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Review Article

Astraea lobata (L) Klotzsch (Euphorbiaceae): An ethnopharmacological review

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Abstract

This is a review on the medicinal uses, phytochemistry and biological activities of A. lobata with a view to present a better understanding of the medicinal potentials of the species. Published literature on A. lobata were sourced from databases such as Google Scholar, Web of Science, SciFinder, Scopus, Science Direct, PubMed, Scielo, Springerlink, Google Patents, Espacenet, BioMed Central (BMC) and Medline. Astraea lobata is native to north, central and south America, and now naturalized in Benin, Ghana, Ivory Coast, Nigeria, Senegal and Togo where it is used to treat numerous diseases including dysentery, malaria, menstrual problems, scorpion bite, rheumatism pain, skin cancer, sterility in women and as purgative. Multiple classes of phytochemicals such as alkaloids, anthraquinones, esters, diterpene alcohols, flavonoids, hydroxy ketones, peptides, phenolics, saponins, steroids, tannins, triterpenes and triglycerides have been isolated from fruits, leaves, roots and stems of A. lobata. Scientific studies on A. lobata indicate that it has a wide range of pharmacological activities which include antibacterial, antidiabetic, antiplasmodial, antioxidant, antitrypanosomal and leishmanicidal activities. The wide usage of A. lobata as a herbal medicine calls for detailed pharmacological and phytochemical studies aimed at correlating the documented medicinal uses of the species with its biological activities and phytochemistry.

Keywords: *Astraea lobata, Euphorbiaceae, herbal medicine, pharmacology, phytochemistry*

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INTRODUCTION

Astraea lobata (L.) Klotzsch (family Euphorbiaceae) is a member of *Astraea* Klotzsch genus. This is a monophyletic north, central and south American genus with only 10 species, and is considered as sister group to the genus *Croton* L., with which it shares many morphological features [1,2]. In tropical Africa, *A. lobata* has been introduced in Benin, Cameroon, Eritrea, Ethiopia, Gambia, Ghana, Guinea-Bissau, Ivory Coast, Mali, Nigeria, Senegal, Sierra Leone, Somalia, South Sudan, Sudan and Togo [3]. It is an invasive species occurring as a pioneer species in the first stage of vegetation establishment after land clearing in tropical Africa [3,4]. The species is also found in fallows, open sandy localities, river banks, along roadsides, waste land and is regarded as an arable weed in farmlands and irrigated agricultural plots [4]. The

naturalized species is difficult to eradicate from arable agricultural fields because of its deep taproot system and strong lateral roots with some small scale farmers using herbicides to control the weed [3,4]. It is sold in informal markets as both herbal medicine and leafy vegetable in Benin [4].

Astraea lobata is an annual, monoecious and herbaceous plant with hairy and dense branches. The plant is erect up to 1 m tall, sometimes woody at the base with a long taproot [3]. The leaves are alternate, with small stipules and palmately 3-5 lobed. The lobes are oblanceolate to obovate in shape, apex acuminate with toothed margins, hairy stellate to almost glabrous on both sides in some cases. The inflorescence is a slender, axillary or terminal raceme; with small male flowers in the upper half and female flowers in lower half. The flowers are regular, unisexual, yellowish green in colour, male flowers with elliptical sepals and oblanceolate petals while female flowers have linear-lanceolate sepals.

The fruit is a globular capsule, stellate hairy, green in colour with three ellipsoid seeds. It is listed by Schmelzer [3] and Neuwinger [5] as an important herbal medicine widely used to treat and manage several human diseases in tropical Africa.

It is against this background that this review was carried out aimed at evaluating the ethnobotany, phytochemistry and biological activities of *A. lobata* so as to highlight the knowledge gap and provide baseline data required for further research on the plant species.

METHOD

To identify relevant information on the botany, medicinal uses, phytochemistry and biological activities of *A. lobata*, a review was compiled based on scientific literature from various sources including Google Scholar, Web of Science, SciFinder, Scopus, Science Direct, PubMed, Scielo, Springerlink, Google Patents, Espacenet, BioMed Central (BMC) and Medline. The keywords used for identification of relevant data included different scientific name and synonyms, common English name, and the terms: biological activities, medicinal uses, ethnobotany, ethnopharmacology, medicinal, pharmacology, phytochemistry and therapeutic value, *Astraea lobata, Croton lobatus* L. and lobed croton. Other relevant scientific publications were obtained from the University of Fort Hare library, Alice campus in South Africa.

Ethnomedicinal uses of *Astraea lobata*

In Benin, Nigeria and Togo, the flower, fruit, leaf, root, seed or stem decoction of *A. lobata* is taken orally as remedy for malaria [6-12] while in Ghana and Nigeria, the leaf decoction is taken orally or applied topically as remedy for skin cancer [13,14] (Table 1). In Ivory Coast, Nigeria and Togo, the bark, fruit, leaf, root, seed or stem decoction is taken orally as a purgative [5,11,15] while in Nigeria and Togo, the flower, fruit, leaf, root, seed or stem decoction is taken orally as remedy for dysentery [6,10,11]. In Benin and Nigeria, the flower, fruit, leaf, root or seed decoction of *A. lobata* is taken orally as remedy for fever [3,8,12,16] and in Ivory Coast and Nigeria, the bark, leaf or root decoction is taken orally as remedy for rheumatic pain [5,15,17,18].

In Ivory Coast and Togo, the leaf decoction of *A. lobata* is used as a lotion or enema as remedy for sterility in women [5] while in Nigeria and Saudi Arabia, the leaf decoction is applied topically as a scorpion sting antidote [17,19]. In Nigeria and Senegal, the bark, leaf, root or seed decoction of *A. lobata* is taken orally as remedy for convulsions [5,15,20,21] and in Nigeria and Venezuela, a fruit decoction is taken orally as remedy for menstrual problems [22,23]. In Benin, the penis is washed with leafy twig macerate of *A. lobata* as an aphrodisiac [3] and flower, leaf or root decoction is used as antispasmodic in cases of threatening miscarriage and hiccups [5,8,12]. The leaf decoction of the species is mixed with honey and palm oil and applied topically on stiff limps [3]. *Astraea lobata* is used to treat jaundice and are recommended to pregnant women for the welfare of the foetus in Benin [4]. Leaves of *A. lobata* are mixed with those of *Hildegardia barteri* (Mast.) Kosterm. as remedy for hypertension [5] and mixed with *Ipomoea mauritiana* Jacq. as colic in children [24]. In Nigeria, the bark, fruit, leaf, root, seed or stem decoction of *A. lobata* is used as remedy for body rash, diabetes, guinea worms, impetigo, lactation, measles, obesity, sickle cell anemia, skin diseases, stomach ache, ulcers, urinary disorders and wounds [5,11,15-18,20,25-31].

In Nigeria, the fruit decoction of *A. lobata* is taken orally mixed with *Vernonia amygdalina* Delile leaves and *Macaranga barteri* Müll. Arg. leaves as remedy for diabetes [32]. In Senegal, leaf or whole plant is used as sterilizer or against mouth infections and whooping cough [5]. In Togo, leaf juice is applied topically as remedy for eye problems and unconsciousness [5] and the flower, leaf or root decoction is taken orally for pregnancy problems [6,10]. In Venezuela, *A. lobata* is used as haemocatharsis [22] and the

entire plant is used as a hunting poison in the coastal interior of the Ivory Coast [5].

Chemical composition of *Astraea lobata*

Plant parts such as fruits, leaves, roots and stems are known to have nutritive and non-nutritive compounds (Tables 2 and 3) which may be used to explain the medicinal uses and pharmacological properties of the species. The reported compounds such as alkaloids, diterpene alcohol, ester, flavonoid, hydroxyl ketone, peptide, phenolic acid, steroid,

Table 1: Ethnomedicinal uses of *Astraea lobata*

Use	Plant parts used	Country	References
Antispasmodic in cases of threatening miscarriage and hiccups	Flower, leaf or root infusion taken orally	Benin	[5,8,12]
Antihypertensive	Leaf infusion taken orally mixed with those of *Hildegardia barteri* (Mast.) Kosterm.	Benin	[5]
Aphrodisiac	Penis washed with leafy twig macerate	Benin	[3]
Body rash	Seed macerate applied topically	Nigeria	[25]
Colic in children	Leaf decoction given orally mixed with *Ipomoea mauritiana* Jacq.	Benin	[24]
Convulsions	Bark, leaf, root or seed infusion taken orally	Nigeria, Senegal	[5,15,20,21]
Diabetes	Leaf, fruit, seed or stem infusion taken orally	Nigeria	[11]
Diabetes	Fruit infusion taken orally mixed with leaves of *Vernonia amygdalina* Delile and *Macaranga barteri* Müll. Arg.	Nigeria	[32]
Dysentery	Flower, fruit, leaf, root, seed or stem decoction taken orally	Nigeria, Togo	[6,10,11]
Eye diseases	Leaf juice applied topically	Togo	[5]
Fever	Flower, fruit, leaf, root or seed decoction taken orally	Benin, Nigeria	[3,8,12,16]
Guinea worms	Bark, leaf, root infusion taken orally	Nigeria	[15,30]
Haemocatharsis	Not specified	Venezuela	[22]
Impetigo	Seed decoction applied topically	Nigeria	[20]
Jaundice	Not specified	Benin	[4]
Lactation	Fruit or seed decoction taken orally	Nigeria	[16]
Malaria	Flower, fruit, leaf, root, seed or stem decoction taken orally	Benin, Nigeria, Togo	[6-12]
Measles	Seed macerate applied topically	Nigeria	[26]
Menstrual problems	Fruit decoction taken orally	Nigeria, Venezuela	[22,23]
Mouth infections	Leaf decoction applied topically	Senegal	[5]
Obesity	Fruit decoction taken orally	Nigeria	[29]
Pregnancy troubles	Flower, leaf or root decoction taken orally	Togo	[6,10]
Purgative	Bark, leaf, fruit, root, seed or stem decoction taken orally	Ivory Coast, Nigeria, Togo	[5,11,15]
Rheumatic pain	Bark, leaf or root infusion taken orally	Ivory Coast Nigeria	[5,15,17,18]
Scorpion sting	Leaf decoction applied topically	Nigeria; Saudi Arabia	[17,19]
Sickle cell anemia	Leaf decoction taken orally	Nigeria	[31]
Skin cancer	Leaf decoction taken orally or applied topically	Ghana, Nigeria	[13,14]
Skin diseases	Bark, leaf or root decoction applied topically	Nigeria	[15,17,18]
Sterility in women	Leaf macerate used as enema or lotion	Ivory Coast, Togo	[5]
Sterilizer	Whole plant applied topically	Senegal	[5]
Stiff limps	Leaf decoction with honey and palm oil applied topically	Benin	[3]
Stomach ache	Leaf decoction taken orally	Nigeria	[17,28]
Ulcers	Leaf, fruit, seed or stem decoction taken orally	Nigeria	[11]
Unconsciousness	Leaf juice applied topically	Togo	[5]
Urinary disorders	Bark, leaf or root infusion taken orally	Nigeria	[15,30]
Used during pregnancy	Not specified	Benin	[4]
Whooping cough	Leaf decoction taken orally	Senegal	[5]
Wounds	Fruit decoction applied topically	Nigeria	[27]

triglyceride and triterpene were identified and characterized by various criteria including high resolution electron impact mass spectrometry, (HREIMS), high-resolution electrospray ionisation mass spectrometry (HRESIMS), high-resolution mass spectrometry (HRMS), i*nfrared spectroscopy* (IR), nuclear magnetic resonance spectroscopy (NMR), *thin-layer chromatography* (TLC) and ultraviolet visible spectroscopy (UV).

Odukoya *et al* [27] and Ezeabara and Okonkwo [33] observed that *A. lobata* has phytochemicals such as alkaloids, anthraquinone, flavonoids, hydrogen cyanide, phenols, saponins, sterols, tannins and terpenoids (Table 2). Stuart and Woo-Ming [34] isolated 3-[(6Z,9Z)dodeca-6,9-dienoyloxy]-2-octanoyloxypropyl(6Z,9Z)dodeca-6,9-dienoate, (Z,Z,Z)-9,12,15-octadecatrienoic acid methyl ester, (Z,Z)-9,12-octadecatrienoic acid, geranylgeraniol, cholesta-5,7-dien-3-ol, ergosterol, 3-hydroxy-cholest-5-en-7-one, cholestan-3-one, betulinic acid, (E)-3-(4-methoxy-phenyl)-2-phenyl-acrylic acid and N-(2-hydroxy-1-phenylpropyl) benzamide from leaves and stems of *A. lobata* (Table 3).

Chabert *et al* [35] isolated geranylgeraniol, betulinic acid, cholestan-3-one, 9,12,15-octadecatrienoic acid methyl ester, 3-(4- methoxy phenyl)-2- phenyl acrylic acid, tetramethyl tetraentetracosanoic acid, octadecadienoic acid, tetramethyl-hexadeca tetraenyl ester, lobaceride, cholestan-5,7-dien-3-ol, ergosterol, 3-hydroxy-choles-5-en-7-one, N-(2- hydroxy-1-phenyl-propyl) benzamide from leaves and stems of A. lobata (Table 3). Similarly, Attioua *et al* isolated 3-[(6Z,9Z)dodeca-6,9-dienoyloxy]-2-octanoyloxypropyl(6Z,9Z)dodeca-6,9-dienoate, (Z,Z,Z)-9,12,15-octadecatrienoic acid methyl ester, 8,11,17,21-tetramethyl-(E,E,E,E)-8,10,17,21-tetraentetracosanoic acid, geranylgeraniol, cholestan-3-one, betulinic acid and (E)-3-(4-methoxy-phenyl)-2-phenyl-acrylic acid from the stems and leaves of *A. lobata* (Table 3). Lagnika *et al.* [9] isolated compounds tiliroside (kaempferol-3-O-β-D-(6-E-p-coumaroyl) glycopyranoside), isovitexin (apigenin-6-C-β-D-glucopyranoside), vitexin (apigenin-8-C-β-D-glucopyranoside), chlorogenic acid (acid-5-O-caffeoylquinic) and 4,5-O-dicaffeoylquinic acid from aerial parts of *A. lobata* (Table 3). Attioua *et al*. [10] isolated palmitanoide, onosmin B, onosmin A, N-(2-hydroxy-1-phenylpropyl) benzamide and aurentiamide acetate from aerial parts of *A. lobata* (Table 3).

Biological activities of *Astraea lobata*

A number of biological activities of *A. lobata* have been reported in literature which may be used to explain some of the medicinal applications of the species. Such biological activities include antibacterial [36], antidiabetic [37], antiplasmodial [9,38,39], antioxidant [27,36], antitrypanosomal [9], leishmanicidal [9], cytotoxicity and toxicity [12,36,39] activities.

Antibacterial activities

The antibacterial activities of methanol extracts of aerial parts of *A. lobata* against *Enteroccocus feacalis*, *Escherichia coli, Pseudomonas aeruginosa* and *Staphylococcus aureus* were evaluated by Lagnika *et al* [36] using micro dilution method with gentamicin as a positive control.

Table 2: Nutrient composition of *Astraea lobata* leaves, roots and stems per 100 g

Caloric, nutritional and phytochemical	Plant part	Value	References
Alkaloids	Leaf, root, stem	1.4±0.1 mg	[33]
Anthraquinones	Leaf, root, stem	1.4±0.1 mg	[33]
Ash	Leaf, root, stem	13.7±0.3 %	[33]
Carbohydrate	Leaf, root, stem	53.1±3.1 %	[33]
Crude fibre	Leaf, root, stem	14.9±0.2 %	[33]
Crude protein	Leaf, root, stem	8.0±0.2 %	[33]
Dry matter	Leaf, root, stem	92.2±0.1 %	[33]
Fat	Leaf, root, stem	2.1±0.1%	[33]
Flavonoid	Leaf, root, stem	1.0±0.1 mg	[33]
Hydrogen cyanide	Leaf, root, stem	1.1±0.1 mg/kg	[33]
Moisture content	Leaf, root, stem	7.8±0.1 %	[33]
Phenols	Leaf, root, stem	1.7±0.0 mg	[33]
Saponins	Leaf, root, stem	0.4±0.1 mg	[33]
Sterols	Leaf, root, stem	0.3±0.0 mg	[33]
Tannins	Leaf, root, stem	0.8±0.1 mg	[33]
Terpenoids	Leaf, root, stem	2.3±0.1 mg	[33]
Total flavonoid content	Fruits	6.9±0.0 mg/ml	[27]
Total phenol content	Fruits	129.6±0.6 mg/ml	[27]

Table 3: Phytochemical compounds isolated and characterized from *Astraea lobata*

Compound	Method of compound characterization	Plant part	References
Alkaloids			
Palmitanoide	NMR, UV, IR and HRESIMS	Aerial parts	[10]
Onosmin B	NMR, UV, IR and HRESIMS	Aerial parts	[10]
Onosmin A	NMR, UV, IR and HRESIMS	Aerial parts	[10]
Diterpene alcohol			
Geranylgeraniol	HREIMS, HRMS, NMR, TLC	Leaves, stems	[10,34]
Ester			
(Z,Z,Z)-9,12,15-octadecatrienoic acid methyl ester	HREIMS, HRMS, NMR, TLC	Leaves, stems	[10,34]
(Z,Z)-9,12-octadecatrienoic acid	HREIMS, HRMS	Leaves, stems	[34]
8,11,17,21-tetramethyl-(E,E,E,E)-8,10,17,21-tetraentetracosanoic acid	NMR, TLC	Leaves, stems	[10]
Chlorogenic acid (acid-5-O-caféoylquinic)	NMR	Aerial parts	[9]
4,5-O-dicaffeoylquinic acid	NMR	Aerial parts	[9]
Flavonoid			
Tiliroside (kaempferol-3-O-β-D-(6-E-p-coumaroyl) glycopyranoside)	NMR	Aerial parts	[9]
Isovitexin (apigenin-6-C-β-D-glucopyranoside)	NMR	Aerial parts	[9]
Vitexin (apigenin-8-C-β-D-glucopyranoside)	NMR	Aerial parts	[9]
Hydroxy ketone			
N-(2-hydroxy-1-phenylpropyl) benzamide	HREIMS, HRESIMS, HRMS, IR, NMR, UV	Aerial parts	[10,34]
Peptide			
Aurentiamide acetate	NMR, UV, IR and HRESIMS	Aerial parts	[10]
Phenolic acid			
(E)-3-(4-methoxy-phenyl)-2-phenyl-acrylic acid	HREIMS, HRMS, NMR, TLC	Leaves, stems	[10,34]
Steroids			
Cholesta-5,7-dien-3-ol	HREIMS, HRMS	Leaves, stems	[34]
Ergosterol	HREIMS, HRMS	Leaves, stems	[34]
3-hydroxy-cholest-5-en-7-one	HREIMS, HRMS	Leaves, stems	[34]
Cholestan-3-one	HREIMS, HRMS, NMR, TLC	Leaves, stems	[10,34]
Triglyceride			
3-[(6Z,9Z)dodeca-6,9-dienoyloxy]-2-octanoyloxypropyl(6Z,9Z)dodeca-6,9-dienoate	HREIMS, HRMS, NMR, TLC	Leaves, stems	[10,34]
Triterpene			
Betulinic acid	HREIMS, HRMS, NMR, TLC	Leaves, stems	[10,34]

The best activity was demonstrated against *Enteroccocus feacalis* with minimal inhibitory concentration (MIC) value of 1.25 mg/ml [36]. These results support the traditional use of *A. lobata* as herbal medicine against dysentery in Nigeria and Togo [6,10,11], stomach ache in Nigeria [17,28], wounds in Nigeria [27] and other pathogenic infections such as mouth infections in Senegal [5] and skin diseases in Nigeria [15,17,18].

Antidiabetic activities

The ameliorative effects of *A. lobata* on alloxan-induced diabetes and associated cardiovascular derangements were evaluated by Fasola *et al* [37] by assessing the effects of the leaf extract on blood glucose level, blood pressure changes, electrocardiographic (ECG) abnormalities, lipid profile, and anti-oxidant status of alloxan-induced diabetic rats. Acute toxicity studies revealed no mortality of rats at the administration of different doses of extract up to the 5,000 mg/kg dose. Histology of the pancreas showed focal area of necrosis and fatty infiltration in diabetic untreated rats, but these lesions were absent in pancreas of rats treated with *A. lobata* extract. Methanol leaf extract of *A. lobata* reduced arteriogenic risk factors, improved antioxidant status, restored the observable pathological lesions associated with experimental diabetes in rats [37].

This study shows that *A. lobata* possesses blood glucose lowering effects, antihypertensive effect, as well as antioxidant and free radical scavenging properties. The exhibited antidiabetic activities validates the traditional use of the leaves, fruits, seeds and stems of *A. lobata* as herbal medicine against diabetes in Nigeria [11,32]. Therefore, further investigation on the different phytochemical constituents may be beneficial for the treatment and management of diabetes mellitus and its complications, and provide a safer and cheaper alternative to the currently available anti-diabetic drugs.

Antiplasmodial activities

The antiplasmodial activities of methalonic and methylene chloride aerial parts and root extracts of *A. lobata* were evaluated by Weniger *et al* [38] against *Plasmodium falciparum* K1 chloroquine resistant and 3D7 chloroquine sensitive strains. The extracts showed activities against *Plasmodium falciparum* strains with half maximal inhibitory concentration (IC_{50}) values ranging from 0.38 ± 0.18 µg/ml to 6.56 ± 3.71 µg/ml [38]. In a related study, Attioua *et al* [39] evaluated antiplasmodial activities of 3-[(6Z,9Z)dodeca-6,9-dienoyloxy]-2-octanoyloxypropyl(6Z,9Z)dodeca-6,9-dienoate, (Z,Z,Z)-9,12,15-octadecatrienoic acid methyl ester, 8,11,17,21-tetramethyl-(E,E,E,E)-8,10,17,21-tetraentetracosanoic acid, geranylgeraniol, cholestan-3-one, betulinic acid and (E)-3-(4-methoxy-phenyl)-2-phenyl-acrylic acid isolated from the stems and leaves of *A. lobata* against *Plasmodium falciparum* K1 chloroquine-resistant strain. The compounds geranylgeraniol, betulinic acid, (Z,Z,Z)-9,12,15-octadecatrienoic acid methyl ester, 8,11,17,21-tetramethyl-(E,E,E,E)-8,10,17,21-tetraentetracosanoic acid and (E)-3-(4-methoxy-phenyl)-2-phenyl-acrylic acid exhibited activity with IC_{50} values ranging from 1.1 µg/mL to 4.9 µg/mL [39].

Similarly, Lagnika *et al* [9] evaluated antiplasmodial activities of compounds tiliroside (kaempferol-3-*O*-β-D-(6-*E*-*p*-coumaroyl) glycopyranoside), isovitexin (apigenin-6-*C*-β-D-glucopyranoside), vitexin (apigenin-8-*C*-β-D-glucopyranoside), chlorogenic acid (acid-5-*O*-caféoylquinic) and 4,5-*O*-dicaffeoylquinic acid isolated from aerial parts of *A. lobata* against *Plasmodium falciparum*. The compounds tiliroside (kaempferol-3-*O*-β-D-(6-*E*-*p*-coumaroyl) glycopyranoside), vitexin (apigenin-8-*C*-β-D-glucopyranoside) and 4,5-*O*-dicaffeoylquinic acid exhibited some activities with IC_{50} values of 7.1 µM, 4.4 µM and 9.7 µM, respectively [9]. These results provide scientific evidence supporting the use of *A. lobata* as an antimalarial remedy in folk medicine in Benin, Nigeria, Togo [6-12].

Antioxidant activities

The antioxidant activities of methanol extracts of aerial parts of *A. lobata* were evaluated by Lagnika *et al* [36] using the 2, 2-diphenylpicrylhydrazyl (DPPH) radical scavenging assay. The extract demonstrated radical scavenging activities with IC_{50} value of 1.96 µg/ml [36]. Similarly, Odukoya *et al* [27] evaluated antioxidant activities of ethanol extracts of *A. lobata* fruits using the DPPH radical scavenging assay and lipid peroxidation using the thiobarbituric acid reactivity method. The extract demonstrated antioxidant capacity of 46.0 ± 0.0 %. It was observed that as the concentration increased, the amount of thiobarbituric reactive substances values decreased indicating low levels of malondialdehyde and a reduction in lipid peroxides both in the raw and cooked homogenate of *Scomber japonicum* Houttuyn fish. Results obtained by Odukoya *et al* [27] showed that there are more reactive oxygen species being destroyed with increasing concentrations of extract. Lipid peroxidation is considered responsible for the impairment of endothelial cells, keratinocyte capillary permeability, fibroblast and collagen metabolism [27]. Therefore, it can be concluded that the increased lipid peroxidation might be one of the factors causing the defect in vascular endothelial growth factor expression and finally producing the impairment in the wound-healing process. These antioxidant activities demonstrated by *A. lobata* extracts are probably due to flavonoids and phenolics that are common in the species [27,33] and also known to exhibit antioxidant activities [40].

Antitrypanosomal activities

The antitrypanosomal activities of compounds tiliroside (kaempferol-3-*O*-β-D-(6-*E*-*p*-coumaroyl) glycopyranoside), isovitexin (apigenin-6-*C*-β-D-glucopyranoside), vitexin (apigenin-8-*C*-β-D-glucopyranoside), chlorogenic acid (acid-5-*O*-caféoylquinic) and 4,5-*O*-dicaffeoylquinic acid isolated from aerial parts of *A. lobata* were evaluated by Lagnika *et al* [9] against *Trypanosoma brucei rhodesiense.* The compound vitexin (apigenin-8-*C*-β-D-glucopyranoside) exhibited some activity with IC_{50} value of 0.1 µM [9]. These results provide scientific evidence supporting the use of *A. lobata* as herbal medicine against infectious diseases such as guinea worms in Nigeria [15,30].

Leishmanicidal activities

The leishmanicidal activities of compounds tiliroside (kaempferol-3-*O*-β-D-(6-*E*-*p*-coumaroyl) glycopyranoside), isovitexin (apigenin-6-*C*-β-D-glucopyranoside), vitexin (apigenin-8-*C*-β-D-glucopyranoside), chlorogenic acid (acid-5-*O*-caféoylquinic) and 4,5-*O*-dicaffeoylquinic acid isolated from aerial parts of *A. lobata* were evaluated by Lagnika *et al* [9] against *Leishmania donovani.* The compound vitexin (apigenin-8-*C*-β-D-glucopyranoside) exhibited some activity with IC_{50} value of 0.6 µM [9]. Moreover, vitexin exhibited a prominent

leishmanicidal effect with an IC_{50} value comparable to that of the reference compound miltefosin (0.6 µM) [9]. These findings provide scientific basis for the traditional use of *A. lobata* of as herbal medicine against infectious diseases such as guinea worms in Nigeria [15,30].

Cytotoxicity and toxicity activities

The cytotoxicity activities of geranylgeraniol and betulinic acid isolated from the stems and leaves of *A. lobata* were evaluated by Attioua *et al* [39] on L6 murine myoblast cells. The compound geranylgeraniol showed good selectivity with an SI value (SI is ratio of cytotoxicity to biological activity) over 25. It is generally considered that biological efficacy is not due to *in vitro* cytotoxicity when SI ≥ 10 [39].

Similarly, Lagnika *et al* [36] evaluated toxicity activities of methanol extracts of aerial parts of *A. lobata* using *Artemia salina* (brine shrimp) toxicity assay. The brine shrimp lethality test results revealed lethal concentration 50% (LC_{50}) value of 8.17 mg/ml [36]. Therefore, the extract tested in his study exhibited very low or no toxicity. Lagnika *et al* [12] evaluated the toxicological effects of *A. lobata* aqueous extracts using oral acute toxicity in the rat model with distilled water as control. Acute toxicity of aqueous extracts of tested plants was assessed at a dose of 2000 mg/kg and the rats were observed for signs of toxicity or death after administration of the extracts. Therefore, the lethal dose 50 (DL_{50}) of aqueous extracts of *A. lobata* was higher than 2000 mg/kg body weight. The results revealed that all tested animals were physically active during the test and no signs of toxicity or morbidity in rats treated with extracts were observed.

A significant decrease of serum alanine aminotransferase and creatinine levels were observed in rats treated with aqueous extract of *A. lobata* while a significantly increased levels of red blood cells and hematocrit were observed. Histopathological examination of liver and kidney sections of rats treated with 2000 mg/kg body weight of aqueous extracts of *A. lobata* did not show any changes when compare to control rats. These results indicate that the oral administration of aqueous extracts of *A. lobata* did not produce any significant toxic effect in rats [12]. Therefore, the extract could be considered non-toxic to females rats. These results obtained by Lagnika *et al* [12,36] indicating the possibility that *A. lobata* extracts may not be toxic calls for thorough toxicological evaluations as the entire plant is regarded as a hunting poison in the coastal interior of the Ivory Coast [5]. The above ground parts of *A. lobata* are traditionally used in preparing arrow poisons in Ivory Coast [5].

CONCLUSION

A. lobata, which is exotic to tropical Africa, is widely used to combat various human ailments and diseases in the region. Utilization of *A. lobata* in tropical Africa support the general hypothesis that exotic plants are now recognized throughout the world as an important component of indigenous pharmacopoeia filling therapeutic vacancies that native plants cannot satisfy. Therefore, the use of exotic plant species as herbal medicines can alleviate pressure on scarce and threatened indigenous plant species. The historical traditional usage of *A. lobata* as herbal medicine in West Africa calls for detailed phytochemical and pharmacological studies aimed at correlating its documented ethnomedicinal uses with the phytochemical and pharmacological properties of the species. There is need for clinical and toxicological evaluations involving the species. There is also need to validate the traditional medicinal applications of *A. lobata* through tests *in vitro* and *in vivo* experiments. Detailed phytochemical and pharmacological studies of the species will provide some insight into the therapeutic potential of *A. lobata*. The phytochemistry and pharmacological activities of *A. lobata* and its compounds, as well as mechanisms of action should be studied further, as this is necessary for global acceptance of this plant in traditional and modern medicinal applications.

DECLARATIONS

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Conflicts of interest

No conflict of interest is associated with this work.

Contribution of authors

The author declares that this work was done by the author named in this article and all liabilities pertaining to claims relating to the content of this article will be borne by him.

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