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Medicinal uses and pharmacological activity of *Ximenia americana* L. - A systematic review

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Abstract

Medicinal plants have traditionally been used as remedies for various ailments. Ximenia americana which belongs to the Olacaceae family is one of the plants used in traditional medicine in Africa. However, it is facing threats of extinction due to its use for other purposes like firewood. It is within this context that this review aims at compiling published data on the ethnobotanical status, pharmacological activities and phytochemical profiles of X. americana in the last decade. A web-based literature search was done using scientific databases including Google Scholar and Pub Med, with inclusion criteria of full-length articles reporting on ethno medicinal surveys, pharmacological activities and phytochemical profiles of X. americana in Africa from the year 2010 to 2024. Data was captured in MS excel format and descriptive statistics used to summarize the findings. X. americana is used traditionally for the treatment of several ailments including digestive system infections, injuries, sexually transmitted infections among others. Literature search on pharmacological and phytochemical studies validates the use of X. americana in folklore medicine. The current review findings support the traditional use of X. americana. However, in-depth studies aimed at efficacy and safety evaluation, in addition to identification of the X. americana plant compounds responsible for the reported therapeutic activities is required.

Keywords: *Ximenia americana, Traditional uses, Pharmacological activity, Phytoconstituents.*

INTRODUCTION

The use of conventional medicine to combat the human health problems and life-threatening diseases is not only expensive but also has several side effects. Over the years medicinal plants play an important role in managing and treating human and animal diseases (Eshete and Molla, 2021). Plants have provided a rich source of medicines to the entire world and still continue to provide important leads to the discovery of new drugs (Süntar, 2020; Rasool *et al*., 2020). *Ximenia americana* is a species belonging to the genus *Ximenia* in the Olacaceae family. The genus *Ximenia* comprises about eight species namely *X. roiigi*, *X. aegyptica*, *X. parviflora*, *X. coriaceae*, *X. aculeata*, *X. caffra*, *X. aegyptica*and *X. americana* (Da Silva *et al*., 2023). The plant is a semi scandent bush-forming shrub about 2.7m high (Pessoa *et al*., 2023). The leaves are alternate and lanceolate, flowers are mainly white, yellow-green, or pink while the fruits are greenish when young, and yellowish when ripe (Bagu *et al*.,,2023). It prefers poor and dry soil, including clay, clay loam, loamy sand, sandy clay loam, and sand (Lemmens, 2023).

In Africa, *Ximenia americana* plant has been used by the rural people for a long time for various purposes such as a source of fruit, as a medicine, construction and as firewood (Bazezew*et al*., 2021). However, only a few studies focused on the importance of this plant (Desissa and Binggeli. 2020). It has been reported that *X. americana* is facing threats of extinction. These threats are occasioned by factors like forest clearing, grazing, timber harvesting, charcoal making, drought, harvesting of fruit for consumption and harvesting of bark and root for medicinal uses (Dejene *et al*., 2020) The most fearful aspect is also that the conservation status of *X. americana* is very low (Dejene *et al*., 2020). According to del Val, (2023) synthesis of over 100 previous reports, it is concluded that unless the situation is reversed by collective efforts, there is fear of extinction of this plant in the near future. It is within this context that this review aimed at assessing the traditional medicinal uses of *X. americana* and the documented pharmacological activities and analyses of phytochemical constituents of the plant species in Africa during the last decade.

METHODS

Literature search strategy

The literature search for information on traditional uses, pharmacological activities and photochemical constituents of *X. americana* was carried out from September 2023 to March 2024.The search was performed using Google Scholar and PubMed search engines covering the period January 2010 to March 2024 and was limited to original journal articles written in English and whose full text were accessible in the internet. The literature search was performed using key terms such as: Ethnobotanical survey/study of *Ximenia americana*, Traditional uses of *Ximenia americana*, Pharmacological activity of *Ximenia americana*, Phytochemicals constituents in *Ximenia americana* and English terms such as 'wild plum' and 'sandal wood'.

Inclusion and Exclusion criteria

Published ethnobotanical reports, pharmacological reports and experimental studies outcomes about *X. americana* in the countries in Africa, reported within the period of January 2010 to March 2024 were included. Information from published ethnobotanical and ethnomedicinal surveys not reporting information on *X. americana* were excluded from the analysis. Review articles were also excluded.

Screening and criteria

For this systematic review, the title and abstract of identified journal articles were downloaded and all those suitable for the purpose were screened out and critically inspected for inclusion. Full articles of the included papers were downloaded and examined thoroughly for relevant information.

Data analysis

Relevant data on the reported traditional uses *X. americana*, pharmacological activities and phytochemical profiles were entered into structured Microsoft office Excel format and exported to Statistical Packages for Social Science (SPSS) software. Descriptive statistical

methods, percentage and frequency were used to analyze the ethno-botanical data on reported medicinal uses of *X. americana* its pharmacological activities and phytochemical constituents.

RESULTS

An extensive search of journal articles published within the period of 14 years (January 2010 to March 2024) revealed 54 peer reviewed articles reporting relevant information on *X. americana* in different countries in Africa. Analysis of the reported medicinal uses, pharmacological activities and phytochemical profiles showed the following results:

Medicinal uses of *Ximenia Americana*

The stem bark, leaves roots and fruits of *X. americana*a are used as herbal medicines for treatment of reported 38 human diseases in different countries in Africa (Tables 1a, 1b and1c).The literature search revealed that *X. americana* is most frequently used for ailments associated with the digestive system (21.7 %) which include stopping infant diarrhea, clearing oral thrust, stopping dysentery, relieving abdominal pain and as an anti-emetic agent. It is reported the plant is also frequently used for treatment of various ailments including bacterial and parasitic infections (13.0 %), for example treatments of malaria, leech infestations, febrile illness and tonsils. *X. americana* is also used to cure injuries like wounds and burns (15.2%) and sexually transmitted infections (13.0%). *X. americana* is also traditionally used in the treatment of respiratory tract infections (6.5 %), and as an antidote for snake and scorpion poison bites (6.5 %). It is used in management of pain and reproductive health problems like erectile dysfunction and fibroids (4.3 %), for promoting good health, alleviating anemia, correcting diabetes mellitus, treating skin rashes, tackling problems of the nervous system such assleep disorders, treating hypertension and relieving toothache (2.2 %) across different communities in Africa (Table 1a,1b,1c). Information from literature shows that the root part of *X. americana* is the most frequently used part (31.7%) followed by the stem bark and leaf parts (24.4 %). Combinations include the use of Stem bark/root (7.3 %), Root/Stem bark/ Fruit, Root/Leaf/Fruit, Stem bark/root, Leaf/stem bark, Leaf/ root (2.2 %) (Table 1a, 1b, 1c). Literature information further revealed that the methods of preparation of *X. americana* in traditional medicine include decoction, boiling, infusion, pounding, conversion to powder and grinding (Table 1a, 1b and 1c)

Pharmacological activities of *X. americana*reports in Africa

Twenty seven published articles were recorded for 20 different pharmacological activities of *X. americana* across different countries in Africa as shown in Table 2. Most of the studies were reported from Nigeria with 10 articles published during the last decade, followed by Kenya with 6 articles, Burkina Faso with 5 articles. Others include Togo with 2 articles, Ivory Coast, Benin, Mali and Ethiopia each with 1 article. Most of the authors reported on antimicrobial and antioxidant activity of *X. americana* with 4 articles each while antiinflamatory and antipyretic activities were reported with 3 articles each.

Phytochemical constituents of *X. americana*

Eighteen published articles were recorded for 26 different phytochemical constituents of *X. americana* across different countries in Africa as shown in Table 3 (a-g). Most of the studies

reported the presence of flavonoids with 16 articles published in the last decade, followed by tannins with 14 articles, saponins with 13 articles, and alkaloids with 12 articles. Terpenoids and phenols were also highly reported with 8 articles each. Glycosides, cardiac glycosides and terpenes were also reported with 4 articles each while anthraquinones and coumarins were reported with 3 articles each. Triterpenoids, steroids, quinones, reducing sugars, resins and anthocyanins were reported by 2 articles each. Others phytochemical compounds reported include amino acids, chalcones, vitamin D, leuco-anthocyanins, quinines, mucilages, reducing compounds and unsaturated fats with one article each.

"Table 1a. Traditional uses of *Ximenia americana* for general health, pain, blood, digestive system and respiratory infections in Africa."

Category	**Medicinal use**	**Plant part**	**Prepa-ration**	**Adminis-tration**	**Local name**	**Country**	**No. of authors**	**% frequency of authors**	**Reference**
General health	Encourage good health	SB	NS	Oral	Olamai	Kenya	1	2.2	Demissew*et al*., (2016).
Pain	Joint Pains	R	Boiled	Oral	Mutula	Kenya	2	4.3	Mutwiwa, *et al*., (2018).
	Joint pains/ Muscular pain/Abdominal pain	S	Grinding	Massage	Mumpeke	Angola			Urso *et al*., (2013)
Blood	Anemia	SB	Boiled-can mix with milk	Oral	Olamai	Kenya	1	2.2	Duncan *et al*., (2016).
Digestive system	Diarrhea	SB	Boiled-can mix with milk	Oral	Olamai	Kenya	10	21.7	Duncan *et al*., (2016).
	Diarrhea	L	Infusion	Oral	Mumpeke	Angola			Urso *et al*., (2013)
	Diarrhea	R/L/F	Decoction	Oral	Munchovwa	Zambia			Chinsembue *t al*., (2016).
	Oral thrust	R	Decoction	Oral	Maayangu	Tanzania			Marealle*et al*., (2021).
	Dysentery	L/SB	Infusion	Oral	Busantu	Tanzania			Kingo and Maregesi, (2020)

	Dysentery	R	Infusion		Mii(gbaya)	Cameroon			Jiofack*et al.*, (2010)
	Abdominal pain		NS	NS	NS	Ethiopia			Masresha *et al.*, (2021).
	Anti-emetic	L	NS	NS	Mileo	Ethiopia			Zenebe *et al.*, (2012)
	Stomach ache	R	Grinding	Oral	Ntsengele	Mozambique			Ribeiro *et al.*, (2010)
	Heartburn	L	Decoction	Oral	NS	Mali			Nordeng *et al.*, (2013)
Respiratory infections	Persistent cough/ Tuberculosis/ chest pain	R	Decoction	Oral	Maayangu	Tanzania	3	6.5	Marealle*et al.*, (2021).
	Cough	L	NS	NS	NS	Tanzania			Ngowi*et al.*, (2015)
	Throat infection	R/L/F	Decoction	Oral	Munchovwa	Zambia			Chinsembu*e t al.*, (2016)

KEY: **NS-** NOT SPECIFIED, **L-** LEAF, **R-** ROOT, **SB-** STEM BARK, **F-** FRUIT, **S-** SEED

"Table 1b. Traditional uses of *Ximenia americana* for treatment of endocrine system, infections, injuries and poisoning in Africa."

Category	**Medicinal use**	**Plant part**	**Preparation**	**Administration**	**Local name**	**Country**	**No. of authors**	**% Frequency of authors**	**Reference**
Endocrine system	Diabetes mellitus	R	Decoction	Oral	Maayangu	Tanzania	1	2.2	Marealle*et al.*, (2021).
Infections	Leech infection/Tonsillitis	L	NS	NS	Mileo	Ethiopia	6	13	Zenebe *et al.*, (2012)
	Tonsillitis/ malaria	R/L/F	Decoction	Oral	Munchovwa,	Zambia			Chinsembu*et al.*, (2016).
	Malaria	SB	Decoction	Oral	Hudha	Ethiopia			Feyssa*et al.*, (2012)
	Malaria	SB	Decoction	Oral	Kinyotwo	Kenya			Rotich *et al.*, (2022).

	Trypanosomiasis	SB/R	NS	NS	Tsada	Niger			Shehu *et al*., (2023)
	Febrile illness	NS	NS	NS	NS	Ethiopia			Masresha *et al*., (2021).
Injuries	Wounds	R/ L	Pounding	Oral	Enkoy	Ethiopia	7	15.2	Alemneh, (2021).
	Wounds	SB	Powder	Topical	Enkoye	Ethiopia			Mekuanen*tet al*., (2015).
	Wounds	NS	NS	NS	NS	Ethiopia			Masresha *et al*., (2021).
	Wounds	R	Grinding	Topical	Ntsengele	Mozambique			Ribeiro *et al*., 2010
	Wounds	SB	Powder	Topical	Hudha	Ethiopia			Feyssa*et al*., (2012)
	Wounds	F/SB/R	NS	NS	Ditsadi	South Africa			Shai *et al*., (2020)
	Wounds/burns	L	Ointment	Topical	Mumpeke	Angola			Urso *et al*., (2013)
Poisoning	Snake bites/Scorpion bites	NS	NS	NS	NS	Ethiopia	3	6.5	Masresha *et al*., (2021).
	Snake/cobra bites	SB	Decoction	Oral/Topic	Hudha	Ethiopia			Feyssa*et al*., (2012)
	Snake bites/ Scorpion bites	L	Decoction	Oral	Mumpeke	Angola			Urso *et al*., (2013)

KEY: **NS**- NOT SPECIFIED, **L**- LEAF, **R**- ROOT, **SB**- STEM BARK, **F**- FRUIT, **S**- SEED

"Table 1c. Traditional uses of *Ximenia americana* in treatment of sexually transmitted infections, skin, reproductive system, nervous system, circulatory system and dental health in Africa"

Category	Medicinal use	Plant part	Preparation	Administration	Local name	Country	No. of authors	% frequency of authors	Reference

Sexually transmitted infections	Syphilis/ gonorrhea	R	Boiling	Oral	Musumu/ Ulemu	Uganda	6	13	Kyazike, (2021).
	Gonorrhea/ Candidiasis	R/L/F	Decoction	Oral	Munchovwa	Zambia			Chinsembu*et al.*, (2016)
	Gonorrhea/ Bacterial vaginosis	SB	Decoction	Oral	Mtengene	Zambia			Chinsembu*et al.*, (2019)
	Genital warts	R/SB	Decoction	Oral	Maayangu	Tanzania			Marealle*et al.*, (2021).
	Genital Wart	NS	NS	NS	NS	Ethiopia			Masresha *et al.*, (2021).
	H.I.V/AIDS	R	Decoction	Oral	Ntsengele	Mozambique			Ribeiro *et al.*, (2010)
Skin	Skin ashes	R/L/F	Decoction	Oral	Munchovwa	Zambia	1	2.2	Chinsembu*et al.*, (2016).
Reproductive system	Erectile dysfunction	SB/R	Decoction	Oral	Cocognanwe	Mali	2	4.3	Togola *et al.*, (2020)
	Fibroids	R	Infusion	Oral	Mii(gbaya)	Cameroon			Jiofack*et al.*, (2010)
Nervous system	Sleep diseases	R	Infusion	Oral	Mii(gbaya)	Cameroon	1	2.2	Jiofack*et al.*, (2010)
Circulatory system	Hypertension	NS	Decoction	Oral	NS	South Africa	1	2.2	Silas and Newman, (2018)
Dental health	Tooth ache	L	Decoction	Oral	Umm Medeka	Sudan	1	2.2	Eisawi*et al.*, (2022)

KEY: **NS**- NOT SPECIFIED, **L**- LEAF, **R**- ROOT, **SB**- STEM BARK, **F**- FRUIT, **S**- SEED

"Table 2. Pharmacological activities of various solvent extracts from different plant parts of *X. americana* reported in different countries in Africa"

Pharmacological	**Plant part**	**Solvent**	**Country**	**References**

Antipyretic	Leaf/ stem bark	Dichloromethane-methanol	Kenya	Gaichu*et al*., (2017)
Antipyretic/ Anti-inflammatory	Leaf/ stem bark	Dichloromethane-methanol	Kenya	Muthee *et al*., (2019)
Antipyretic/ antimicrobial/ antidiarrheal	Root	Acetone	Burkina Faso	Kiessoun*et al*., (2018)
Anti-inflammatory	Root bark	ethanol-water (80:20 (v/v))	Burkina Faso	Olabissi*et al*., (2011)
Antimalarial	Stem bark	Methanol, water	Kenya	Rotich *et al*., (2015)
Antifertility	Leaf	Methanol	Kenya	Kamita *et al*., (2014)
Cardio preventive	Leaf	Water	Kenya	Gaichu*et al*., (2023)
Antityphoid	Stem bark	Methanol	Nigeria	Muhammad *et al* 2021
Antimicrobial	Leaf	Ethanol	Nigeria	Hassan *et al* (2021)
Antimicrobial	Leaf/stem bark	Petroleum ether / Methanol	Nigeria	Zeinab, *et al*., (2016)
Antimicrobial	Leaf/stem bark/root	Ethanol/water	Nigeria	Shagal *et al*., (2013)
Antimicrobial/ antioxidant	Leaf	Ethanol	Burkina Faso	Pare *et al*., (2019)
Antibacterial/ antiradical	Stem bark	ethanol, water, hydro ethanol	Benin	Alain *et al*., (2014)
Anti-mycobacterium	Leaf	Hexane, chloroform, n-butanol	Nigeria	Nvau*et al*., (2014)
Antioxidant	Stem bark	ethanol-water (70/30, V/V)	Togo	Togbossi*et al*., (2020)
Antioxidant	Leaf	Ethanol/ water	Mali	Mariko *et al*., 2016
Antioxidant	Stem bark	Methanol	Nigeria	Maikai*et al*., (2010)
Free radical scavenging	Fruit/ Seeds	Ethanol	Ethiopia	Bazezew*et al*., 2021
Antidepressant	stem bark	ethanol-water (70/30, V/V)	Togo	Togbossi*et al*., (2020)
Antitrypanosomal	Stem bark	Methanol/ Water	Nigeria	Maikai&Maikai., (2015)
Antitrypanosomal	Roots	Methanol/acetone/ethanol	Nigeria	Olanrewaju *et al*., (2019)
Antisickling/ antibacterial	Root	Methanol	Nigeria	Bagu *et al*., (2023)
Antinociceptive	Stem bark	Methanol, Water	Kenya	Nyangacha*et al*., (2016)
Antinociceptive/ Anti-inflammatory	Root	Methanol	Burkina Faso	Konate *et al*., (2018)

Antiulcer	Root bark	Ethanol/ water (80:20, V/V),	Burkina Faso	Delma *et al*., (2023)
Gastroprotection	Stem bark	Methanol	Nigeria	Agyigra *et al*., (2017)
Analgesic	Stem bark	Water	Ivory Coast)	Soro *et al*., (2016)

"Table 3a. Phytochemical constituents of different plant parts of *X. americana* in Africa: Terpenoids, Glycosides and steroids"

Phytochemical constituents	**Solvent**	**Plant part**	**Country**	**References**
Terpenoids	Methanol	Leaf	Kenya	Kamita *et al*., 2014
	Methanol/Ethanol	Leaf	Sudan	Sharief *et al*., (2022)
	Methanol/water	Leaf	Nigeria	Hassan *et al*., 2021
	DCM-MeOH	Stem bark	Kenya	Gaichu*et al*., 2017
	Methanol	Stem bark	Nigeria	Maikai*et al*., (2010)
	Methanol	Stem bark	Nigeria	Agyigra *et al*., (2017)
	Water/Methanol/Acetone/Ethanol	Fruit pulp	Botswana	Matenanga*et al*., (2024)
	Water/Methanol/ethanol	Stem bark	Niger	Manzo *et al*., (2017)
Glycosides	Methanol	Leaf	Kenya	Kamita *et al*., 2014
	Methanol/Ethanol	Stem bark/Leaf/root	Sudan	Sharief *et al*., (2022)
	Ethanol	Stem bark/root/ Leaf	Nigeria	Shagal *et al*., (2013)
	Methanol	Root	Bukinafaso	Konate *et al*., (2018)

Steroids	Methanol	Leaf	Kenya	Kamita *et al*., 2014
	Methanol	Leaf	Nigeria	Kawo*et al*., (2011)

KEY:DCM-MeOH – Dichloromethane-methanol

"Table 3b: Phytochemical constituents of different plant parts of *X. americana* in Africa: Phenols, Triterpenoids and Cardiac glycosides"

Phytochemical constituents	**Solvent**	**Plant part**	**Country**	**References**
Phenols	Methanol	Leaf	Kenya	Kamita *et al*., 2014
	DCM-MeOH	Leaf/ Stem bark	Kenya	Gaichu*et al*., 2017
	Water	Leaf	Nigeria	Hassan *et al*., 2021
	Ethanol	Leaf	Burkina faso	Pare *et al*., (2019)
	Water/Ethanol	Leaf/ Stem bark/Roots	Nigeria	Shagal *et al*., (2013)
	Ethanol	Fruits	Ethiopia	Bazezew*et al*., 2021
	Methanol/Acetone	Fruit pulp	Botswana	Matenanga*et al*., (2024)
	Water/Methanol, ethanol	Stem bark	Niger	Manzo *et al*., (2017)
Triterpenoids.	Methanol	Leaf	Kenya	Kamita *et al*., 2014

	Water	Leaf	Nigeria	Hassan *et al*., 2021
Cardiac glycosides	DCM-MeOH	Leaf/stem bark	Kenya	Gaichu*et al*., 2017
	Water	Leaves	Sudan	Sharief *et al*., (2022)
	Methanol/Water	Leaves	Nigeria	Hassan *et al*., 2021
	Methanol	Stem bark	Nigeria	Maikai*et al.*, (2010)

KEY:DCM-MeOH – Dichloromethane-Methanol

"Table 3c: Phytochemical constituents of different plant parts of *X. americana* in Africa: Flavonoids"

Phytochemical constituents	**Solvent**	**Plant part**	**Country**	**References**
Flavonoids	DCM-MeOH	Leaf	Kenya	Gaichu*et al*., 2017
	Methanol	Leaf	Nigeria	Kawo*et al*., (2011)
	Methanol/ ethanol/ water	Leaf	Sudan	Sharief *et al*., (2022)
	Methanol/ water	Leaf	Nigeria	Hassan *et al*., 2021
	Water/ ethanol	Stem bark/ leaf/ root	Nigeria	Shagal *et al*., (2013)
	Petroleum ether / Methanol/ Chloroform/ Ethyl acetate	Stem bark/ Leaf	Nigeria	Zeinab, *et al*., 2016
	Hydroethanolic	Stem bark	Benin	Alain *et al*., (2014)
	Ethanol-water (70/30, V/V)	Stem bark	Togo	Togbossi*et al*., (2020)

	Methanol	Stem bark	Nigeria	Maikai*et al.*, (2010)
	Methanol	Stem bark	Nigeria	Agyigra *et al*., (2017)
	Water	Stem bark	Mali	Togola *et al*., (2020)
	Ethanol	Fruits	Ethiopia	Bazezew*et al*., 2021
	Methanol	Root	Nigeria	Olanrewaju *et al*., (2019)
	Methanol	Root	Bukinafaso	Konate *et al.*, (2018)
	Methanol/ ethanol	Fruit pulp	Botswana	Matenanga*et al*., (2024)
	Water/methanol/ ethanol	Stem bark	Niger	Manzo *et al*., (2017)

KEY:DCM-MeOH – Dichloromethane-Methanol

"Table 3d. Phytochemical constituents of different plant parts of *X. americana* in Africa: Saponins, Quinones and Anthraquinones"

Phytochemical constituents	**Solvent**	**Plant part**	**Country**	**References**
Saponins	DCM-MeOH	Leaves/ Stem bark	Kenya	Gaichu*et al*., 2017
	Methanol/ water	Leaves	Nigeria	Kawo*et al*., (2011)
	Ethanol/ water/ methanol	Leaves/stem bark/ roots	Sudan	Sharief *et al*., (2022)
	Methanol/ water	Leaves	Nigeria	Hassan *et al*., 2021

	Petroleum ether / Methanol/ Chloroform/ Ethyl acetate	Leaves/ stem bark	Nigeria	Zeinab *et al.*, 2016
	Ethanol/ water	Leaves/ roots/ stem bark	Nigeria	Shagal *et al.*, (2013)
	Ethanol-water (70/30, V/V)	Stem bark	Togo	Togbossi*et al.*, (2020)
	Methanol	Stem bark	Nigeria	Maikai*et al.*, (2010)
	Methanol	Stem bark	Nigeria	Agyigra *et al.*, (2017)
	Methanol	Roots	Nigeria	Olanrewaju *et al.*, (2019)
	Methanol	Roots	Bukina Faso	Konate *et al.*, (2018)
	Water	Stem bark	Mali	Togola *et al.*, (2020)
	Water, Methanol, ethanol	Stem bark	Niger	Manzo *et al.*, (2017)
Quinones	Water/ Methanol/ Ethanol	Leaves Stem bark	Sudan	Sharief *et al.*, (2022)
	Water	Leaves	Nigeria	Hassan *et al.*, 2021
Anthraquinones	Methanol	Leaves	Nigeria	Hassan *et al.*, 2021
	Methanol	Stem bark	Nigeria	Maikai*et al.*, (2010)
	Methanol	Stem bark	Nigeria	Agyigra *et al.*, (2017)

KEY:DCM-MeOH – Dichloromethane-Methanol

"Table 3e. Phytochemical constituents of different plant parts of *X. americana* in Africa: Tannins"

Phytochemical constituents	**Solvent**	**Plant part**	**Country**	**References**
Tannins	Methanol/ water	Leaves	Nigeria	Kawo*et al.*, (2011)

	Methanol/ Ethanol/ Water	Leaves/ stem bark	Sudan	Sharief *et al*., (2022)
	Methanol/ water	Leaves	Nigeria	Hassan *et al*., 2021
	Water/ ethanol	Leaves/ stem bark/ roots	Nigeria	Shagal *et al*., (2013)
	Petroleum ether / Methanol/ Chloroform/ Ethyl acetate	Leaves/ stem bark	Nigeria	Zeinab, *et al*., (2016)
	Hydroethanolic	Stem bark	Benin	Alain *et al*., (2014)
	Ethanol-water (70/30, V/V)	Stem bark	Togo	Togbossi*et al*., (2020)
	Methanol	Stem bark	Nigeria	Maikai*et al*., (2010)
	Methanol	Stem bark	Nigeria	Agyigra *et al*., (2017)
	Methanol	Roots	Nigeria	Olanrewaju *et al*., (2019)
	Methanol	Roots	Bukinafaso	Konate *et al*., (2018)
	Water	Stem bark	Mali	Togola *et al*., (2020)
	Methanol	Fruit pulp	Botswana	Matenanga*et al*., (2024)
	Water/Methanol	Stem bark	Niger	Manzo *et al*., (2017)

KEY:DCM-MeOH – Dichloromethane-Methanol

"Table 3f. Phytochemical constituents of different plant parts of *X. americana*: Reducing sugars, Alkaloids and Terpenes"

Phytochemical constituents	**Solvent**	**Plant part**	**Country**	**References**
Reducing sugars	Methanol/ Water	Leaves	Nigeria	Kawo*et al*., (2011)
	Ethanol-water (70/30, V/V)	Stem bark	Togo	Togbossi*et al*., (2020)
Alkaloids	Water	Leaves	Nigeria	Kawo*et al*., (2011)
	Methanol	Leaves	Nigeria	Hassan *et al*., 2021
	DCM-MeOH	Stem bark	Kenya	Gaichu*et al*., 2017
	Methanol/ Ethanol/ Water	Stem bark	Sudan	Sharief *et al*., (2022)
	Ethanol	Stem bark/ Roots	Nigeria	Shagal *et al*., (2013)
	Hydroethanol	Stem bark	Benin	Alain *et al*., (2014)
	Methanol	Stem bark	Nigeria	Maikai*et al*., (2010)
	Methanol	Stem bark	Nigeria	Agyigra *et al*., (2017)
	Methanol	Roots	Bukinafaso	Konate *et al*., (2018)
	Water	Stem bark	Mali	Togola *et al*., (2020)
Terpenes	Methanol/ Ethanol/ Water	Leaves Stem bark	Sudan	Sharief *et al*., (2022)
	Petroleum ether / Methanol/ Chloroform/ Ethyl acetate	Leaves Stem bark	Nigeria	Zeinab, *et al*., 2016
	Hydroethanol	Stem bark	Benin	Alain *et al*., (2014)
	Methanol	Roots	Nigeria	Olanrewaju *et al*., (2019)

KEY:DCM-MeOH – Dichloromethane-Methanol

"Table 3g. Phytochemical constituents of different plant parts of *X. americana*: Resins, Amino acids, Chalcones, Vitamin D, Anthocyanins, Leuco-anthocyanins, Coumarins, Quinines, Mucilages, Carbohydrates, Reducing compounds and Unsaturated fatty acid"

Phytochemical constituents	Solvent	Plant part	Country	References
Resins	Methanol	Leaves	Nigeria	Hassan *et al.*, 2021
	Water/ Ethanol	Leaves/ Stem bark/ Roots	Nigeria	Shagal *et al.*, (2013)
Amino acids/ Chalcones/ Vitamin D	Methanol/ Water	Leaves	Nigeria	Hassan *et al.*, 2021
Anthocyanins	Water	Leaves	Nigeria	Hassan *et al.*, 2021
	Hydroethanol	Stem bark	Benin	Alain *et al.*, (2014)
Leuco-anthocyanins	Hydroethanol	Stem bark	Benin	Alain *et al.*, (2014)
Coumarins	Water	Leaves	Nigeria	Hassan *et al.*, 2021
	Petroleum ether / Methanol/ Chloroform/ Ethyl acetate	Leaves/ Stem bark	Nigeria	Zeinab *et al.*, 2016
	Acetone	Fruit pulp	Botswana	Matenanga*et al.*, (2024)
Quinines/ Mucilages	Hydroethanol	Stem bark	Benin	Alain *et al.*, (2014)

Carbohydrates	Ethanol-water (70/30, V/V)	Stem bark	Togo	Togbossi*et al*., (2020)
	Methanol	Stem bark	Nigeria	Agyigra *et al*., (2017)
Reducing compounds	Ethanol-water (70/30, V/V)	Stem bark	Togo	Togbossi*et al*., (2020)
Unsaturated fatty acid	Ethanol	Seeds	Ethiopia	Bazezew*et al*., 2021

KEY:DCM-MeOH – Dichloromethane-Methanol

DISCUSSION

Published articles indicate that *X. americana* has vast medicinal applications among different communities in the Africa region. Most of the studies done in the last decade report that the species is commonly used to treat ailments related to the digestive system. This range from stopping infant diarrhea in infants, oral thrust, dysentery, stomachache and as an anti-emetic (Table 1a,b,c). Stomach problems like the ones mentioned are mainly caused by microbial infections including bacteria, fungi and viruses. A number of pharmacological studies conducted in various countries in Africa validate this use.

Investigations on Petroleum ether, Methanol, Chloroform, Ethyl acetate extracts of the leaves and stem bark of *X. americana* in Nigeria have reported activity against five common microbial isolates which include *Pseudomonas areuginosa, Bacillus subtilis, Escherichia coli, Staphylococus aureus and Candiaa albicans* (Zeinab, *et al*., (2016). This is corroborated by the use of this plant for treatment of candidiasis in Zambia as reported by Chinsembu*et al*., (2016). Similarly, the root, stem bark and leaves of aqueous and methanolic extracts of the plant have been established to inhibit growth of *Staphylococusaureus, Klebsiella pneumonia* and *Salmonella typhy*bacteria as reported in Benin (Alain *et al*., (2014)). Antibacterial activity of *X. americana* against various microbial isolates has also been reported in Nigeria (Muhammad *et al* 2021; Hassan *et al* 2021; Shagal *et al*., 2013; Nvau*et al*., 2014) and in Burkina Faso (Kiessoun*et al*., 2018; Pare *et al*., 2019). These studies support the traditional use of the plant in solving stomach problems. Additionally, the use of *X. americana* for treatment of skin rashes in Zambia as reported by Chinsembu*et al*., (2016) could still be attributed to its antimicrobial activity. Furthermore, Shettar and Vedamurthy, (2017), reported antihelmintic activity of *X. americana* which explains the use of the plant in curing skin rashes which could be caused by host allergic response to helminthes infestation.

X. americana is also reported to cure infectious diseases like Leech infestation, Tonsillitis and febrile illness which are mainly caused by bacteria and malaria caused by protozoa. This reported curative use is supported by antimicrobial studies in different countries (Zeinab, *et al*., 2016.; Alain *et al*., 2014; Muhammad *et al* 2021; Hassan *et al* 2021; Shagal *et al*., 2013;Nvau *et al*.,

2014; Kiessoun*et al.*, 2018; Pare *et al*., 2019). Rotich *et al*., (2015) has also reported good antimalalrial activity of *X. americana* in mice infected with *P. berghei*.

X. americana has been reported to cure wounds in folklore medicine in the African region (Table 1b). Furthermore, Delma *et al*., (2023) also reported anti-ulcer activity of *X. americana.* This might explain the use of this plant in curing wounds and stomach problems due to skin and gastric cancers. This fact is further supported by Agyigra *et al*., (2017), who demonstrated gastro-protective activity of *X. americana* in rats in Nigeria. The plant is used also to cure respiratory infections, an aspect which can be explained by the findings of Alain *et al*., (2014) who established *in vitro* activity of *X. americana* against *Klebsiella pneumonia* the causative agent of pneumonia, a respiratory disease. Similarly Nvau*et al*., (2014), reported the anti-mycobacterium activity of Hexane, chloroform, n-butanol leaf extract of *X. americana* plant. This supports the traditional use of *X. americana* to treat tuberculosis in Tanzania (Mareall*eet al*., 2021).

Gaichu*et al*., (2017) evaluated the antipyretic activity of dichloromethane-methanolic (DCM-MeOH) stem bark and leaf extracts of *X. americana* in rats in Kenya. It was found to have good antipyretic activity hence supporting its use in the management of fever in traditional medicine as observed in its use to cure febrile illness in Ethiopia (Masresha *et al*., 2021) and to promote good health in some parts of Kenya (Demissew*et al*., 2016).

Nyangacha*et al*., (2016) evaluated the anti-nociceptive effect of stem bark of *X. americana.* Nociception refers to a sensory stimulus which warns about a possible harm and is mostly perceived as pain (Konate *et al.*, 2018). The analgesic activity was determined by the tail flick and formalin test techniques in male albino mice. Both the methanol and aqueous extracts of *X. americana* significantly ($p<0.05$) reduced the time spent in pain behavior in both the early and late phases indicating good antinociceptive/ analgesic activity. This study supports the use of this plant in folklore medicine in the management of pain. For instance, its use in the management of joint pain in Kenya as reported by Mutwiwa *et al*., (2018). Antinociceptive activity has also been demonstrated in methanol extract of the root of *X. americana* by Konate *et al.*, (2018) in Burkina Faso.

According to Mareall*eet al*., (2021) *X. americana* is used to treat diabetes mellitus in Tanzania. Pharmacological reports on antidiabetic activity of *X. americana* in Africa were scanty. However, this use is supported by the findings in the study conducted by Shettar*et al*., (2017) in India which confirmed that aqueous extract of the leaves of this plant exhibited high antidiabetic activity supporting the use of this plant in folklore medicine. Similar results on antidiabetic activity of this plant have also been reported by Siddaiah*et al*., (2011) in India.

X. americana is used to treat sexually transmitted diseases for instance gonorrhea and syphilis in Uganda (Kyazike, 2021), genital warts in Ethiopia (Masresha *et al*., 2021) and bacterial vaginosis and candidiasis in Zambia (Chinsembu*et al*., 2019). This might be attributed to the antimicrobial properties of this plant (Zeinab, *et al*., 2016.; Alain *et al*., 2014; Muhammad *et al* 2021; Hassan *et al* 2021; Shagal *et al*., 2013; Nvau*et al*., 2014; Kiessoun*et al.*, 2018; Pare *et al*., 2019; Rotich *et al*., 2015). Particularly, Geyid*et al.*, (2005) reported that methanol extract from leaves of *X. americana* inhibited growth of *Neisseria gonorrhea* organisms. Hence supporting the use of the plant to treat sexually transmitted infections.

Various studies have reported the antioxidant potential of *X. americana* in different countries in Africa (Pare *et al*., 2019; Togboss*iet al*., 2020; Mariko *et al.*, 2016; Maikai*et al.*, 2010; Alain *et al*., 2014; Bazezew*et al*., 2021). According to Konate *et al.*, (2018) antioxidants from plants increase the antioxidant capacity of the plasma hence reduce the risk of heart diseases and cancer.

This might explain the cardiopreventive properties in *X.americana* as reported by Gaichu*et al*., (2023) and therefore its use in traditional medicine to cure hypertension.

Literature search on phytochemical constituents of *X. americana* revealed the presence of several phytochemical compounds (Table 3a-g). These phytochemical constituents are responsible for the pharmacological activities of *X. americana*. Alkaloids for instance have been reported to inhibit prostaglandin synthesis and antipyretic effect (Niazi *et al*., 2010). Tannins and flavonoids on the other hand are associated with analgesic activity (Konate *et al.*, 2018). According to Rice-Evans *et al*., (1997), phenols are effective hydrogen donors a property that makes them good antioxidants (Konate *et al.*, 2018). Flavonoids are gastroprotective since they stimulate preventive factors like vasodilation (Serafim *et al*., 2020) and mucus secretion (Atmani *et al*., 2009). Flavonoids and tannins have also been reported to be toxic to microorganisms (Pare *et al*., 2019). Therefore, the reported pharmacological activities could be due to the mentioned phytochemical constituents validating their uses in traditional medicine.

CONCLUSIONS AND RECOMMENDATIONS

This review gives broad information about the traditionally claimed medicinal uses, pharmacological activities and phytochemical constituents of *X. americana*. The traditional usage of *X. americana* herbal medicine in Africa calls for detailed phytochemical and pharmacological properties investigations of the species aimed at identifying the compounds responsible for its broad usage as herbal medicine. At the moment, there are few data regarding phytochemistry, pharmacological properties and clinical research on *X. americana* extracts and compounds. There are very few experimental studies, clinical research trials and target-organ toxicity studies involving *X. americana* extracts and its compounds that have been carried out so far. Given this background, it is quite difficult to correlate the traditional uses of the species with the few phytochemical profiling and pharmacological evaluations that have been done so far. There is need therefore, to evaluate pharmacological properties of the species, as these may be directly related to the species traditional uses. Detailed pharmacological studies will provide some insight into the therapeutic potential of *X. americana*. There is also need for urgent conservatory measures for this plant to avoid any possible extinction of this important plant species.

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CONFLICT OF INTEREST

The authors express no conflict of interest associated with this work.

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