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Mahamane Idi Issa Abdoulahi
Laboratory of Natural Substances and Synthesis Organic, Faculty of Science and Technology, Abdou Moumouni University, BP 10662 Niamey, Niger

Hama Hamadou Habibou
Laboratory of Natural Substances and Synthesis Organic, Faculty of Science and Technology, Abdou Moumouni University, BP 10662 Niamey, Niger

Alio Sanda Abdelkader
Laboratory for Management and Valorization of Biodiversity in Sahel, Faculty of Science and Technology, University Abdou Moumouni, BP 10662 Niamey, Niger.

Nodjitoloum Mborbe
Natural Substances Research Laboratory, Faculty of Exact and Applied Sciences, University of N'Djamena, Tchad.

Moctar Chaibou
Laboratory of Natural Substances and Synthesis Organic, Faculty of Science and Technology, Abdou Moumouni University, BP 10662 Niamey, Niger

Hama Garba Rahila
Laboratory of Natural Substances and Synthesis Organic, Faculty of Science and Technology, Abdou Moumouni University, BP 10662 Niamey, Niger

Bakasso Sahabi
Laboratory of Natural Substances and Synthesis Organic, Faculty of Science and Technology, Abdou Moumouni University, BP 10662 Niamey, Niger

Ilagouma Amadou Tidjani
Laboratory of Natural Substances and Synthesis Organic, Faculty of Science and Technology, Abdou Moumouni University, BP 10662 Niamey, Niger

Corresponding Author:
Mahamane Idi Issa Abdoulahi
Laboratory of Natural Substances and Synthesis Organic, Faculty of Science and Technology, Abdou Moumouni University, BP 10662 Niamey, Niger

Ethno Botanical, Pharmacology and Phytochemistry of widely used medicinal plants in Niger: A Review

Mahamane Idi Issa Abdoulahi, Hama Hamadou Habibou, Alio Sanda Abdelkader, Nodjitoloum Mborbe, Moctar Chaibou, Hama Garba Rahila, Bakasso Sahabi and Ilagouma Amadou Tidjani

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Abstract
The plants *Cassia italica* (Mill.) F.W. Anders, *Limeum pterocarpum* (L.), *Strychnos innocua* Del, *Ipomoea asarifolia* (DESR.) Roem. & Schult, *Blepharis linariifolia* Pers, *Boscia senegalensis* (Pers) Lam. Ex Poir, *Neocarya macrophylla* (Sabine) Prance, *Phyllanthus pentandrus* Schum & Tonn and *Ximenia americanum* L belong to different families and are used for the treatment of several pathologies. The aim of this review is to present the current state of research on the ethnopharmacological use of these medicinal plants and to give an overview of the significant results documented. Scientific information about these plants reported were used. Literature review was conducted using search engines and other scientific database websites for chemicals such as ChemSpider, PubChem. Phytochemical work on some of these plants has revealed the presence of several chemical groups and more than 100 compounds have been isolated from some of these plants. The isolated compounds belong to various chemicals classes such as stilbenes, flavonoids, terpenoids, Tannins. Some crude extracts showed a wide spectrum of biological activities, such as antiproliferative, analgesic, anti-inflammatory, antioxidant, antimicrobial and antiplasmodial activities. This review provides an overview of the use, pharmacology and phytochemistry of these plants.

Keywords: Medicinals plants, ethnopharmacology, pharmacology, phytochemistry, Niger

Introduction
In Africa, according to the World Health Organization (WHO, 2008) [1], more than 80% of the population still use medicinal plants for their health care needs [1]. Plants are generally presented as having efficacy; they are low cost and available. Sustainability of the use of medicinal plants is important concern. The demand for medicinal plants is increasing in Africa as the population grows and pressure on medicinal plant resources will become greater than ever. Interest in plant derived medicines has also increased in the developed countries between the pharmaceutical companies. In contrast, due to their minor side effects, the medicinal plants are widely used to treat many human diseases. The increasing cost of health care and the failure of allopathic medicine to treat some diseases have also participated to the increasing consumption of traditional medicine to cure some disease. Medicinal plants with a long history of safe and efficient use are likely to have a pharmaceutical outcome. In Niger, many research has been done on the traditional pharmacopoeia, ethnobotanical and pharmacological (Khalid *et al.*, 1984; Baoua et *al.*, 1974; Manzo *et al.*, 2017; Jazy *et al.*, 2017) [2-5]. This review describes the traditional uses, phytochemistry and pharmacology of nine (9) medicinal plants from Niger. These plants are distributed in 9 families. They are: *Cassia italica* (Mill.) F. W. Anders (Caesalpiniaceae), *Limeum pterocarpum* (L.) (Molluginaceae), *Strychnos innocua* Del (Loganiaceae), *Ipomoea asarifolia* (DESR.) Roem. & Schult (Convolvulaceae), *Blepharis linariifolia* Pers (Acanthaceae), *Boscia senegalensis* (Pers) Lam. Ex Poir (Capparidaceae), *Neocarya macrophylla* (Sabine) Prance (Chrysobalanaceae), *Phyllanthus pentandrus* Schum & Tonn (Euphorbiaceae) and *Ximenia americanum* L (Olacaceae). These plants are used in the treatment of many diseases.

Methodology
An extensive literature review was conducted using Sci-finder, Pubmed, Scopus, Web of Science, Science Direct, J-Gate, Google Scholar and other scientific database websites for

chemicals such as Chem Spider, PubChem. Keywords used included botany, conservation, Ethno botany, phytochemistry, toxicology and pharmacology. The scientific name of each plant was then combined separately with the terms antimicrobial, antiparasitic, anti-inflammatory, hepatoprotective, antiulcer, immunomodulatory, antioxidant, and antidiarrheal. Scientific names were validated using the lexicon of vernacular plant names from Niger "*Lexique des Plantes du Niger*". The literature sources used in this article is ranging from French to English.

Results and discussion

The data obtained on the state of research on these plants concerns traditional uses, phytochemistry and biological potential. The compounds isolated from these plants belong to the families of steroids, flavonoids, saponins, quinone, Cyanogenic Glucoside. Only the isolated glycocapparin from *B. senegalensis* has been tested for it hypoglycemic *in vivo.*

Limeum pterocarpum (L.)

There is hardly any work that has been done to show the biological activities of *Limeum pterocarpum* minus the phytochemical composition of this plant. Ethnobotanical surveys have shown that the plant is used in the treatment of malaria, bacterial and fungal infections (Diallo *et al.,* 2001) [6]. The leaves are dried, crushed and used with milk to treat malaria. Another antimalarial preparation consists to macerate the whole plant until the water changes colour. The solution is drunk for three days (Diallo *et al.,* 2001) [6].

Previous work on *Limeum pterocarpum* has allowed the isolation of the simeolide, a drimane-type sesquiterpene (Ikhiri *et al.,* 1995) [7]. Thus, D-pinitol was isolated and characterised from successive treatments of the aqueous extract of the plant (Abdoulaye *et al.,* 2004) [8]. A study conducted by Diallo *et al.,* in 2001 [6] on the antifungal, antioxidant, molluscicidal and larvicidal properties of 20 medicinal plants, including *L. pterocarpum*, showed that the dichloromethane extract of the aerial parts has antifungal activity, especially on the *Candida albicans* germ (Diallo *et al.,* 2001) [6].

Table 1: Previous pharmacological works on *L. Pterocarpus*

Type of extract	Activities	Biological/chemical model	Results	References
Methanolic extract Dichloromethane extract	Antifungal Antifungal	*Cladosporium cucumerinum* *Candida Albicans* *Cladosporium cucumerinum* *Candida albicans*	Active No active Not active Active	(Diallo *et al.,* 2001) [6] (Diallo *et al.,* 2001) [6]
Methanolic and dichloromethane extract	Larvicide	*Culex Anopheles Aedes*	Non actif Actif Non actif	(Diallo *et al.,* 2001) [6]
Methanolic and dichloromethane extract	Antioxydant	DPPH TLC β-carotene TLC	Negative Positive	(Diallo *et al.,* 2001) [6]

Blepharis linariifolia Pers (Acanthaceae)

Khalid *et al.,* 1984 [2] reported that the *Blepharis linariifolia* plant is used in the treatment of measles and oedema, it is also used for stomach aches, it is cited as an aphrodisiac plant and is included in recipes used in child care. The leafy stems are used to treat malaria and abscesses. The juice of the leaves is antibiotic, anti-protozoal and antiseptic. The leafy stems are used in the treatment of feverish aches and panic attacks. The juice of the leaves is purgative, anti-inflammatory, stimulating the intestine and uterine muscles (Nacoulma, 1996) [8]. Women use *B. linariifolia* against stomach ache (Wezel, 2002) [9]. According to the African pharmacopoeia, in Niger the leafy plant is used against panicitis, the whole plant against syphilis and the leaves are purgative; in Burkina Faso the stem of the plant is used in the treatment of neck ganglions (Eklu-Natey et Balet, 2012) [10].

Little work has been done on the phytochemical composition of *Blepharis linariifolia* Pers. The aqueous extract of the whole plant contains flavonoids, saponosides and tannins (Baoua *et al.,* 1974) [3]. The plant contains tannins, saponosides, sterols and triterpenes; quinones and cyanogenic glycosides are absent; alkaloids and flavonoids are present only in the fruits (Khalid *et al.,* 1992) [12]. Nacoulma, in 1996 [8] showed that this plant contains saponosides, flavonoids, steroids, anthocyanins in the flowers, triterpenes, Mucilages in the seeds and coumarins.

The aqueous extract was tested on *S. typhimirium* of the isolated strains (Mahamane *et al.,* 2020) [13]. Nasereldeen *et al.,* in 2018 [14] showed the hepatoprotective properties of the hydroethanolic extract obtained from the whole plant. The antioxidant activity was shown by several methods: FRAP (Mahamane *et al.,* 2020) [15]; by DPPH (Wamtinga, 2006; Dirar *et al.,* 2019) [16, 17]. The hexane extract of the plant seeds did not show activity against *Bacillus subtilis*, *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Aspergillus niger* (Osama *et al.,* 2017) [18].

Table 2: Previous pharmacological works on *Blepharis Linariifolia*

Type of extract	Activities	Biological / Chemical Model	Results	References
Hexane extract Aqueous extract	Antibacterial	*Bacillus subtilis, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa* and *Aspergillus niger* *S. Typhimurium* (clinical) *S. Typhimurium* (lettuce)	No active 7,5±0,70 mm 13,5±2,12 mm	(Osama *et al.,* 2017) [18] (Mahamane *et al.,* 2020) [13]
Hydroethanolic extract Hydroethanolic, aqueous, acetone and dichloromtane extracts Aqueous extract	Antioxydant Antioxydante Antioxydant	DPPH DPPH FRAP	% I = 78±0.01 20.28 ± 0.64 to 0.85 ± 0.12 µg/mL 1,78±0,04 mmol EAA/g	(Nasereldeen *et al.,* 2018) [14] (Dirar *et al.,* 2019) [17] (Mahamane *et al.,* 2020) [15]
Hydroethanolic extract	Hepato protective	*In vivo*	400mg/Kg	(Nasereldeen *et al.,* 2018) [14]
Hydroethanolic, aqueous, acetone and dichloromethane extracts	Enzymatic inhibition	Pancreatic lipase	0,63 to 23,47 µg/mL	(Dirar *et al.,* 2019) [17]

***Phyllanthus pentandrus* Schum & Tonn (Euphorbiaceae)**

The plant *P. pentandrus* is widely used in several treatments in Niger for child weaning, scorpion stings, stomach aches and indigestion (Jazy *et al.*, 2017) [5]. It is used in the composition of several recipes used in the treatment of infectious diseases. This plant is widely used for infants.

Phytochemical studies carried out on *P. pentandrus* reveal the presence of alkaloids, saponosides and quinones only in the seeds, flavonoids are present only in the leaves and tannins are present in all organs; the absence of cyanogenic glycosides is also noted (Baoua *et al.*, 1974; Alio *et al.*, 2020; Mahamane *et al.*, 2020) [2, 19, 13].

However, little work has been done on the biological activities of this plant, methanolic extracts have been tested on *E. coli*, *S. aureus* and *P. aeruginosa* (Kwaji *et al.*, 2015) [20], aqueous, dichloromethane and ethanolic extracts have been tested on *S. typhimirium* of the isolated strains (Alio *et al.*, 2020; Mahamane *et al.*, 2020) [19,13]. Chika and Bello in 2019 [21] showed the hepatoprotective properties of aqueous extracts obtained from the leaves. The antioxidant activity by FRAP method was demonstrated by (Mahamane *et al.*, 2020) [15].

Table 3: Previous pharmacological works on *Phyllanthus Pentandrus*

Type of extract	Activities	Biological / chemical model	Results	References
Aqueous extract Methanolic extract	Antibacterial Antibacterial	S. Typhimurium (clinical) S. Typhimurium (lettuce) E. Coli S. Aureus P. Aeruginosa	11,5±0,70 mm 17,5±0,70 mm 17 mm 24 mm	(Mahamane *et al.*, 2020) [13] (Alio *et al.*, 2020) [19] (Kwaji *et al.*, 2015) [20]
Aqueous extract	Antioxydant	FRAP	2,21±0,02 mmol EAA/g	(Mahamane *et al.*, 2020) [15]

***Boscia senegalensis* (Pers) Lam. Ex Poir (Capparidaceae)**

Khalid *et al.*, in 1992 [12] reported that *B. senegalensis* is one of the plants with aphrodisiac use, plants treating oedema and rheumatism. The bark is used as a fumigation to treat haemorrhage after childbirth. The infusion of the leaves is used against stomach aches, sinusitis and rheumatism. A decoction of the roots is recommended for the treatment of diarrhoea, oedema, eczema and jaundice (Ikhiri *et al.*, 2000) [22]. In Senegal, the roots, barks and leaves are indicated for the treatment of stomach aches. The powder of the dried leaves added to salt is used as an anti-bilharzian and as a tranquilliser for certain forms of mental illness. The roots are presumed to be vermifuge (Pousset, 2004) [23]. The leaves, twigs, bark, roots, root bark and fruit are indicated for tooth decay, inflammation, sprains, sickle cell disease, persistent headaches, rheumatism and haemorrhoids (Jazy *et al.*, 2017) [5]. The plant is traditionally used to protect cereals against pathogens (Seck *et al.*, 1993; Dicko *et al.*, 2001) [24, 25].

Some works have been done on the different parts and biological activities of *B. senegalensis*. Diallo *et al.*, 2001 [6] showed the antifungal, larvicidal, molluscicidal and antioxidant activities of *Boscia senegalensis* extracts. In addition, the insecticidal power of the plant extracts on the groundnut bruchid (Caryedon serratus (O.L) was carried out by Gueye *et al.*, in 2011 [26]. Sakine *et al.*, in 2012 [27] evaluated the hypoglycemic activity of glycocapparin isolated from the seeds of this plant by assessing the level of hepatic glycose release *in vivo*. Cook *et al.*, in 1998 [28], evaluated the antioxidant activities of the aqueous extract of *B. senegalensis* leaves with trolox as a control. The extract showed an antioxidant capacity of 22 µmol/g trolox equivalent per gram of dry matter. Antioxidant activity of methanolic extract of *B. Senegalensis* fruits using 2,2-diphenyl-picrylhydrazyl radical (DPPH) and β-carotene assay was carried out by Diallo *et al.*, in 2001[6]. The antioxidant activity of the plant fruits was also shown by Ka *et al.*, in 2020 [29] by FRAP and DPPH methods. Aliyu *et al.*, in 2008 [30], evaluated the antibacterial activities of ethanolic extract of *B. Senegalensis* roots against *Staphylococcus aureus* with an inhibition diameter of 19 mm, a minimum inhibitory concentration (MIC) of 5mg/ml and a minimum bactericidal concentration (MBC) of 6mg/ml. The anthelmintic activity of ethanolic extracts obtained from the leaves and roots of the plant was demonstrated by Chaibou *et al.*, in 2020 [31] these extracts showed a 100% mortality rate after 10 hours at the concentration of 10g/L. Morgan *et al*, in 2014 [32] isolated a flavonol glucoside called bosenegaloside and identified 7 other compounds already known: rhamnocitrin-3-O-β-D-(6"-O-E-p-coumaroyl)-glucopyranoside (I), rhamnocitrin-3-O-β-D-glucopyranoside (II), 3,4,5-trimethoxyphenol-β-D-glucopyrinoside (III), Lasianthionoside A (IV), 3,7-dimethyl-1-octene-3,6,7-triol-6-O-β-D-glucopyranoside (V), Syringin (VI) and Austroside B (VII).

Table 4: Previous pharmacological works on *Boscia senegalensis*

Type of extract	Activities	Biological/chemical model	Results	References
Dichloromethane extract	Antifungal	*Candida Albicans* *Cladosporium cucumerinum*	Active	(Diallo *et al.*, 2001) [6]
Isolated glycocapparin	Hypoglycemic	*In vitro*	30 mg/mL	(Sakine *et al.*, 2012) [27]
Aqueous extract	Antioxidant	Trolox	22µmol/ g	(Cook *et al.*, 1998) [28]
Methanolic extract	Antioxidant	DPPH and β-carotene by TLC	Positive	(Diallo *et al.*, 2001) [6]
	Antibacterial	*Staphylococcus aureus*	CMI=5mg/mL CMB=6mg/mL	(Aliyu *et al.*, 2008) [30]
Ethanolic extract	Anthelmintic	*In vitro*	Mortality rate = 100% at 10g/L	(Chaibou *et al.*, 2020) [31]

***Cassia italica* (Mill.) F. W. Anders (Caesalpiniaceae)**

The roots and flowers of the plant are used in case of stomach bloating and against colic. The decoction of the flowers is used for splenomegaly. The leaves are used by maceration to treat stomach ache (Pousset, 1989) [33]. The decoction of the whole plant or the leaves are used as a laxative, purgative, for rheumatism and urinary infections (Al-Said, 1993) [34]. In Saudi Arabia the plant is used for constipation, oedema and skin infections (Al-Yahya *et al.*, 1990) [35].

The decoction of the roots is used against jaundice, snake bites and leprosy. An infusion of the leaves is used as a laxative and purgative (Ikhiri *et al.*, 2000) [22]. In Senegal, the

leaves are indicated to treat constipation, hepatobiliary diseases, venereal diseases and those caused by helminths (Pousset, 1989) [33]. Jazy *et al.,* 2017 [5] reported that the leaves and the whole plant are used against chronic constipation, stomach ache, chronic haemorrhoids, typhoid fevers, sickle cell disease, sickle cell crises and facilitate digestion.

Some work has been done on antiproliferative activities by MTT and antioxidant activities by DPPH and ABTS (Bayala *et al.,* 2020) [36]. Rwaida and Mai in 2020 [37] isolated a benzoic acid derivative as well as the compounds 1-p-hydroxy benzoyl-3-palmitoyl glycerol (1) and 6-p-hydroxy benzoyl daucosterol (2) scutellarein-6-methyl ether (3), quercetin (4), and rutin (5) which were identified and separated. The aqueous extract of the leaves is hepatotoxic by increasing the total bilirubin level as well as liver enzymes at the dose of 1500mg/Kg of body weight (Shehu *et al.,* 2018) [38]. Gamal in 2014 [39] isolated a new cycloartane triterpene compound, (22E)-3-β-hydroxycycloart-22-en-24one, and 8 already known compounds: β-sitosterol (I), UVAOL (II), daucosterol (III), Me 3,4 dihydroxybenzoate (IV), emodin (V), 4-hydroxypheny-O-β-D-glucopyranoside (VI), aloin (VII), and rutin (VIII). GC-MS analysis of the methanolic extract of the leaves of the plant shows the presence of 17 compounds, most of which are used in industry as flavouring, antioxidant, anti-inflammatory, antimicrobial, pesticide and antiproliferative (Sermakkani and Thangapandian 2012) [40]. Kazmi *et al.,* in 1994 [41] identified: β-sitosterol, stigmasterol, α-amyrin, 1, 5-dihydroxy-3-Me anthraquinone and a new anthraquinone (I) which is believed to be antibacterial and has anticancer activity. The plant also has purgative properties by stimulating intestinal motricity (Assane *et al.,* 1994) [42].

Table 5: Previous pharmacological works on *Cassia Italica*

Type of extract	Activities	Biological/chemical model	Results	References
Hydromethanolic extract	Anti-DPPH, anti-ABTS;	DPPH, ABTS	IC_{50} = 0.53 ± 0.04 µg ext. / µg DPPH C= 0.302 ± 0.003 µMET / g ext.	(Bayala *et al.,* 2020) [36]
Methanolic extract	Anti-DPPH	DPPH	800 µg/mL	(Gamal, 2014) [39]
Hydromethanolic extract	Anti-proliferative	MTT Assay		(Bayala *et al.,* 2020) [36]
Aqueux, hexane and methanolic extracts	Antibacterial	Staphylococcus aureus, Salmonella typhi, Escherichia coli, Pseudomonas aeruginosa et Streptococcus pneumonies	20.0 ± 0.82, 32.0 ± 0.50, 32.0 ± 0.50, 33.0 ± 1.64 et 31.25 ± 0.25 mm at the concentration of 120 mg/mL	(Dabai *et al.,* 2012) [43]
Aqueux extract	Hepatotoxicity	Albino rats *In vivo*	1500 mg/Kg	(Shehu *et al.,* 2018) [38]
Ethyl acetate fraction	Anti-DPPH	DPPH	%I = 95.8	(Rwaida et Mai 2020) [37]

***Neocarya Macrophylla* (Sabine) Prance (Chrysobalanaceae)**

Manzo *et al.,* 2017 [4] reported that the bark from the trunk of the plant is used in the treatment of diarrhoeal diseases. *Neocarya macrophylla* (Sabine) Prance is a plant used in the traditional pharmacopoeia of Niger. The bark of the plant is used against intestinal parasitosis. Khalid *et al.,* in 1984 [2] showed that this plant is used in the treatment of stomach ailments and leprosy.

The plant has been the subject of some studies against inflammatory pain for its richness in saponoside. The plant has analgesic and anti-inflammatory activities; the extract from the trunk bark is more active than the roots (Jega *et al.,* 2019) [44]. The oil extracted from the fines of this plant has important properties for application in cosmetology, GC-MS analysis revealed the presence of: myristic acid, palmitic acid, stearic acid, palmitoleic acid, elaidic acid, oleic acid, erucic acid, Behenic acid, Heneicosanoic acid, icosatetraenoate and Eicosatrienoic acid (Warra *et al.,* 2019) [45]. Most of the studies done on this plant focus on the nutritional aspect of the seeds, gingerbread etc... (Amza *et al.,* 2015) [46]. The plant has not been subject to phytochemical and biological studies.

***Strychnos innocua* Del (Loganiaceae)**

The plant's leaves and roots alone or in combination are used to treat typhoid fever and jaundice (Jazy *et al.,* 2017) [5].

Previous studies on *Strychnos innocua* Del focus mainly on the nutritional side and it has been shown that it is rich in sodium and carbohydrates (Bello *et al.,* 2007) [47]. The ethanolic extract of the plant has inhibitory activities of the following enzymes: hyaluronidase, phospholipase A2 and protease. Anthenobilic acid has been identified as the major phenol (Molander *et al.,* 2014) [48]. The root bark contains alkaloids, iridoids, carbohydrates, and phenolic acids; the following compounds have been identified loganic acid, glucose, fructose, Quinic acid, and phenols (Angenot and Wauters 1974) [49]. The plant is mentioned as a plant used in the treatment of infectious diseases such as diarrhoea and typhoid fever, but no work has been done to evaluate its activity against the bacteria responsible for these diseases. The plant has not been the subject of in-depth phytochemical and biological studies.

Table 6: Previous pharmacological works on *Strychnos Innocua*

Type of extract	Activities	Biological/chemical model	Results	References
Ethanolic extract	Enzymatic inhibition	Hyaluronidase, phospholipase A2 and protease	IC_{50}=100 µg/mL	(Molander *et al.,* 2014) [48]

***Ipomoea Asarifolia* (DESR) Roem & Schult (Convolvulaceae)**

The plant belongs to the Convolvulaceae family and is used in the traditional treatment of several infectious diseases such as typhoid fever, diarrhoea and fungal infections. The leaves, stem and/or whole plant are indicated for sickle cell disease, rheumatism, joint pain, skin allergy, hair loss, haemorrhoids and bacterial infections (Jazy *et al.,* 2017) [5].

Previous work has focused on phytochemical, biological and toxicological aspects. The plant does not show activity against *E. coli* ATCC 25992 according to the study conducted by Santos *et al.,* in 2018 [50]. The hydro ethanolic extract of the plant exhibits cardioprotective activity (Akindele *et al.,* 2018) [51]. The antioxidant activity of the plant was studied by DPPH methods by Muhammad *et al.,* 2018 [52] Meda *et al.,* 2017 [53]; ABTS and FRAP by Meda *et al.,* 2017 [53]. The aqueous

extract of the plant possesses anti-inflammatory activities using the murine model of oedema, peritonitis and air pouch inflammation HPLC-DAD and LC-DAD-MS analyses identified the following compounds rutin, chlorogenic acid and caffeic acid which are believed to be responsible for this activity (Furtado *et al.*, 2016) [54]. Other authors have also shown that the aqueous extract has antioxidant activities, against inflammation of the intestine. Two triacyclic and tetraglucosylated anthocyanins derived from cyanidin were isolated from the flowers of the plant and their structures elucidated by GC, MS and NMR methods (1H and 13C, TOCSY-1D, DQF-COSY, DIFFNOE and HMBC) (Pale *et al.*, 2003) [55]. Indolic diterpenic alkaloids were isolated by HPLC-HRMS, 1D and 2D NMR spectroscopy methods and compounds associated with tremorrhagic syndrome in cattle (Stephen *et al.*, 2017; Dale *et al.*, 2018) [56, 57]. The aqueous extract of the plant leaves exhibits hepato-protective activity against CCl_4-induced damage in rats (Farida *et al.*, 2012) [58]. Ethyl acetate and methanol extracts showed acetylcholinesterase inhibitory activity (Feitosa *et al.*, 2011) [59]. Toxicity of *Ipomoea asarifolia* has not been reported in humans but in animals in North Brazil, it has been investigated and was linked to the presence of lectins in the plant (Steiner *et al.*, 2011) [60].

Table 7: Previous pharmacological works on *Ipomoea Asarifolia*

Type of extract	Activities	Biological/chemical model	Results	References
Ethanolic extract	Antibacterial	*E. Coli* ATCC 25992	Not active	(Santos *et al.*, 2018) [50]
Ethyl acetate and methanol extracts	Enzymatic inhibition	Acétylcholinestérase	IC_{50} = 0.12mg/mL	(Feitosa *et al.*, 2011) [59]
Methanolic extract	Hepatoprotective	*In Vivo*	100, 200 et 400mg/kg	(Farida *et al.*, 2012) [58]
Aqueous and methanolic extract Aqueous extract	Antioxidant Antioxidant Antioxidant	DPPH FRAP ABTS	IC_{50} =92 µg/mL IC_{50} =92 µg/mL 363.963 µmol TE/g 169.828 to 2559.512 µmol AAE/g	(Muhammad *et al.*, 2018) [52] (Meda *et al.*, 2017) [53] (Meda *et al.*, 2017) [53]

***Ximenia americanum* L (Olacaceae)**

Manzo *et al.*, 2017 [4] reported that the bark of the trunk of the plant is used in treatments of diarrhoeal diseases. The leaves, twigs, barks, roots and fruits of the plant are used in dracunculiasis, aches and pains, HTA, gonococcal disease, wound, haemorrhoids, abdominal pain, indigestion, jaundice (Jazy *et al.*, 2017) [5]. The ethnobotanical survey conducted by Khalid *et al.*, in 1984 [2] showed that this plant is used in the treatment of jaundice, stomach ache and is indicated as a haemostatic plant.

This plant is one of the most used in the treatment of infectious diseases in West Africa. It has been the subject of several studies to determine its antimicrobial activity. Several types of extracts obtained from the different organs of the plant have been tested on a wide range of pathogens. Ethanolic and o-tolidine extracts were tested on *Escherichia coli*, *Staphylococcus aureus*, *Salmonella spp* and *Candida albicans* (Gunasekhar *et al.*, 2017) [61]. Antimicrobial and antidiarrheal activity of the saponoside-rich root extract was evaluated in Wistar rats (Kiessoun *et al.*, 2018) [62]. The essential oil obtained from the leaves of the plant showed antibacterial activity against *Staphylococus aureus* (Mulugeta *et al.*, 2015) [63]. The antioxidant activity of the plant was evaluated by several DPPH, FRAP and ABTS methods. Thus, the ethanolic extract of the leaves showed a percentage inhibition of 62.32±0.17% and a reducing power of 3.45 ± 0.97 mmol EAA/10 g (Dramane *et al.*, 2019) [64]. The aqueous extract of the plant obtained by infusion has analgesic activity at the concentration of 100 mg/mL but this extract is toxic at 400 mg/mL (Soro *et al.*, 2009) [65]. Aqueous and methanolic extracts obtained from leaves, barks and roots were tested against the following strains *Bacillus subtilis*, *Staphyllococcus aureus*, *Escherichia coli*, *Psedomonas aeruginosa* of which the methanolic extract showed the best activity with 0.31 mg/mL against *Bacillus subtilis* (Omer and Elmina 2003) [66]. The methanolic extract of the plant leaves was active against *Candidas albicans* and *Trichophyton rubrum* with IC50 = 8.12 µg/mL and IC50 = 26.06 µg/mL respectively. The hexanolic, methanolic extracts were not active on *Esherichia coli* and *Mycobacterium Chelonae*, but showed activity on *Staphylococcus aureus* with IC50 < 64 µg/mL (Traoré *et al.*, 2015) [67]. The phenol-rich extract obtained after liquid-liquid separation of the hydro acetone extract with dichloromethane is active on the following strains *Shigella dysenteriae*, *Shigella boydii*, *Shigella Flexneri*, *Salmonella thyphi*, *Klebsiella pneumonia*, *Proteus mirabilis* with MICs ranging from 25 to 50 µg/mL and BMCs ranging from 50 to 100 µg/mL. However, this extract is not active on *Klebsiella Arogenes* and *Escherichia coli*, (Kiessoun *et al.*, 2018) [62].

Table 8: Previous pharmacological works on *Ximenia Americanum*

Type of extract	Activities	Biological/chemical model	Results	References
Ethanolic extract	Anti-DPPH, Reducing power	DPPH, FRAP	%I=62.32 ± 0.17 3.45 ± 0.97 mmol EAA/10g	(Dramane *et al.*, 2019) [64]
Methanolic extrait	Antifungal	Candidas albicans Trichophyton rubrum	IC_{50} = 8,12 µg/mL IC_{50} = 26,06 µg/mL	(Traoré *et al.*, 2015) [67]
Hydro acetone extracts Hexanolic, methanolic extract	Antibacterial	Shigella dysenteriae, Shigella boydii, Shigella flexneri, Salmonella thyphi, Klebsiella pneumonia, Proteus Mirabilis Staphylococcus Aureus	CMI 25 à 50 µg/mL CMB 50 à 100 µg/mL IC_{50} < 64 µg/mL	(Kiessoun *et al.*, 2018) [62] (Traoré *et al.*, 2015) [67]
Aqueous extract	Analgesic	Albino rats *In vivo*	At the concentration C= 100 mg/mL	(Soro *et al.*, 2009) [65]

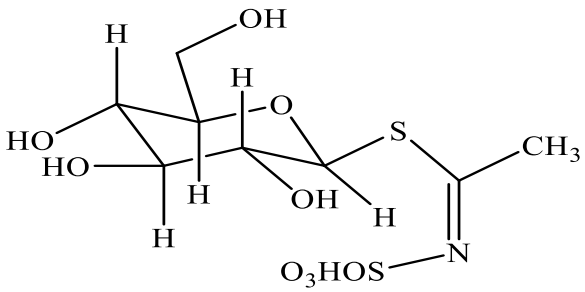
Table 9: Traditionnals uses of the nine plants

Plants	Part(s) used	Traditional uses	Forms of use	References
L. Pterocarpum	**Leaves, Whole plant**	**Malaria, Bacterial and Fungal Infections**	**Maceration / Decoction for drinking**	**(Diallo *et al.*, 2001) [6]**
B. Linariifolia	Whole plant Leafy stems Leaf juice Leafy plant	Measles Edema Aphrodisiac Children's care Stomach aches Malaria Abscesses Antibiotic, anti-protozoal, antiseptic, anti-inflammatory, stimulant of the intestine and uterine muscles Panariasis, syphilis, purgative,	Maceration/decoction for drinking By enema	(Khalid *et al.*, 1984) [2] (Wezel, 2002) [10] (Nacoulma, 1996) [9] (Nacoulma, 1996) [9] (Eklu-Natey et Balet, 2012) [11]
P. Pentandrus	Whole plant Aerial part	Weaning children, Scorpion sting, Stomach ache, Indigestion, Treatment of infectious diseases	Maceration/decoction for drinking	(Jazy *et al.*, 2017) [5]
B. Senegalensis	Roots Roots Leaves Barks	Aphrodisiac use, treatment of oedema and rheumatism Treatment of bleeding after childbirth Stomach aches Treatment of diarrhoea, oedema, eczema and jaundice Tooth decay, inflammation, sprains, sickle cell disease, persistent headaches, rheumatism and haemorrhoids Infections	Maceration/decoction/ Infusion for drinking and enema Fumigation	(Khalid *et al.*, en 1992) [12] (Ikhiri *et al.*, 2000) [22] (Chaibou *et al.*, 2020) [31] (Chaibou *et al.*, 2020) [31] (Jazy *et al.*, 2017) [5]
C. Italica	Roots Flowers Whole plant Whole plant Roots Leaves Leaves and whole plant	Belly bloating, colic Splenomegaly Laxative, purgative, rheumatism and urinary infections Constipation, oedema and skin infections Icterus, snake bites and leprosy Hepatobiliary disorders, venereal diseases, those caused by helminths Bellyache, chronic haemorrhoids, typhoid fevers, sickle cell disease,	Macération/décoction/ Infusion à boire et lavement	(Pousset, 1989) [33] (Al-Said 1993) [34] (Al-Yahya *et al.*, 1990) [35] (Ikhiri *et al.*, 2000) [22] (Pousset, 1989) [33] (Jazy *et al.*, 2017) [5]
N. Macrophylla	Roots, bark Barks Barks	Treatment of diarrhoeal diseases, Intestinal parasitosis, Treatment of stomach ache and leprosy	Oral decoction or maceration	(Khalid *et al.*, 1984) [2] (Jazy *et al.*, 2017) [5] (Manzo *et al.*, 2017) [4]
S. Innocua	Barks and/or leaves	Typhoid fever and jaundice	Oral decoction or maceration	(Jazy *et al.*, 2017) [5]
I. Asarifolia	Leaves, stem, whole plant	Typhoid fever, diarrhoea and fungal infections Sickle cell disease, rheumatism, joint pain, skin allergy, hair loss, hemorrhoids and bacterial infections	Oral decoction, infusion or maceration and enema	(Jazy *et al.*, 2017) [5]
X. Americana	Trunk bark Leaves, twig, bark, root, fruit	Treatment of diarrhoeal diseases, bacterial infections Dracunculosis, aches and pains, HTA, gonorrhoea, wounds, haemorrhoids, abdominal pain, indigestion, jaundice Icterus, stomach ache and is indicated as a haemostatic plant	Oral decoction, infusion or maceration and enema	(Manzo *et al.*, 2017) [4] (Khalid *et al.*, 1984) [2] (Jazy *et al.*, 2017) [5]

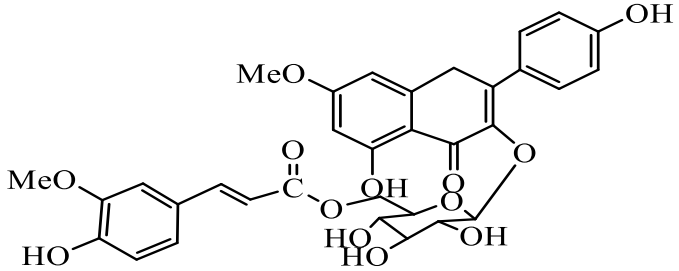
Table 10: Isolated compound

Name	Plant Species	Part	Country of Origin	Références
Cycloartane triterpene (1), (22E)-3-β-hydroxycycloart-22-en-24one, β-sitosterol (2), uvaol (3), daucosterol (4), Me 3,4 dihydroxybenzoate (5), emodin (6), 4-hydroxypheny-O-β-D-glucopyrinoside (7), aloin (8), and rutin (9)	*C. Italica*	Leaves	Saudi Arabia	(Gamal, 2014) [39]
1-p -hydroxy benzoyl-3-palmitoyl glycerol (10), 6 - p -hydroxy ben-zoyl daucosterol (11), scutellarein-6-methyl ether (12), quercetin (13), rutin (14)	*C. Italica*	Partie aérienne	Saudi Arabia	(Rwaida et Mai 2020) [37]
β-sisterol (15), stigmasterol (16), α-amyrin, 1,5-dihydroxy-3-methyl anthraquinone (17), anthraquinone (18)	*C. Italica*	Plante entière	Pakistan	(Kazmi *et al.*, 1994) [41]
Bosenegaloside (19), rhamnocitrin-3-O-β-D-(6"-O-E-p-coumaroyl)-glucopyrinoside (20), rhamnocitrin-3-O-β-D-glucopyrinoside (21), 3,4,5-trimethoxyphenol-β-D-glucopyrinoside (22), lasianthionoside A (23), 3,7-dimethyl-1-octene-3,6,7-triol-6-O-β-D-glucopyranoside (24), syringin (25), austroside B (26)	*B. Senegalensis*	Feuilles	Nigéria	(Morgan *et al.*, 2014) [32]
Liméolide (27), D-pinitol (28)	*L. Pterocarpum*	Plante entière	Niger	(Abdoulaye *et al.*, 2004) [8]
6,7-Dehydro-11-hydroxy-12,13-epoxyterpendole A (29), terpendole K (30), 6,7-dehydroterpendole A (31), 11-hydroxy-12,13-epoxyterpendole K (32), terpendole C (33), paxilline (34) terpendole K (35), terpendole E (36), 11-hydroxy-12,13-epoxy-terpendole K (37), 6,7-dehydroterpendole A(38)	*Ipomea asarifolia* *Ipomea asarifolia*	Graines Graines	Brésil Brézil	(Dale *et al.*, 2018) [57] (Stephen *et al.*, 2017) [56]
cyanogenic	*Ximenia*	Feuilles	Mali	(Le *et al.*,

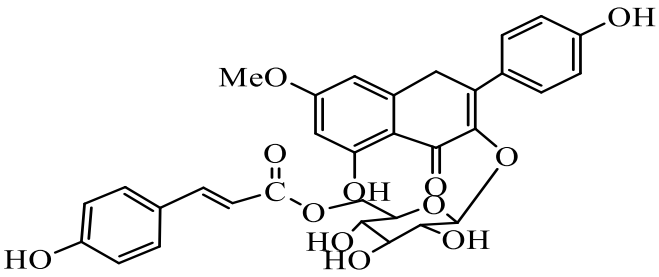
glycoside sambunigrin (39), gallic acid (40), gallo tannins-β-glucogalline (41), 1,6-digalloyl-β-glucopyranose (42), quercetin (43), quercitrin, (quercetin-3-O-α-rhamnopyranoside) (44), avicularin, (quercetin-3-O-α-arabinofuranoside) (45), quercetin-3-O-β-xylopyranoside (46), quercetin-3-O-(6''-galloyl)-β-glucopyranoside (47), kaempferol-3-O-(6''-galloyl)-β-glucopyranoside (48)	*americana*			2012) [68]



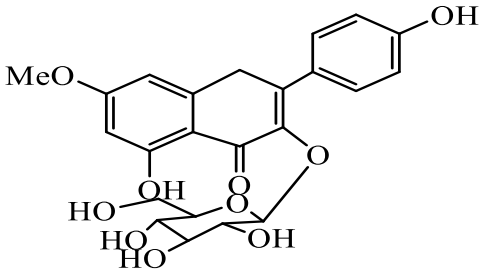
Glucocapparin (I)



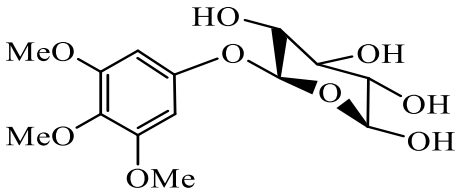
Bosenegaloside A



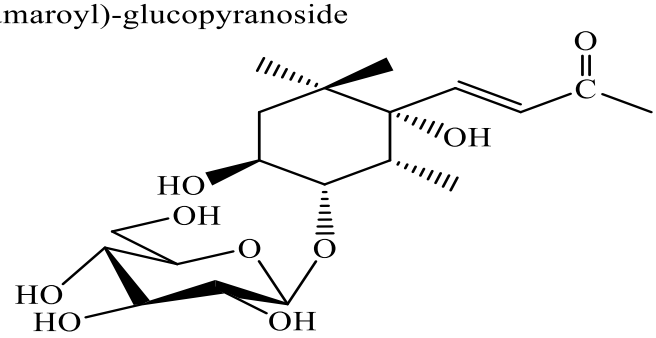
Rhamnocitrin-3-O-ß-D-(6"- O-E-p- coumaroyl)-glucopyranoside



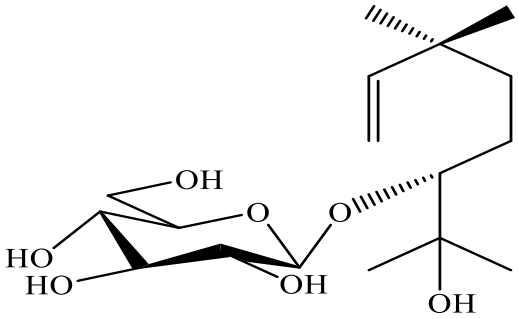
Rhamnocitrin-3- O-ß-D-glucopyranoside



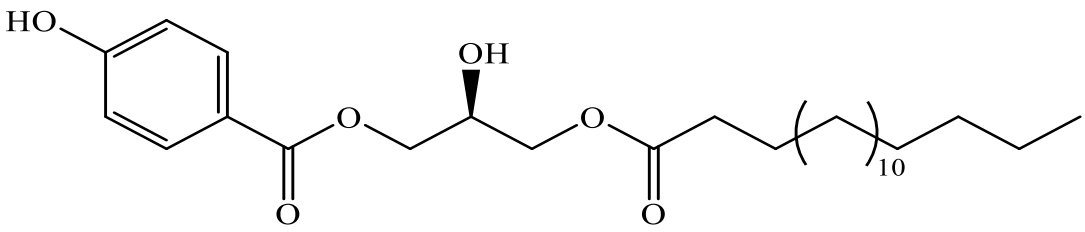
3,4,5-trimethoxyphenol- ß-D-glucopyrinoside



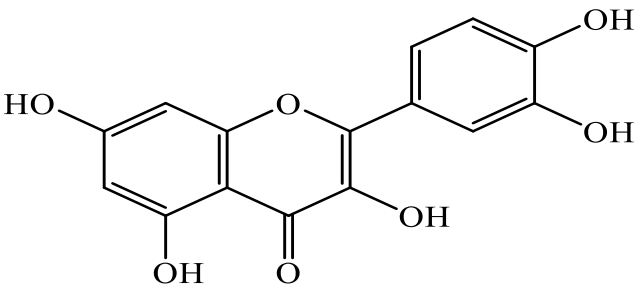
lasianthionoside A



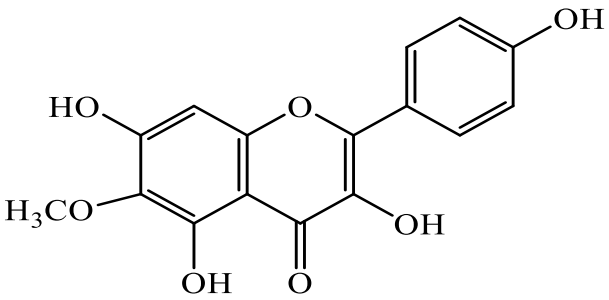
3,7-dimethyl-1-octene-3,6,7-triol-6- O-ß-D-glucopyranoside



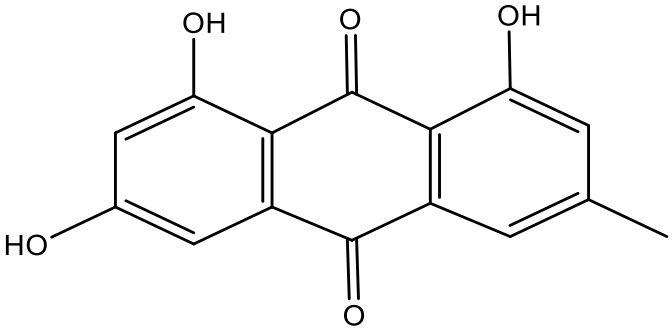
1-p -hydroxybenzoyl-3-palmitoyl glycerol



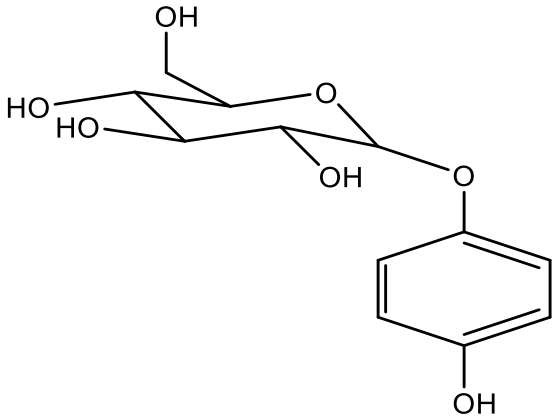
Quercetin



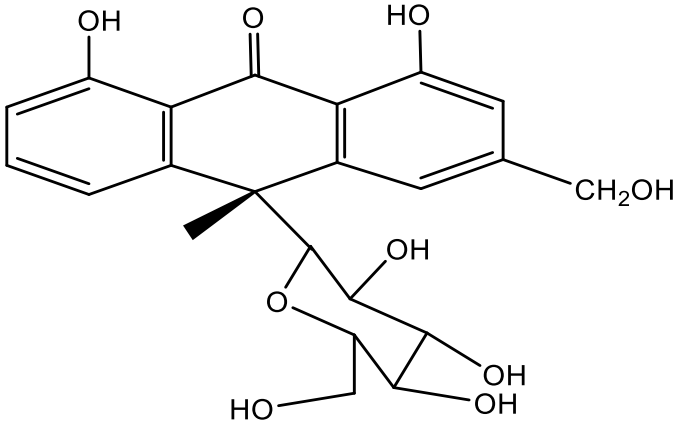
scutellarein-6-methyl ether



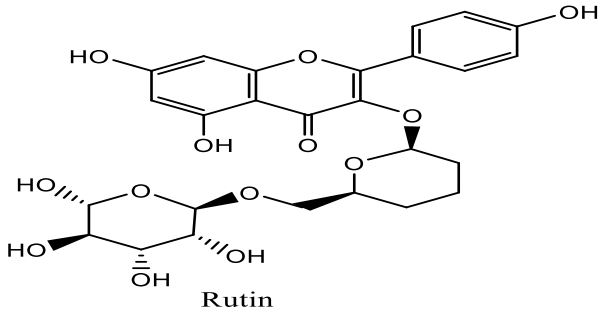
Emodin



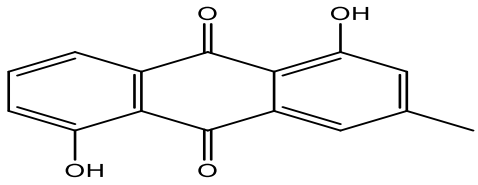
4-hydroxypheny-O- b- D -glucopyranoside



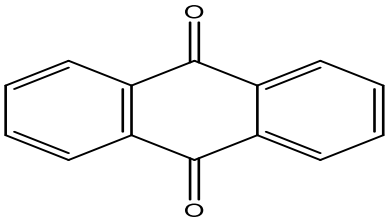
Aloin



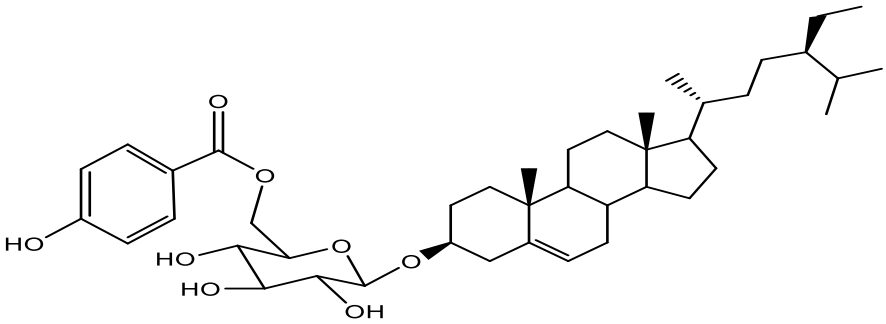
Rutin



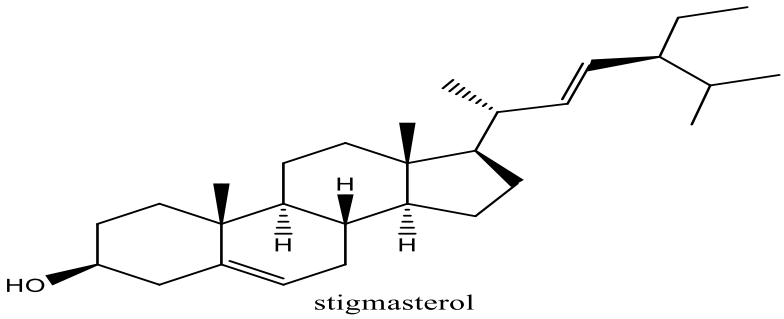
1,5-dihydroxy-3-methyl anthraquinone



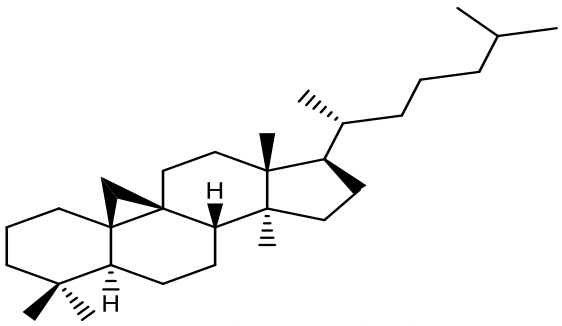
anthraquinone



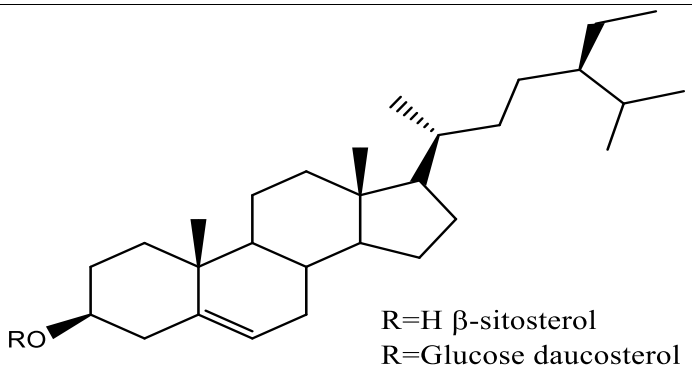
6 - p -hydroxy ben-zoyl daucosterol



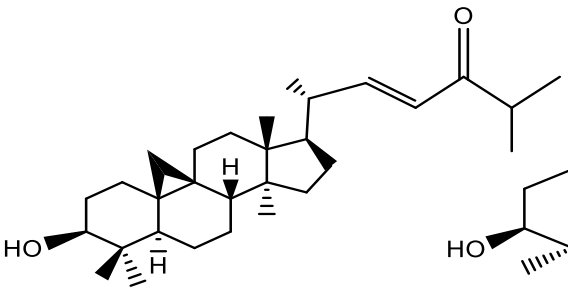
stigmasterol



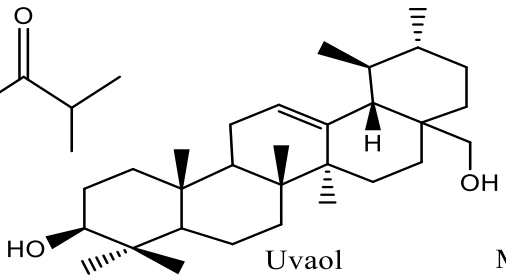
cycloartane triterbene



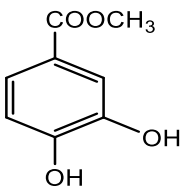
R=H β-sitosterol
R=Glucose daucosterol



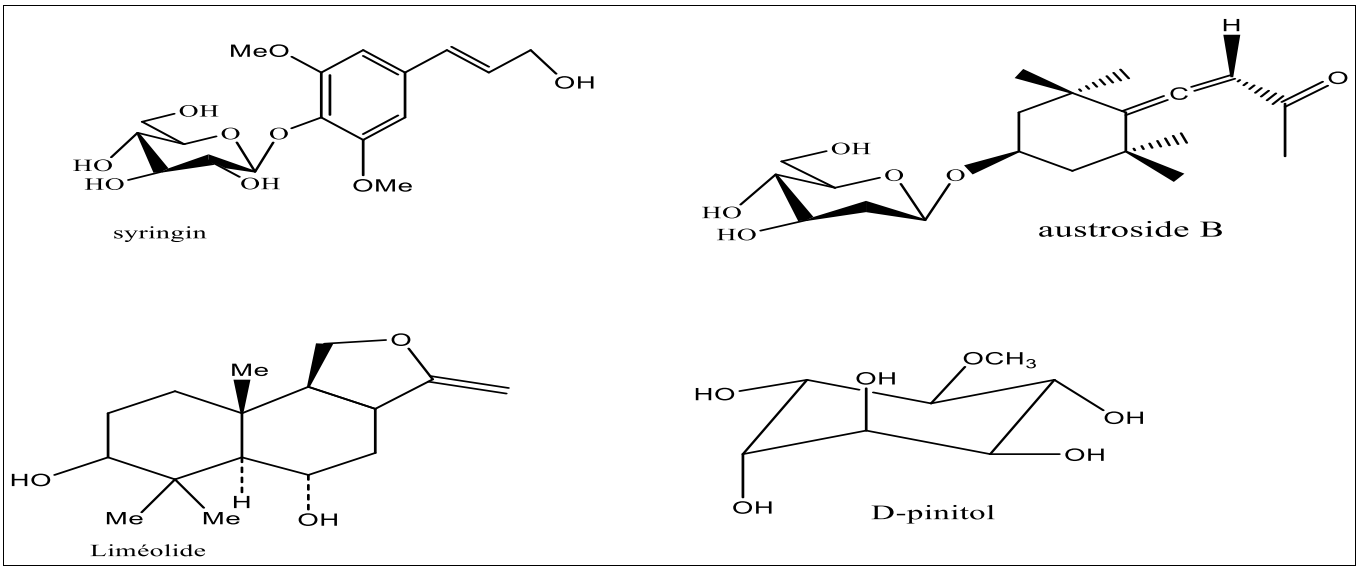
(22 E)-3-β-hydroxycycloart-22-en-24-one

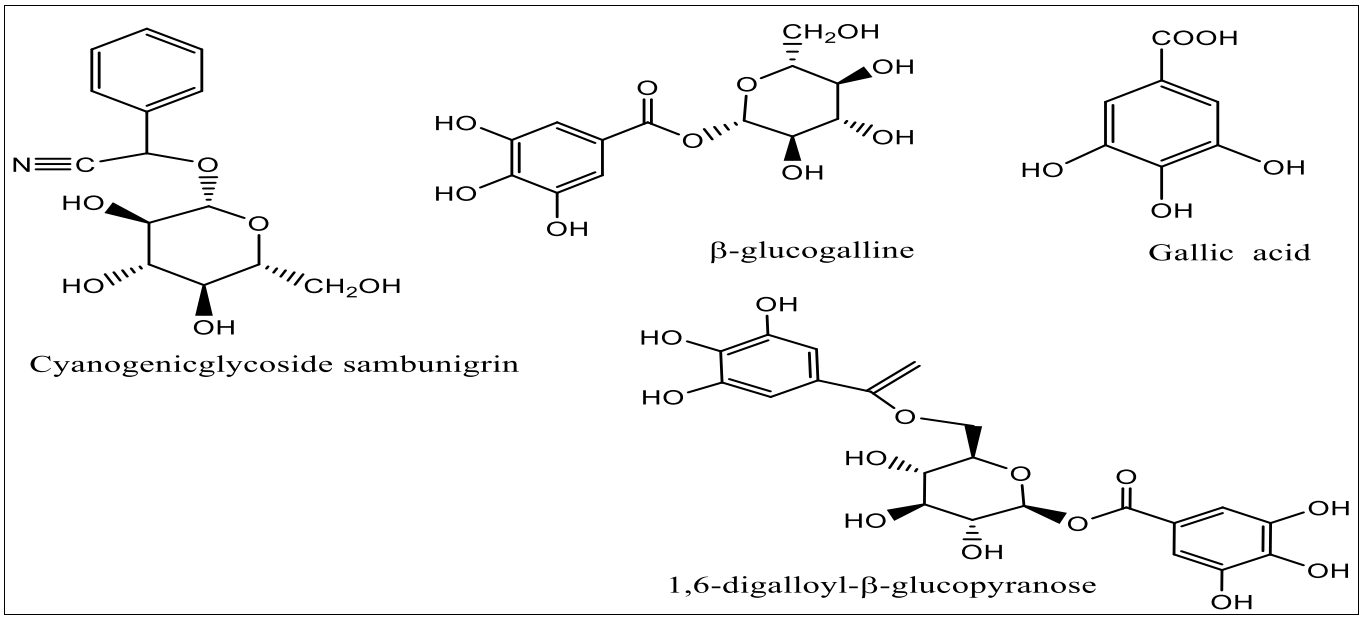


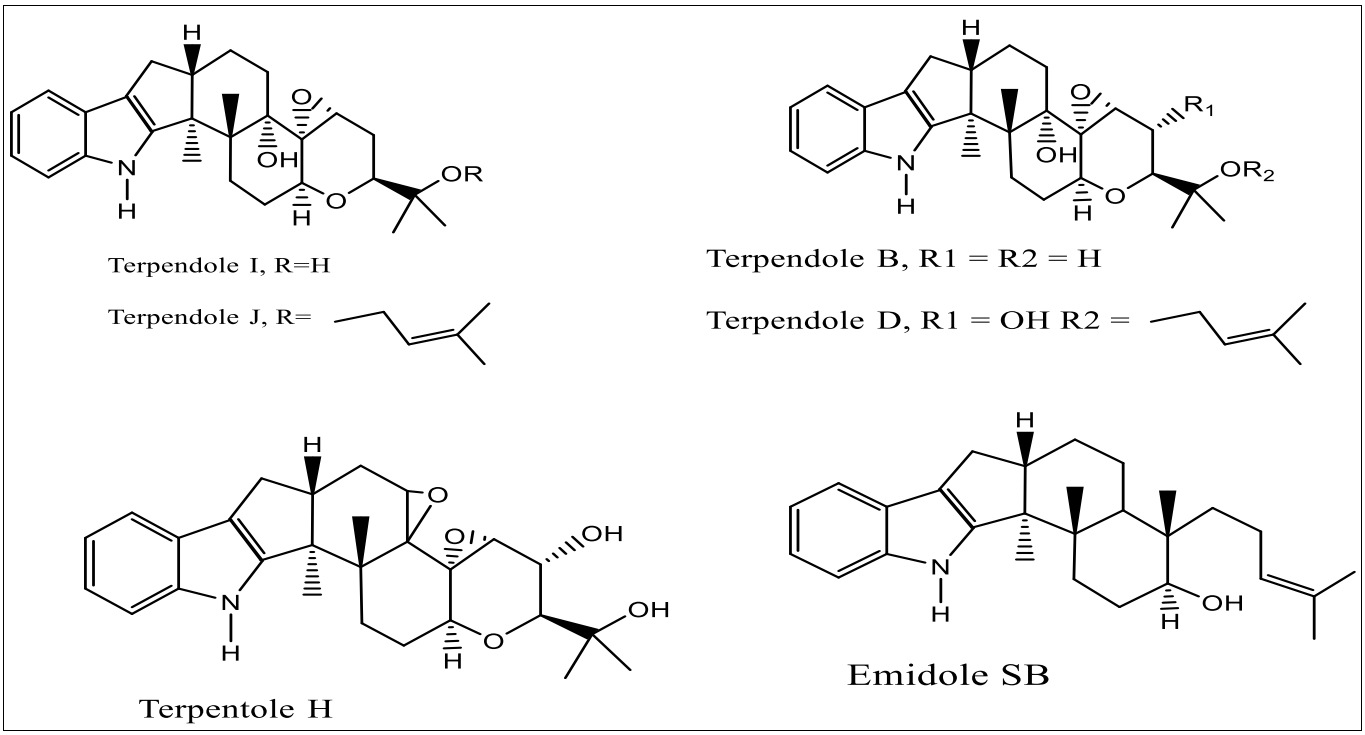
Uvaol

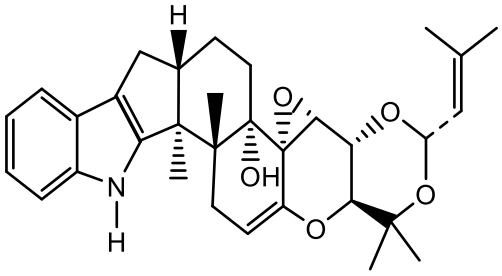


Methyl-3,4-dihydroxybenzoate

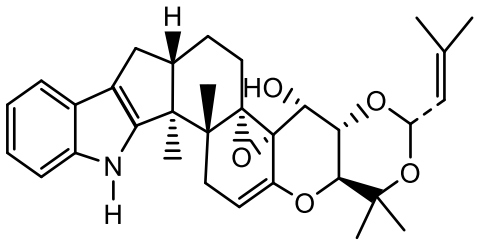

syringin
austroside B
Liméolide
D-pinitol


Cyanogenicglycoside sambunigrin
β-glucogalline
Gallic acid
1,6-digalloyl-β-glucopyranose

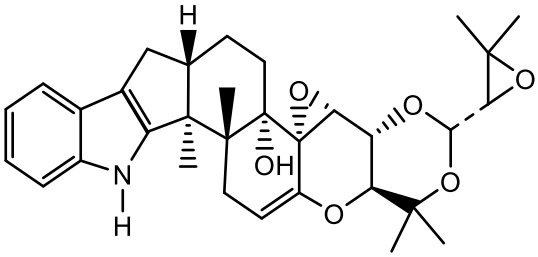

Terpendole I, R=H
Terpendole J, R=
Terpendole B, R1 = R2 = H
Terpendole D, R1 = OH R2 =
Terpentole H
Emidole SB



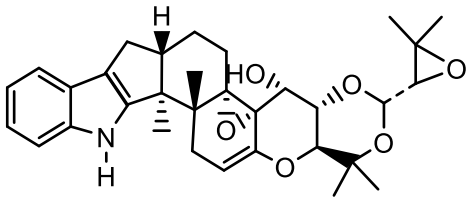
Terpendole K



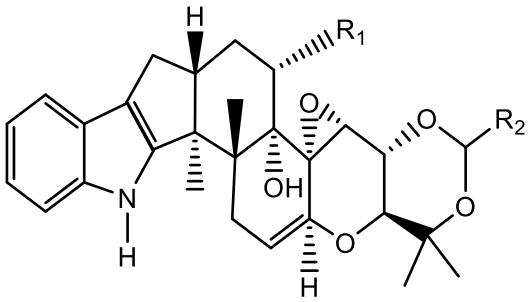
11-hydroxy-12,13-epoxyterpendole



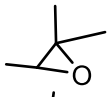
6,7-dehydroterpendole



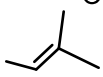
6,7-dehydro-11-hydroxy-12,13-epoxyterpendole



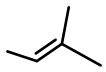
Terpendole C R1=H, R2=

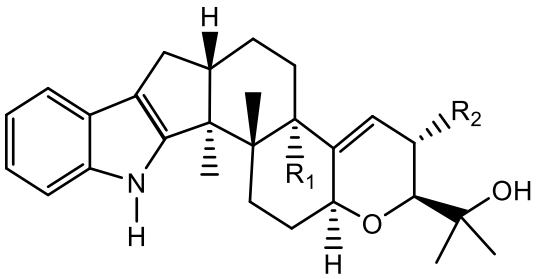


Terpendole A R1=H, R2=

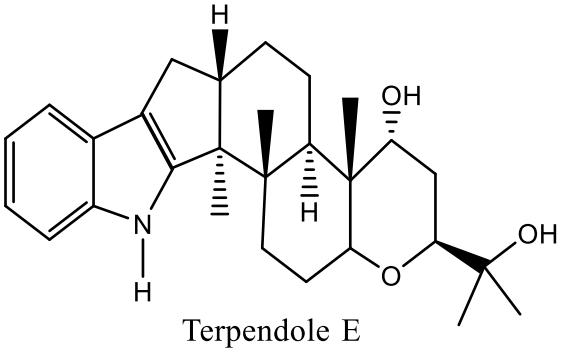


Terpendole M R1=OH, R2=

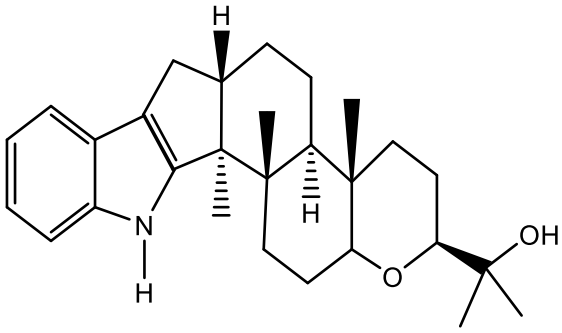




Paxilline R1=OH, R2=O
13-DesoxypaxillineR1=H, R2=O
Paxitriol R1=R2=OH



Terpendole E



Paspaline

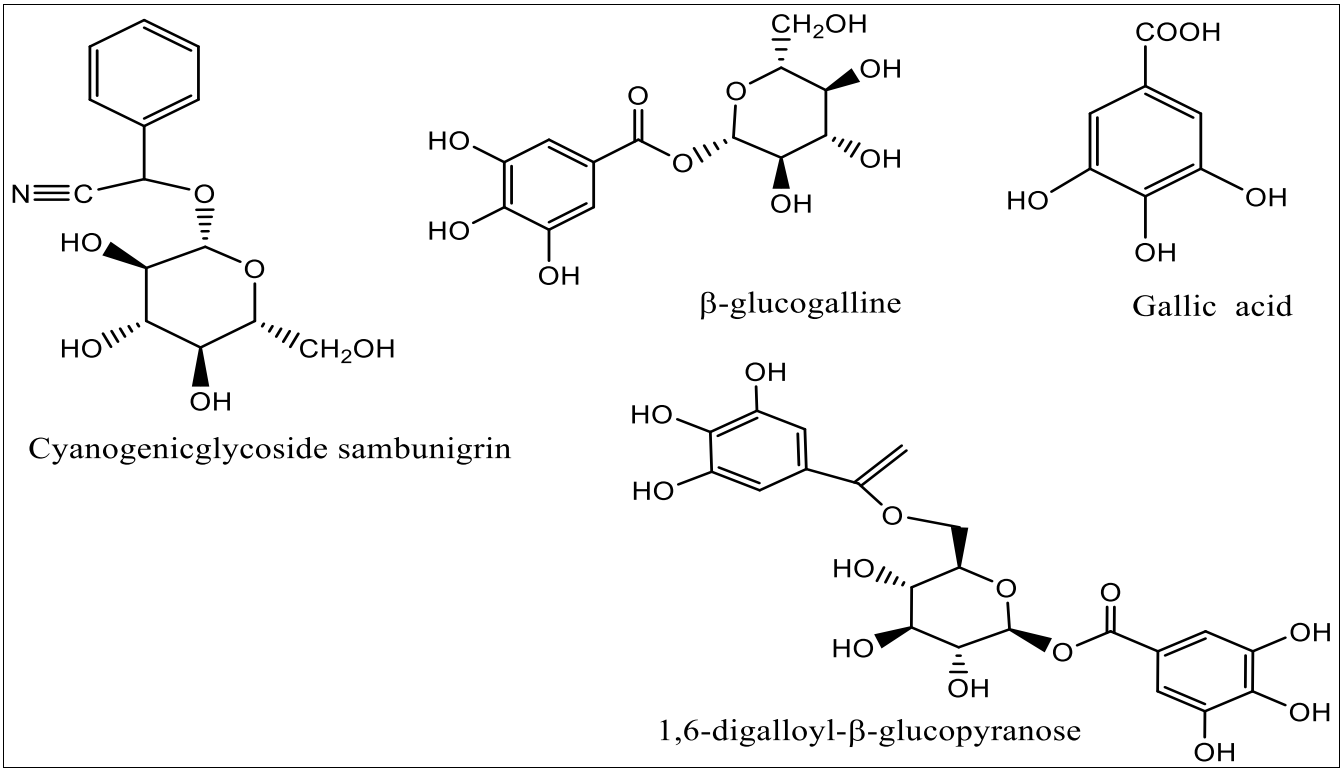


Fig 1: Isolated compounds from some plants

Conclusion

This review provides an overview of the status of 9 medicinal plants widely used in Niger especially in the treatment of infectious diseases based on available published works. Although these plants are widely used, little work has been undertaken to demonstrate the efficacy and safety of these plants and to isolate the pure compounds responsible for their biological activities. Thus to date in Niger there is not yet a phytomedicine based on one of these plants. It should also be noted that the study of the mechanism of action of plants extracts on microorganisms is still at a very preliminary stage. This should be seen as a challenge.

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