with MIQ values of 50 g, and chloramphenicol showed activities with MIQ values ranging from 0.25 g to 10 g [68]. Using the broth microdilution technique, Tchinda et al. (2017) [75] assessed the antibacterial properties of A. adianthifolia methanol bark and root extracts against Pseudomonas aeruginosa, Klebsiella pneumoniae, Enterobacter aerogenes, Escherichia coli, and Providencia stuartii. With MIC values ranging from 128 μg/mL to 1024 μg/mL, the extracts demonstrated moderate to weak activity against the investigated pathogens [75].

Using the broth microdilution method, Tamokou et al. (2012) [27] assessed the antibacterial properties of ethyl acetate extract, aurantiamide acetate 9, docosanoic acid 65, n-hexadecanoic acid 66, octadecanoic acid 67, oleic acid 68, and lupeol 86 isolated from the stem bark of A. adianthifolia against Salmonella typhi, Salmonella typhi, Escherichia coli, Pseudomonas aeruginosa, Escherichia coli, Klebsiella pneumoniae, Proteus mirabilis, Shigella flexneri, and Enterococcus faecalis. MIC values for the ethyl acetate extract and aurantiamide acetate 9 ranged from 0.09 mg/ml to 0.78 mg/ml and 0.05 mg/ml to 0.1 mg/ml, respectively, indicating their effectiveness against every pathogen tested [27]. With MIC values ranging from 0.1 mg/ml to 0.4 mg/ml, 0.05 mg/ml to 0.4 mg/ml, and 0.1 mg/ml to 0.8 mg/ml, respectively, the compounds lupeol 86, a combination of n-hexadecanoic acid and oleic acid 68, and a mixture of compounds docosanoic acid 65, n-hexadecanoic acid 66, and octadecanoic acid 67 demonstrated activity against Shigella flexneri, Proteus mirabilis, and Enterococcus faecalis. Minimum bactericidal concentrations (MBC) for the ethyl acetate extract ranged from 0.39 to 1.56 mg/ml, 0.1 to 0.4 mg/ml for n-hexadecanoic acid 66 and oleic acid 68, 0.2 to 0.8 mg/ml for docosanoic acid 65, n-hexadecanoic acid 66, and octadecanoic acid 67, 0.2 to 0.4 mg/ml for compound lupeol 86, and 0.05 to 0.1 mg/ml for aurantiamide acetate 9 [27]. The traditional use of A. adianthifolia as a herbal remedy to treat bacterial infections that cause diarrhea, dysentery, and stomachaches in the Democratic Republic of the Congo, Madagascar, Mozambique, South Africa, and Tanzania is supported by the documented antibacterial properties displayed by various extracts and compounds isolated from the plant [26, 30–36].

11. Antimycobacterial Activities

Using the broth microdilution method, Eldeen and Van Staden [76] assessed the antimycobacterial properties of A. adianthifolia bark and leaf extracts in ethanol, ethyl acetate, and dichloromethane against Mycobacterium aurum A+. With a MIC of 6.3 mg/ml, only the ethanol root extract showed considerable efficacy [76]. According to these results, A. adianthifolia may be used in Cameroon, Mozambique, Nigeria, and South Africa to treat and manage respiratory conditions such bronchitis, cough, and sinusitis [25–29].

12. Anti-Sexually Transmitted Infections Activities

Using the microtitre plate dilution method, Naidoo et al. (2013) [77] assessed the anti-STI properties of A. adianthifolia bark extracts in aqueous and dichloromethane and methanol (1:1) against Candida albicans, Gardnerella vaginalis, Neisseria gonorrhoeae, Oligella ureolytica, Trichomonas vaginalis, and Ureaplasma urealyticum. Ciprofloxacin and amphotericin B were used as positive controls. The interaction between A. adianthifolia and Trichilia dregeana against sexually transmitted infections was assessed by adding up the fractional inhibitory concentrations (∑FIC) against Oligella ureolytica. In contrast to the controls, ciprofloxacin (0.01 mg/mL) and amphotericin B (0.1 mg/mL), which showed MIC values of 0.04 μg/mL to 0.6 μg/mL and 2.5 μg/mL, respectively, the extracts showed activity with MIC values ranging from 0.3 mg/mL to >16.0 mg/mL with an average MIC value of 6.3 mg/mL [77]. With MIC values ranging from 0.8 mg/mL to > 16.0 mg/mL and ∑FIC values ranging from 0.2 to 0.5, the combination of A. adianthifolia and Trichilia dregeana suggested synergistic effects regardless of the ratio at which these two species were combined, supporting the traditional practice of combining the two species as a herbal remedy for syphilis in South Africa [42].

13. Antifungal Activities

Abubakar and Majinda [68] used the modified agar overlay method with miconazole as the positive control to assess the antifungal properties of chloroform and n-hexane extracts of A. adianthifolia heartwood against Candida albicans. With a MIQ value of >100 μg, the extracts showed modest activity, significantly greater than the miconazole's MIQ value of 0.25 μg [68]. Similarly, using the broth microdilution method with nystatin as the positive control, Tamokou et al. (2012) [27] assessed the antifungal activities of ethyl acetate extract and compounds aurantiamide acetate 9, docosanoic acid 65, n-hexadecanoic acid 66, octadecanoic acid 67, oleic acid 68, and lupeol 86 isolated from the stem bark of A. adianthifolia against Candida albicans, Candida parapsilosis, Candida lusitaniae, Candida tropicalis, Candida krusei, Candida glabrata, and Cryptococcus neoformans. MIC values for the ethyl acetate extract and aurantiamide acetate 9 ranged from 0.4 mg/ml to 6.3 mg/ml and 0.01 mg/ml to 0.05 mg/ml, respectively, indicating their effectiveness against every pathogen tested [27]. With MIC values ranging from 0.1 mg/ml to 0.4 mg/ml, the chemical lupeol 86 demonstrated activity against Candida albicans, Candida parapsilosis, Candida lusitaniae, Candida krusei, and Cryptococcus neoformans. With MIC values ranging from 0.1 mg/ml to 0.4 mg/ml, a combination of docosanoic acid 65, n-hexadecanoic acid 66, and octadecanoic acid 67, as well as a mixture of n-hexadecanoic acid 66 and oleic acid 68, shown efficacy

against Candida albicans, Candida lusitaniae, Candida tropicalis, and Cryptococcus neoformans. 0.8 mg/ml to 6.3 mg/ml for ethyl acetate extract, 0.8 mg/ml for compounds n-hexadecanoic acid 66 and oleic acid 68, 0.2 mg/ml to 0.8 mg/ml for docosanoic acid 65, n-hexadecanoic acid 66, and octadecanoic acid 67, 0.2 mg/ml to 0.4 mg/ml for lupeol 86, and 0.006 mg/ml to 0.05 mg/ml for aurantiamide acetate 9 [27].

14. Anti-Inflammatory Activities

In an in vitro test for cyclooxygenase inhibitors, Ja¨ger et al. (1996) [78] assessed the anti-inflammatory properties of A. adianthifolia bark extracts in both aqueous and ethanolic form, using indomethacin (0.5 μg) as the control. The ethanolic extract of A. adianthifolia demonstrated a 69% inhibition, greater than the indomethacin control's 66.5% inhibition. These findings could support the ethnopharmacological assertion that A. adianthifolia has anti-inflammatory qualities [78]. Similar to this, Eldeen et al. (2005) [73] used the cyclooxygenase (COX-1 and COX-2) tests to assess the anti-inflammatory properties of A. adianthifolia bark and root extracts in water, ethanol, and ethyl acetate. With inhibition percentages ranging from 61% to 90%, aqueous, ethanol, and ethyl acetate bark and root extracts were effective against COX-1, while aqueous, ethanol, and ethyl acetate bark and root extracts were effective against COX-2, with inhibition percentages ranging from 58% to 87% [73]. The traditional usage of A. adianthifolia as a herbal remedy for anal wounds, back pain (lumbago), and abdominal aches in Cameroon, Guinea-Bissau, and Mozambique is supported by these findings [27, 36, 50, 60].

15. Antioxidant Activities

Beppe et al. (2014) [28] used the 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging experiment to assess the antioxidant properties of aqueous leaf extracts of A. adianthifolia. A total antioxidant activity of 58.2% was demonstrated by the DPPH technique [28]. Sonibare et al. (2017) [69] used the DPPH free radical scavenging activity assay to assess the antioxidant properties of A. adianthifolia leaf extracts in methanol, ethyl acetate, chloroform, and n-hexane. With IC50 values ranging from 55.8 μg/mL to 232.2 μg/mL, all of the extracts demonstrated activity [69]. Using the DPPH free radical scavenging and trolox equivalent antioxidant capacity (TEAC) assays, Tamokou et al. (2012) [27] assessed the antioxidant properties of ethyl acetate extract and compounds aurantiamide acetate 9 and lupeol 86 that were extracted from the stem bark of A. adianthifolia. Compound 10 demonstrated the highest antioxidant activity using both the DPPH and TEAC methods, with half maximal effective concentration (EC50) values of 9.5 μg/mL and TEAC values of 78.8 μg/mL, whereas ethyl acetate extract displayed EC50 values of 70.1 μg/mL and TEAC values of 46.7 μg/mL [27]. Superoxide dismutase, glutathione peroxidase, and catalase specific activities, as well as the total amount of reduced glutathione, protein carbonyl, and malondialdehyde levels, were used by Beppe et al. (2015) [79] to assess the antioxidant activity of aqueous leaf extracts of A. adianthifolia. The administration of the aqueous extract of A. adianthifolia leaves resulted in decreased levels of protein carbonyl and malondialdehyde and increased activities of superoxide dismutase, glutathione peroxidase, catalase, and glutathione level, suggesting that this plant extract has strong antioxidant properties [79]. Using the DPPH free radical scavenging assay, Sulaiman et al. (2017) [80] assessed the antioxidant properties of magnetic iron oxide nanoparticles made from leaf extracts of A. adianthifolia. Based on its consistent antioxidant effects, the magnetic iron oxide nanoparticles' capacity to scavenge free radicals was validated [80].

16. Anxiolytic and Antidepressant Activities

In the amygdala of rats treated with 6-hydroxydopamine in a model of Parkinson's disease, Beppe et al. (2015) [79] assessed the anxiolytic and antidepressant properties of aqueous leaf extracts of A. adianthifolia. Male Wistar rats were given 150 mg/kg and 300 mg/kg of the extract orally every day for 21 days. The elevated plus-maze and forced swimming tests were used to measure the rats' levels of anxiety and sadness. A decrease in exploratory activities, the percentage of time spent, and the number of entries in the open arm during elevated plus-maze tests, as well as a decrease in swimming time and an increase in immobility time during forced swimming tests, were among the anxiolytic and antidepressant-like effects that resulted from administering the extract [79].

17. Cognitive-Enhancing Activities

Beppe et al. (2014) [28] used the 6-hydroxydopamine-lesion rat model of Parkinson's disease to assess the cognitive-enhancing properties of A. adianthifolia aqueous leaf extracts. Male Wistar rats were given 150 mg/kg and 300 mg/kg of the extract orally every day for 21 days. Y-maze and radial arm-maze tests were used to evaluate the rats' spatial memory abilities. Rats given 6-hydroxydopamine showed a higher percentage of working memory and reference memory errors in the radial arm maze test and a lower percentage of spontaneous alternations in the y-maze task. These characteristics were markedly enhanced by administering the aqueous extract of A. adianthifolia leaves, indicating beneficial effects on the establishment of spatial memory [28].

18. Haemolytic Activities

Haddad et al. (2003) [66] evaluated the haemolytic activities of the crude saponin mixture, compounds 84, 85, and 78 isolated from the roots of A. adianthifolia using the haemolysis assay against sheep erythrocytes. The crude saponin mixture exhibited good haemolytic activ- ities with half maximal haemolytic concentration (HC50) value of 12 μg/mL, while compounds 16α-hydroxy-21β-[(2-hydroxybenzoyl)oxy]-3β-[(O-β-D-xylopyranosyl-(12)-O-β-D-fucopyranosyl-(16)-2-(acetylamino)-2-deoxy-β-D-glucopyranosyl)oxy]olean-12-en-28-oic acid 28-O-α-L-arabinofuranosyl-(14)-O-[β-D-glucopyranosyl-(13)]- O-α-L-

rhamnopyranosyl-(12)-β-D-glucopyranosylester 77 and 16α-hydroxy-21β-[(2-hydroxybenzoyl)-oxy]-3β-[(O-β-D-glucopyranosyl-(12)-O-[O--D-xylopyranosyl-(1 2)-O-β-D-fucopyranosyl-(16)]-β-D-glucopyranosyl)oxy]- olean-12-en-28-oic acid 28-O-α-L-arabinofuranosyl-(14)O-[β-D-glucopyranosyl-(13)]-O-α-L-rhamnopyrano- syl-(12)β-D-glucopyranosyl ester 78 exhibited activities with HD50values of 17.5 μg/mL and 48 μg/mL, respectively [66]. Similarly, Haddad et al. [81] evaluated the haemolytic activities of compounds 16α-hydroxy-21β-[(2-hydroxyben-zoyl)oxy]-3β-[(O-β-D-xylopyranosyl-(12)-O-β-D-fuco-pyranosyl-(16)-2-(acetylamino)-2-deoxy-β-D-glucopyr-anosyl)oxy]olean-12-en-28-oic acid 28-O-α-L-arabinofuran-osyl-(14)-O-[β-D-glucopyranosyl-(13)]-O-α-L-rham- nopyranosyl-(12)-β-D-glucopyranosyl ester 77, 16α-hydroxy-21β-[(2-hydroxybenzoyl)-oxy]-3β-[(O-β-D-glucopy- ranosyl-(12)-O-[O-β-D-xylopyranosyl-(12)-O-β-D-fucopyranosyl-(16)]-β-D-glucopyranosyl)oxy]-olean-12-en-28-oic acid 28-O-α-L-arabinofuranosyl-(14)O-[β-D-glucopyranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)β- D-glucopyranosyl ester 78, and 21-O-{(2E,6S)-6-{{4-O-[(2E, 6S)-2,6-dimethyl-6-(β-d-quinovopyranosyloxy)octa-2,7-di-enoyl]-β-d-quinovopyranosyl}oxy}-2-(hydroxymethyl)-6-methylocta-2,7-dienoyl}-3-O-{O-β-D-xylopyranosyl-(12)-O-β-d-fucopyranosyl-(16)-2-(acetylamino)-2-deoxy-β-d-glucopyranosyl}acacic acid 28-{O-α-L-arabinofuranosyl-(14)-O-[β-d-glucopyranosyl-(13)]-O-α-L-rham-nopyranosyl-(12)-β-d-glucopyranosyl} ester 80 isolated from the roots of A. adianthifolia using the haemolysis as-say against sheep erythrocytes. The compounds 16α-hydroxy-21β-[(2-hydroxybenzoyl)oxy]-3β-[(O-β-D-xylopyranosyl- (12)-O-β-D-fucopyranosyl-(16)-2-(acetylamino)-2-deoxy-β-D-glucopyranosyl)oxy]olean-12-en-28-oic acid 28-O-α-L-arabinofuranosyl-(14)-O-[β-D-glucopyranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)-β-D-glucopyran- osyl ester 77, 16α-hydroxy-21β-[(2-hydroxybenzoyl)-oxy]-3β-[(O-β-D-glucopyranosyl-(12)-O-[O-β-D-xylopyran-osyl-(12)-O-β-D-fucopyranosyl-(16)]-β-D-glucopy- ranosyl)oxy]-olean-12-en-28-oic acid 28-O-α-L-arabinofur-anosyl-(14)O-[β-D-glucopyranosyl-(13)]-O-α-L-rha-mnopyranosyl-(12)β-D-glucopyranosyl ester 78, and 21- O-{(2E,6S)-6-{{4-O-[(2E,6S)-2,6-dimethyl-6-(β-d-quinovo- pyranosyloxy)octa-2,7-dienoyl]-β-d-quinovopyranosyl}oxy}-2-(hydroxymethyl)-6-methylocta-2,7-dienoyl}-3-O-{O-β-D-xylopyranosyl-(12)-O-β-d-fucopyranosyl-(16)-2-(ac- etylamino)-2-deoxy-β-d-glucopyranosyl}acacic acid 28-{O-α-L-arabinofuranosyl-(14)-O-[β-d-glucopyranosyl-(1 3)]-O-α-L-rhamnopyranosyl-(12)-β-d-glucopyranosyl} ester 80 exhibited haemolytic activities with HC50 values ranging from 12.5 μg/mL to 36.6 μg/mL [81].

19. Hypoglycemic and Antihyperglycemic Activities

By giving guinea pigs (Cavia porcellus) 500 mg/kg of leaf extracts of A. adianthi-folia, Amuri et al. (2017) [45] assessed the hypoglycemic and antihyperglycemic effects of the extracts under both glucose baseline circumstances and an oral glucose tolerance test with a follow-up of 210 minutes. The extract produced activities in hypoglycemic tests, reducing normal glycemia by 33%, which was similar to the positive control's activities, while glibenclamide (6 mg/kg) had a 55% blood glucose lowering impact. The extract was active in the oral glucose tolerance test, resulting in a 57% inhibition of glycemia increase, which was similar to glibenclamide's 50% hyperglycemic inhibition rate [45]. The traditional use of A. adianthifolia leaf and stem bark decoction as a natural remedy for diabetes in Nigeria [29] and the Democratic Republic of the Congo [45] is supported by these findings.

20. Immunomodulatory Activities

Haddad et al. (2003) [66] evaluated the immunomodulatory activities of the crude saponin mixture, compounds acacic acid 3-O-beta-D-xylopyranosyl-(1–>2)-beta-D-fucopyrano-syl-(1–>6)- 2-acetylamino-2-deoxy-beta-D-glucopyranoside 84, acacic acid 3-O-(beta-D-xylopyranosyl-(1–>2)-beta-D-fucopyranosyl-(1–>6)- [beta-D-glucopyranosyl-(1–>2)]-beta-D-glucopyranosyl)-21-O-(6(S)-2- hydroxymethyl-6-methyl-6-O-(beta-D-quinovopyranosyl)-2,7-octadienoyl) ester 85, and 16α-hydroxy-21β-[(2-hydroxybenzoyl)-oxy]-3β-[(O-β- D-glucopyranosyl-(12)-O-[O-β-D-xylopyranosyl-(12)-O-β-D-fucopyranosyl-(16)]-β-D-glucopyranosyl)oxy]- olean-12-en-28-oic acid 28-O-α-L-arabinofuranosyl-(14)O-[β-D-glucopyranosyl-(13)]-O-α-L-rhamnopyrano- syl-(12)β-D-glucopyranosyl ester 78 isolated from the roots of A. adianthifolia using an in vitro lymphocyte proliferation assay. The cellular proliferation was measured by 3H-thymidine incorporation in Jurkat tumor cell lines (human T cell leukemia). The compounds acacic acid 3-O-beta-D-xylopyranosyl-(1–>2)-beta-D-fucopyranosyl-(1–>6)-2-acetylamino-2-deoxy-beta-D-glucopyranoside 84 and acacic acid 3-O-(beta-D-xylopyranosyl-(1–>2)-beta-D-fucopy- ranosyl-(1–>6)- [beta-D-glucopyranosyl-(1–>2)]-beta-D-glu- glucopyranosyl)-21-O-(6(S)-2- hydroxymethyl-6-methyl-6-O-(beta-D-quinovopyranosyl)-2,7-octadienoyl) ester 85 ex- hibited a dose-dependent immunomodulatory effect in the concentration range of 0.01 μM to 10 μM, whereas compound 16α-hydroxy-21β-[(2-hydroxybenzoyl)-oxy]-3β-[(O-β-D-glucopyranosyl-(12)-O-[O-β-D-xylopyranosyl-(12)-O-β-D-fucopyranosyl-(16)]-β-D-glucopyranosyl)oxy]- olean-12-en-28-oic acid 28-O-α-L-arabinofuranosyl-(14)O-[β-D-glucopyranosyl-(13)]-O-α-L-rhamnopyrano- syl-(12)β-D-glucopyranosyl ester 78 showed a lympho- proliferative activity in the concentration range of 0.01 μM to 10 μM [66].

21. Cytotoxicity Activities

Naidoo et al. (2013) [77] used the 3-[4,5-dimethyl-2-thiazol-yl]-2,5-diphenyl2H-tetrazolium bromide (MTT) cell viability assay on the human embryonic kidney epithelial (Graham, HEK-293) cell line to assess the cytotoxicity activities of aqueous and dichloromethane and methanol (1:1) bark extracts of A. adianthifolia. The human kidney epithelial cell line was not harmed by the extracts at 100 mg/ml, according to the cell viability assay. However, the aqueous and organic extracts showed cell growth of 110% and 112%, respectively, suggesting that they increased cellular activity,

which would aid in wound healing [77]. The cytotoxicity of A. adianthifolia's methanol bark and root extracts against the sensitive leukemia CCRF-CEM cells was assessed by Kuete et al. (2016) [84]. A panel of eight human cancer cell lines, including MDR phenotypes, was used to evaluate the extracts further. The bark and root extracts shown activity in the CCRF-CEM cells preliminary experiment, with IC50 values of 0.98 μg/mL and 1.5 μg/mL, respectively. Both bark and root extracts demonstrated activity against glioma U87MG and other cell lines as well as normal AML12 hepatocytes, with IC50 values ranging from 2.7 to 10.8 g/mL.Breast adenocarcinoma and ΔEGFR cells MDA-MB-231-BCRP cells and HCT116(p53−/−) cells from colon cancer. By activating caspases and lowering mitochondrial membrane potential, the root extracts caused CCRF-CEM cells to undergo apoptosis [84]. The cytotoxic effects of magnetic iron oxide nanoparticles made from leaf extracts of A. adianthifolia on human breast cancer cells (AMJ-13) and MCF-7 were assessed by Sulaiman et al. (2017) [80]. Cell death and apoptosis induction are the causes of the antiproliferative effects seen against AMJ-13 and MCF-7. Magnetic iron oxide nanoparticles only cause cell death by apoptosis, according to single cell and DNA gel electrophoresis investigations, mitochondrial membrane potential, and acridine orange-propidium iodide staining experiments [80].

Using MTT, ATP, and lactate dehydrogenase tests, Gengan et al. (2013) [82] assessed the cytotoxic effects of silver nanoparticles (AgNP) made from aqueous leaf extracts of A. adianthifolia on the A549 human lung cancer cell line and normal healthy human peripheral lymphocytes. After six hours of exposure to AgNPs, the viability data for A549 cells revealed a 21% (10 μg/ml) and 73% (50 μg/ml) cell vitality, in contrast to the normal peripheral lymphocytes' 117% (10 μg/ml) and 109% (50 μg/ml) cell viability [82]. The cytotoxic effects of silver nanoparticles (AgNP) made from aqueous leaf extracts of A. adianthifolia on A549 lung cells were assessed by Govender et al. (2013) [83]. Cellular oxidative status, lipid peroxidation and glutathione levels, ATP concentration, caspase-3/-7, caspase-8, and caspase-9 activities, apoptosis, mitochondrial membrane depolarization (flow cytometry), DNA fragmentation, CD95 receptors, p53, bax, PARP-1, and smac/DIABLO were all measured by the MTT assay in order to determine cell viability [83]. A. adianthifolia silver nanoparticles significantly increased lipid peroxidation, decreased intracellular lipid peroxidation and glutathione, decreased cellular ATP, increased mitochondrial depolarization, increased apoptosis, decreased CD95 receptor expression, decreased caspase-8 activity, and increased caspase-3/-7 and caspase-9 activities. Western blots revealed increased expression of p53, bax, and PARP-1, and decreased expression of smac/DIABLO [83]. Haddad et al. (2004) [81] evaluated the cytotoxic activities of compounds acacic acid 3-O-beta-D-xylopyranosyl-(1–>2)-beta-D-fucopyranosyl-(1–>6)-2-acetylamino-2-deoxy-beta-D-glucopyranoside 84, acac- ic acid 3-O-(beta-D-xylopyranosyl-(1–>2)-beta-D-fucopy- ranosyl-(1–>6)-[beta-D-glucopyranosyl-(1–>2)]-beta-D-glu- copyranosyl)-21-O-(6(S)-2- hydroxymethyl-6-methyl-6-O- (beta-D-quinovopyranosyl)-2,7-octadienoyl) ester 85, 16α- hydroxy-21β-[(2-hydroxybenzoyl)oxy]-3β-[(O-β-D-xylopy- ranosyl-(12)-O-β-D-fucopyranosyl-(16)-2-(acetylam- ino)-2-deoxy-β-D-glucopyranosyl)oxy]olean-12-en-28-oic acid 28-O-α-L-arabinofuranosyl-(14)-O-[β-D-glucopy- ranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)-β-D-glu-copyranosyl ester 77, 16α-hydroxy-21β-[(2-hydroxybenzoyl)-oxy]-3β-[(O-β-D-glucopyranosyl-(12)-O-[O-β-D-xylopyranosyl-(12)-O-β-D-fucopyranosyl-(16)]-β-D-glucopyranosyl)oxy]-olean-12-en-28-oic acid 28-O-α-L-arabinofuranosyl-(14)O-[β-D-glucopyranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)β-D-glucopyranosyl ester 78, and 21-O-{(2E,6S)-6-{{4-O-[(2E,6S)-2,6-dimethyl-6-(β-d-quinovopyranosyloxy)octa-2,7-dienoyl]-β-d-quinovopyranosyl}oxy}-2-(hydroxymethyl)-6-methylocta-2,7-dienoyl}-3- O-{O-β-D-xylopyranosyl-(12)-O-β-d-fucopyranosyl-(1 6)-2-(acetylamino)-2-deoxy-β-d-glucopyranosyl}acacic acid 28-{O-α-L-arabinofuranosyl-(14)-O-[β-d-glucopy- ranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)-β-d-glu- copyranosyl} ester 80 isolated from the roots of A. adianthifolia on human leukemia T-cells (Jurkat cells) and on splenocytes. The compounds 16α-hydroxy-21β-[(2-hydroxybenzoyl)oxy]-3β-[(O-β-D-xylopyranosyl-(12)-O-β-D-fucopyranosyl-(16)-2-(acetylamino)-2-deoxy-β-D-glucopyranosyl)oxy]olean-12-en-28-oic acid 28-O-α-L-arabinofuranosyl-(14)-O-[β-D-glucopyranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)-β-D-glucopyranosyl ester 77, 16α-hydroxy-21β-[(2-hydroxybenzoyl)-oxy]-3β-[(O-β-D-glucopyranosyl-(12)-O-[O-β-D-xylopyranosyl-(12)- O-β-D-fucopyranosyl-(16)]-β-D-glucopyranosyl)oxy]- olean-12-en-28-oic acid 28-O-α-L-arabinofuranosyl-(14)O-[β-D-glucopyranosyl-(13)]-O-α-L-rhamnopyrano- syl-(12)β-D-glucopyranosyl ester 78, and 21-O-{(2E,6S)- 6-{{4-O-[(2E,6S)-2,6-dimethyl-6-(β-d-quinovopyranosyl- oxy)octa-2,7-dienoyl]-β-d-quinovopyranosyl}oxy}-2-(hy- droxymethyl)-6-methylocta-2,7-dienoyl}-3-O-{O-β-D-xylo- pyranosyl-(12)-O-β-d-fucopyranosyl-(16)-2-(acety- lamino)-2-deoxy-β-d-glucopyranosyl}acacic acid 28-{O-α- L-arabinofuranosyl-(14)-O-[β-d-glucopyranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)-β-d-glucopyranosyl} ester 80 exhibited cytotoxic activities on Jurkat cells, while the compounds acacic acid 3-O-beta-D-xylopyranosyl-(1–>2)-beta-D-fucopyranosyl-(1–>6)-2-acetylamino-2-deoxy-beta-D-glucopyranoside 84 and acacic acid 3-O-(beta-D-xylopyranosyl-(1–>2)-beta-D-fucopyranosyl-(1–>6)- [beta-D-glucopyranosyl-(1–>2)]-beta-D-glucopyranosyl)-21-O-(6(S)-2- hydroxymethyl-6-methyl-6-O-(beta-D-quinovopy-ranosyl)-2,7-octadienoyl) ester 85 exhibited lymphoproliferative activities on this cell type. Cytotoxic activity on Jurkat cells was observed at 10-1 μM and 1 μM for compound 21-O-{(2E,6S)-6-{{4-O-[(2E,6S)-2,6-dimethyl-6-(β-d-quinovopyranosyloxy)octa-2,7-dienoyl]-β-d-quinovopyranosyl}oxy}-2-(hydroxymethyl)-6-methylocta-2,7-dienoyl}-3-O-{O-β-D-xylopyranosyl-(12)-O-β-d-fucopyranosyl-(16)-2-(acetylamino)-2-deoxy-β-d-glucopyranosyl}acacic acid 28-{O-α-L-arabinofuranosyl-(14)-O-[β-d-glucopyranosyl-(13)]- O-α-L-rhamnopyranosyl-(12)-β-d-glucopyranosyl} ester 80 and at 1 μM for compounds 16α-hydroxy-21β-[(2-hy-

droxybenzoyl)oxy]-3β-[(O-β-D-xylopyranosyl-(12)-O-β-D-fucopyranosyl-(16)-2-(acetylamino)-2-deoxy-β-D-glucopyranosyl)oxy]olean-12-en-28-oic acid 28-O-α-L-ara- binofuranosyl-(14)-O-[β-D-glucopyranosyl-(13)]-O-α-L-rhamnopyranosyl-(12)-β-D-glucopyranosyl ester 77 and 16α-hydroxy-21β-[(2-hydroxybenzoyl)-oxy]-3β-[(O-β-D-glucopyranosyl-(12)-O-[O-β-D-xylopyranosyl-(1 2)-O-β-D-fucopyranosyl-(16)]-β-D-glucopyranosyl)oxy]-olean-12-en-28-oic acid 28-O-α-L-arabinofuranosyl-(14)O-[β-D-glucopyranosyl-(13)]-O-α-L-rhamnopyrano-syl-(12)β-D-glucopyranosyl ester 78 [81].

22. Conclusion

Tropical Africa has long employed Albizia adianthifolia as a herbal remedy, and in the past four decades, important progress has been made in understanding the species' pharmacological and phytochemical characteristics. The relationship between the species' pharmacological properties and chemical compounds and their ethnomedical uses and the chemicals and extracts of the species is still unknown, though. It is necessary to conduct thorough investigations into the pharmacokinetics, in vivo, and clinical trials of chemicals that have been identified from A. adianthifolia and its extracts. In Mozambique, the roots of A. adi-anthifolia are used as fish poison [85], and its bark is reported to be toxic [25]. Similarly, the gum from the bark of A. adianthi-folia is used as a hunting poison in southern Cameroon, while the bark and leaves of the plant are employed as fish poison in the Central African Republic [86]. In order to determine the toxicity and/or potential adverse effects of using the species and its products as herbal medicines, these papers emphasize the necessity of thorough toxicological analyses of the species' extracts as well as the chemicals identified from A. adianthifolia.

Conflicts of Interest

Regarding the publishing of this paper, the author states that there are no conflicts of interest.

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