Parkia biglobosa (Mimosaceae): Botany, Uses, Phytochemical Properties and Pharmacological Potential

Collen Musara[1,*], Elizabeth Bosede Aladejana[1], Silas M. Mudyiwa[2] and Charles Karavina[3]

[1]*Department of Botany, University of Fort Hare, Private Bag X1314, Alice 5700, South Africa*

[2]*Department of Livestock and Pasture Science, University of Fort Hare, Private Bag X1314, Alice 5700, South Africa*

[3]*Department of Crop Science, Bindura University of Science Education, P Bag 1020, Bindura, Zimbabwe*

Abstract: *Parkia biglobosa* (Jacq.) R. Br. ex G. Don, popularly known as the African locust bean tree, is a perennial tree legume that belongs to Mimosoïdeae sub-family and family of Fabaceae. This study is aimed at reviewing the botany, nutritional uses, phytochemical and pharmacological properties of *P. biglobosa* and the information was undertaken using electronic databases such as Scopus, Google Scholar, Elsevier, Science Direct, Web of Science, Pubmed, SciFinder, BMC and Open-thesis. *Parkia biglobosa* is a very important multipurpose tree that is used essentially for food, medicinal, cultural, economic and magico-therapeutic purposes. Due to its socio-economic and cultural importance, *P. biglobosa* species are vulnerable to unsustainable harvesting and are declining in numbers because they remain semi- or undomesticated in some west Africa countries. Different aqueous and organic extracts of *P. biglobosa* indicate that the species are rich in saponins, tannins, flavonoids, resins, carbohydrates, terpenoids, phenols, sterols, and cardiac glycosides. The nutritional and pharmacological benefits of *P. biglobosa* has been associated with its physicochemical properties. Pharmacological studies on *P. biglobosa* exhibited antimalarial, anti-helminthic, antibacterial, antidiabetic, antihypertensive, anti-inflammatory, analgesic, anti-carcinogenic, anti-trypanosomic activities and antioxidant properties. Threats to the survival of this multipurpose species are also highlighted.

Keywords: African locust bean tree, botany, agroforestry, medicinal, phytochemistry, pharmacology, threats.

INTRODUCTION

Parkia biglobosa (Jacq.) R. Br. ex G. Don, (subfamily *Mimosoideae* and family Fabaceae), also known as the African locust bean tree, monkey cutlass tree or fern tree, is a perennial legume tree that is widespread over the sahelo-Sudanian region [1,2]. It is a multipurpose tree that is native to West and Central African countries such as Senegal, The Gambia, Guinea Bissau, Guinea, Sierra Leone, Mali, Côte d'Ivoire, Burkina Faso, Ghana, Togo, Benin, Niger, Nigeria, Cameroon, Chad, Central African Republic, The Democratic Republic of Congo, Sudan, and Uganda [3,4]. The tree currently exists within a wide range of natural communities, including tropical rainforests and arid zones, but is most abundant where cultivation is semi-permanent [5,6]. It is also present in Australia, South-East Asia, North America and tropical South America as an introduced species [7].

Several benefits of *P. biglobosa* tree have been reported and these include the vital economic role it plays in recycling nutrients from the soil, it's a good source of timber and valuable food source [8]. The seeds are used as a condiment for multiple uses; the husks and pods are good feed for livestock; the floury pulp can be made into a refreshing drink, which contains macronutrient, vitamins A and C, and the bark is also used with lemon for wounds and ulcers [8]. Other traditional and medicinal importance of *P. biglobosa* is discussed in this review.

Apart from these benefits, its wide adaptability, drought resistance and multifunctional usage make it a sustainable source of its by-products. Thus, the present study is undertaken to document the indigenous knowledge and review the botany, nutritive, medicinal uses, ecological use, phytochemical properties and pharmacological potential of the African locust bean tree for scientific purposes.

Research Methodology and Justification of the Study

The literature search was performed from September 2019 to March 2019 and the study is based on a mixed-method review approach, which includes combining quantitative and qualitative research. A systematic and comprehensive literature search was conducted using electronic scientific journals articles, books, and theses. The databases and literature sources were chosen based on the topic covered and the main search key terms included "*Parkia biglobosa*",

Address correspondence to this author at the Department of Botany, University of Fort Hare, Private Bag X1314, Alice 5700, South Africa;
E-mail: collinmusara@gmail.com

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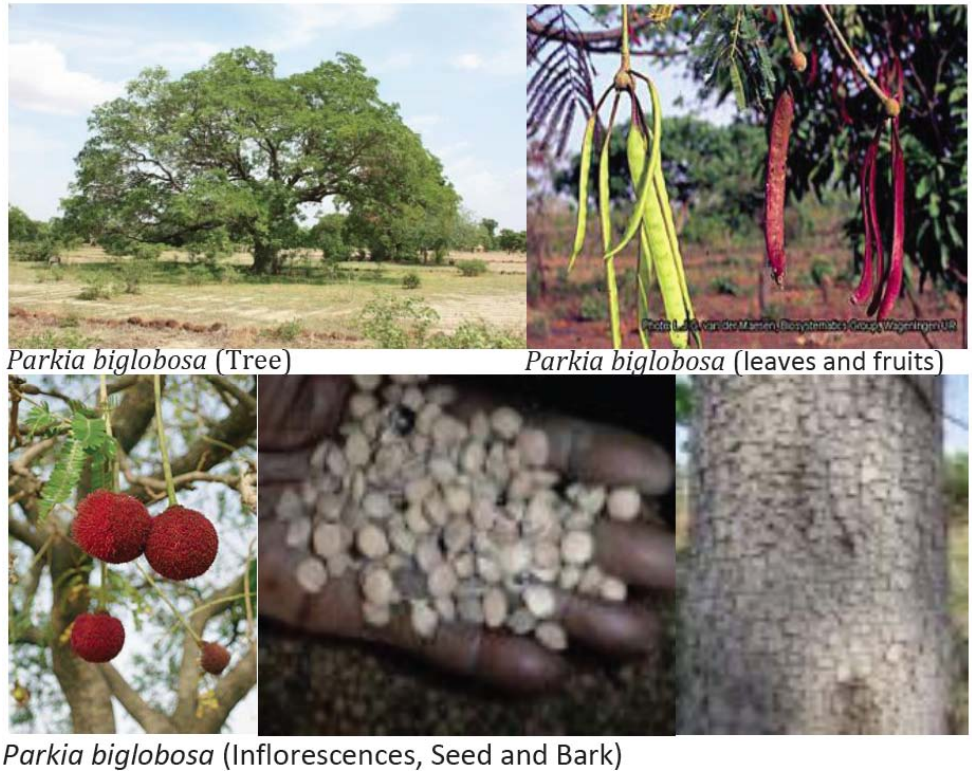

Figure 1: Parkia biglobosa (Tree).

Source: Tropical Plants Database, [9].

"botany", "phytochemical properties" and "pharmacological potential". Search terms were set to be in the title, keywords and abstract. To avoid too much filtering of literature, the search terms were done individually. The review has a particular focus on sub-Saharan Africa; however, the literature and case studies from outside South Africa were obtained and also used in the review. Previous research by [10-13] and Builders *et al*. [14] emphasized the importance of *Parkia biglobosa* as a very important multipurpose tree that is used essentially for food, medicinal, cultural, economic and magico-therapeutic purposes hence it is treated as priority plant resources for the future benefit of local communities in southern Africa and the world at large. It is within this context that the current study was undertaken aimed at reviewing the botany, uses, phytochemical properties and pharmacological potential of the African locust bean tree.

Botany of the African Locust Bean Tree

The African locust bean plant is a dicotyledonous angiosperm that is characterized under spermatophytes, vascular plants [15,16]. It is a woody perennial deciduous tree reaching up to 30 m in height [17]. It has a straight robust bole with a dense, wide spreading, umbrella-shaped crown, often branching low, and thick dark grey brown bark, fissured, and, exuding an amber gum [18]. The leaves are alternate, dark green, bipinnate and about 8 - 30mm x 1.5 - 8mm in size with about 13-60 pairs of leaflets of distinct venation on a long rachis [19,20]. The pinnae of *P. biglobosa* are about 10 - 26 pairs and the leaflets occur in 14 - 30 pairs [21], 8-30 mm x 1.5-8 mm in size, of distinctive shape and venation [18]. Leaflets are held on a long rachis and inflorescence is a pendulous head arranged racemosely [18]. The fruit is a linear-oblong pod, pink brown to dark brown when mature, about 400 mm long and 20 mm wide, which may contain up to 20 seeds embedded in a yellow pericarp [17]. Seeds are brown, smooth, large (mean weight of 0.26 g/seed), have a hard and thick testa, and large cotyledons forming about 70 % of their weight [18]. The tough testa protects seeds from the natural conditions of the savanna: extreme heat, low moisture, drought, and digestive juices of ruminants and primates [22]. The tree can grow in disturbed and open places, grassland and in rocky areas [23]. Figure **1** shows different components of the African locust bean tree (ALBT).

Importance of the African locust bean tree/plant

Parkia biglobosa is a multipurpose tree used essentially for food, medicinal, cultural, economic and magico-therapeutic purposes [10].

Table 1: Nutritional and Anti-Nutritional Composition of *Parkia biglobosa* Fruit Pulp

Proximate Analysis		Antinutritional Factors/Toxins	
Chemical component	**Composition (%)**	**Anti-nutritional factor**	**Composition (mg/100g)**
Protein	6.56	Phytic acid	60.00
Moisture content	8.41	Crude saponins	17.80
Fat	1.80	Tannins	81.00
Crude fibre	11.75	Total phenols	204.60
Ash	4.18	Hydrocyanic acid (HCN)	17.30
Carbohydrate	67.30		

Source: Gernah *et al*. [13].

Nutritional and Traditional Uses

The most significant product from the African locust bean tree is food; and the tree's food products are vital due to their seasonality of maturation and availability [11]. During periods of food shortage and drought, it contributes to household food security, income and poverty reduction [2,24]. The food products derived from this tree are rich in protein and some beneficial health components [12,13]. Fruit pulp and seeds are rich in sucrose, carbohydrates, lipids, protein and amino acids, with a high concentration of glutamic acid [21,25]. An analysis of the nutritional and anti-nutritional components of *P. biglobosa* fruit pulp made by Gernah *et al*., [13] is shown in Table **1**.

Fermented seeds of *P. biglobosa* are used throughout the savannah regions of sub-Saharan Africa for seasoning traditional soups [21]. In Nigeria, the fermented seeds (commonly called Irú) are processed and sold either fresh or dried, serving as a nutritious spice or condiment in cooking [26]. They may be used as ingredients in the preparation of various stews, soups and sauces for the consumption of cereals. They can also be pressed into cakes, or fermented into an alcoholic beverage [13]. The roasted seeds are used as a coffee substitute known as 'Sudan coffee' or 'café nègre'. The ground seeds are mixed with moringa (*Moringa oleifera* Lam.) leaves to prepare a sauce or to make doughnuts [23]. The leaves are boiled and eaten as a vegetable together with cereal flour meal, while young flower buds are used in the preparation of salads [23]. The leaves, with low phosphorus, magnesium and sodium content, are used as fodder [11, 23]. Pods, fruit pulp and even young seedlings can be used to feed pigs, goats, sheep, cattle and ducks [16].

Timber and Ecological Uses

The tree is used for timber, handcraft and firewood [10]. It plays key roles in the functioning of agro-ecological landscapes, delivering essential goods and many ecosystem services that sustain smallholder farmers and pastoralist livelihoods [27,28]. The tree remains green throughout the dry season, thus providing shade to both animals and people. Its branches are lopped and the not-so-palatable leaves with low phosphorus, magnesium and sodium content are used as fodder [16, 18,23].

The African locust bean tree generates many non-timber forest products [29]. For example, it produces abundant pollen and nectar for beekeepers [30]. It has a great potential to store carbon [27] and so can be used in microclimate amelioration [16]. It provides ecological services including soil fertility improvement by leaf fall [17,31] and is a useful windbreak and shade tree. Its root distribution is complementary and non-competitive with traditional local crops hence it can be intercropped with several crops (e.g. cassava, maize, sorghum and millet) to enrich physico-chemical soil characteristics, which in turn help to increase crop yields [10,18].

Traditional Uses

Parkia biglobosa is often traditionally used in ceremonies connected with virility, pregnancy, birth, circumcision, marriage, funeral, fetishism, and spiritual protection [16]. The fruit pulp can be used to purify water [18]. Pods are used as sponges [17] and roots as strings for musical instruments [23]. The mucilage from part of the fruit is made into a fluid and used for hardening earth floors [18]. Boiled pods are used by potters to dye pottery and give it a black glaze and the ash is applied as a caustic [23]. Husks of pods are mixed with indigo to improve the lustre of dye products [32]. Seeds and bark contain tannin, and the bark is used in tanning. Nonetheless, the resulting leather is often of moderate quality especially with regard to colour, which is often reddish, uneven, and darkens when exposed to light [23].

Table 2: Medicinal uses of *P. biglobosa*

Plant part used	Medicinal use/Therapeutic indication	Medicinal preparation (and administration mode)	Country	References
All parts	Treatment of diarrhoea, dysentery, abdominal pain, diseases of the cardiovascular system, injuries and burns, shingles, malaria, abscesses, yellow fever, scabies, measles, chicken-pox, oedema, jaundice, cough, pain, fungal infection, toothache, diabetes, skin infection, snake bite, paediatric pathologies, symptoms and syndromes: malaise, tiredness, headaches, hip pain, ache, rheumatism, elephantiasis, onset of paralysis,	Stem bark, leaves, fruits, pulp, seeds are ground, soaked in local gin and taken orally decoction, maceration, filtration, powder, boiled pulp.	Nigeria; Senegal, Ivory Coast; Burkina Faso; Mali; Benin	[10] [48] [49]
Stem bark	Cardio-protection	Maceration	Togo	[50]
	Personal health (Hypertension, hepatitis, wounds), insect management	Not reported	Mali	[51]
	Malaria, wounds, dysentery, rheumatism, headache, cough, pain, fungal infection, tonic, anti-diarrhoea, female sterility, skin infection, leprosy, blennorrhoea, *Schistosoma* infection, sores, ulcers, mumps, enema, antiemetic, severe colic and snake bites.	Decoction, powder	Nigeria, Senegal, Ivory Coast, Burkina Faso, Mali.	[52]
	Trypanosomiasis	maceration	Nigeria (south west)	[53]
	Wound, antiseptic, disinfectant, cicatrizing	Infusion (oral)	Togo	[54]
	Diarrhoea	Maceration	Nigeria	[55]
	Hypertension	Not reported	Nigeria (South East)	[56]
Bark	Toothache	Fumigation	Burkina Faso	[57]
	Toothache, diarrhoea, ear complaints, mouthwash	Gum extract	Not reported	[25]
	Diarrhoea and veneral diseases	Not reported	Nigeria	[58]
	Leprosy, skin infections, sores, ulcers, bronchitis, pneumonia, colic	Macerated in bath	Not reported	[25]
	Schistosomiasis, rheumatism, circumcision wounds, general wounds	Decoction	Not reported	[11]
	Gastric and duodenal ulcer	Powder, maceration (oral)	Togo	[59]
	Depurative, diuretic	Maceration (oral)	Benin	[60]
Bark + fruit pulp	High blood pressure, yellow fever, constipation	Decoction, powder Bark and fruit are soaked and drunk (oral)	Mali	[61]
Bark + leaves + fruits	Snake bite, animal placenta retention, anthelmintic	Not reported	Burkina Faso	[62]
Stem bark + leaves	Wounds, pain, fungal infection	Decoction of bark in water (bath and/or to drink) The powder is usually dissolved in water (bath and/or to drink) or is thrown into fire (inhalation)	Burkina Faso	[63]
Leaves	Abscess	Grinding (local application)	Benin	[60]
	Liver diseases, hepatic deficiency	Decoction (oral, bath)	Ivory Coast	[64]
	Inflammations	Not reported	Nigeria (North)	[65]
	Stroke, leprosy, skin lesion, eye infections	Not reported	Nigeria	[66]
	Sore eyes, burns	Lotion preparation	Not reported	[11]
	Malaria, pain, diabetes, palpitation eye lotion, toothache, burns, fever, haemorrhoids, constipation, anorexia, bronchitis, whooping cough, amenorrhoea, snake bites.	Decoction, poultices	Nigeria,Senegal, Niger, Gambia, Mali, Togo, Burkina Faso	[52]

(Table 2). Continued.

Plant part used	Medicinal use/Therapeutic indication	Medicinal preparation (and administration mode)	Country	References
Leaves + bark	Tonic, malaria, diabetes and dysentery	Decoction	Nigeria	[67]
Leaves+ stem bark + fruit	Malaria, urinary tract infection and internal wounds of pregnant women	Decoction	Mali	[68]
Leaves + stem bark + raw fruit + seed (fermented)	Treatment of malaria, stomach ache	Decoction	Ghana	[69]
Leaves + pods + stem bark	Wounds	Powder, decoction (local application)	Burkina Faso, Mali	[70,71]
Pulp	Sedative, diuretic, purgative, malaria	Not recorded	Guinea Conakry	[52]
Seed	Whitlow	Fermentation(local application) infusion	Cameroun	[72]
	Tension, wounds, mouth ulcers, wasp and bee sting	Not recorded	Nigeria, Mali	[52]
	Tension, mouth ulcers, skin infections, wasp and bee sting	Pounded with salt, fermented decoction	Not reported	[11]
	Diabetes	Consumption in sauce (oral)	Nigeria	[58]
Seed/fruit	Veterinary use, treatment of hypertension	Not reported	Nigeria	[66]
	Hypertension	Not reported	Burkina Faso	[73]
Seed (Fermented)	Hypertension	Infusion (oral)	Togo	[54]
Seed + leaves	Anthelmintic	Powder	Nigeria	[74]
Roots	Haemorrhoids, coal disease	Decoction in salty water (oral)	Togo	[75]
	Bronchitis, pneumonia, dysentery, diarrhoea	Decoction	Senegal	[52]
	Diarrhoea, dysentery, eye infections, Guinea worm	Decoction	Not reported	[11]
	Fever, malaria	Not reported	Nigeria	[76]
	Hypertension, infertility, stomach ache, sore eye, anti-poison, skin diseases	Not reported	Nigeria	[66]
Roots + stem bark	Haemorrhoids	Powder, decoction	Togo	[75]
	Diarrhoea, general weakness, abdominal pains	Powder, decoction (oral)	Benin	[77]
Root bark + stem bark + leaves	Digestive, nervous, cutaneous and pregnancy-birth disorders, infection	Decoction, calcinations, trituration and maceration (oral, bath application)	Burkina Faso	[78]
Fruits + bark + leaves	Constipation, anorexia, rickets, icterus, Mumps, Haemorrhoid, ascariasis, Burns	powder, maceration Fruits flour (oral); gargle, inhalation, fumigation of bark; maceration of fresh leaves, roast the young leaves (local application)	Ivory coast,	[79]
Fruits	Skin eruption, abscess, stomach ache, yellow fever, conjunctivitis, snake bites.	Maceration	Ghana, Benin, Mali	[52]
Flowers/flower bud	Hypertension, lumbago, leprosy prophylactic	Grilled and macerated infusion	Not reported	[11]
Pods	Stomach ache	Pounded with salt, fermented	Ghana	[52]
Root or stem	Weight loss	Decoction	Burkina Faso	[80]
Bark and seeds	Appetite suppression	Decoction	Burkina Faso	[80]

Medicinal Uses

Parkia biglobosa has many medicinal uses in Africa [33] as shown in Table **2**. It provides an ingredient that is used in treating leprosy and hypertension [34]. It has been identified as one of the candidates with promising therapeutic potential in the prevention, treatment, and management of a number of metabolic diseases including diabetes mellitus [34]. According to Tokoudagba *et al*. [35], *P. biglobosa* leaf extracts induce redox-sensitive endothelium-dependent relaxations in porcine coronary artery rings thereby acting as an antihypertensive agent.

The leaves are used in lotions for sore eyes, burns, haemorrhoids and toothache [33,36]. A decoction of the leaves, bark and roots are used in treating leprosy, eye sores, toothache, fever, hypertension, wounds and ulcers [17,37]. In some parts of West Africa, bark infusion is used as an analeptic for diarrhoea and as an enema [38], whilst pulped bark is mixed with lemon to treat wounds and ulcers [39]. The bark is also used as a mouthwash, vapour inhalant for toothache or ear complaints, while the plant is macerated in baths to treat leprosy, bronchitis, pneumonia, diarrhoea [21], skin infections, sores, ulcers, bilharzia, fever, malaria, diarrhoea, violent colic and vomiting, sterility, venereal diseases, guinea worm, oedema and rickets [40]. The seed is taken for tension, and pulp for fevers, as a diuretic and as a mild purgative [18]. In Nigeria, the plant is used to treat snakebites [41].

Seed extracts of raw *P. biglobosa* exhibited termiticidal properties attributed to the presence of some heavy metals as well as the interacting polar organic compounds in the raw seed extracts [42]. In veterinary medicine, the pulp is frequently used for treating trypanosomes and mouth ulcers of ruminant livestock [43]. In poultry, a root decoction is used to treat coccidiosis; the leaves are used against poultry lice and the flowers and seeds are used to treat Newcastle disease [43]. Table **2** summarises the medicinal uses of the *P biglobosa* in different countries.

Though *Parkia biglobosa* is non-toxic to humans, it has been reported to have piscicidal properties [14,44-46] attributed to its phytochemical constituents including alkaloids, tannins and flavonoids [47]. Green pods are usually crushed and added to rivers to kill fish. Nonetheless, the nutritional value of the fish is not adversely affected as long as the fish are cooked or dried [21]. The pulp is also used against cockroaches and the parasitic weed striga, *Striga hermonthica* [16].

Phytochemistry of *Parkia biglobosa*

Several studies have shown that the African locust bean plant parts are rich in various phytochemicals. According to Femi-Ola *et al.* [81], Alinde *et al*. [48] and Bawa-Allah and Akinnouye, [45], multiple phytochemicals are present in the bark, leaves and roots of the plant. These secondary metabolites include saponins (which provide cardioprotective effects in the experimental model), tannins (reduce serum cholesterol and triglycerides), flavonoids, resins, carbohydrates, terpenoids (known to display antioxidant, anti-hypercholesterolemic and cardioprotective activities), phenols, sterols, isoquinoline alkaloids, indole alkaloids, reducing sugars and cardiac glycosides (act as cardiotonic agent). In addition, coumarins, anthocyanins and anthracenosides are present in the stem bark and leaf of this plant [1]. Also present are mineral elements, such as magnesium, calcium, iron, zinc, potassium, sodium and copper [82]. Long-chain ester of trans-ferulic acid, a mixture of long-chain cisferulates and different kinds of catechins, have been identified in the stem bark of *P. biglobosa* [83]. The coumarin derivatives in leaf extracts have anticoagulant activity while the aglycone flavonoids in the leaves have spasmolytic activity on smooth muscles, and also vasodilatory and antiseptic effects [48].

Bello *et al*. [84] have reported that the yellowish fruit pulp of *P. biglobosa* contained carbohydrate (60 %), 10-20% of which is sucrose, and 291 mg Vitamin C. Also, the seeds contain proteins (35 %), lipids (29 %), carbohydrates (16 %), calcium and have good organoleptic properties [85]. In the study of Alabi *et al*. [86], the proximate analysis of the nutritive contents of *P.biglobosa* seeds indicated the presence of high amount of lipid, carbohydrates, crude protein, total soluble sugar, pureprotein and starch.

Pharmacological Potential of *Parkia biglobosa*

Different aqueous and organic extracts of *P. biglobosa* exhibit antimalarial, anti-helminthic, antibacterial, antidiabetic, antihypertensive, anti-inflammatory, analgesic, anti-carcinogenic, anti-trypanosomic activities and antioxidant properties as shown in Table **3** [14,35,52,53,87,88]. Adi *et al*. [50] have reported that the stem bark hydro-alcoholic extract (HAE) of *P. biglobosa* had cardioprotective effects against isoproterenol (ISO) induced myocardial infarction (MI). Thus, *P. biglobosa* ameliorated positively biochemical alterations, prevented oxidative stress and histological and morphological changes

Table 3: Pharmacological Properties of *P. biglobosa* [37]

Biological Activity	Part Tested	Bioassay Models	Results	Reference
Antimicrobial activities	Ethyl acetate, ethanol and water extracts of leaves	The agar cup diffusion and dilution method	The extracts exhibited a concentration-dependent antibacterial, inhibiting the growth of *S. aureus, B. cereus, E. coli, P. aeruginosa, A. niger and C. utilis*	[87]
	Methanolic extract and aqueous fractions of the leaf, stem bark and root	Agar well diffusion method	*S. aureus, B. subtilis, E. coli, P. aeruginosa* were inhibited by the extracts and their aqueous fractions at concentrations between 2.5-20 mg.	[35]
Antibacterial	Methanolic extract and aqueous fractions of the leaf, stem bark and root	Agar well diffusion method	The extracts and their fractions were tested against two Gram-positive organisms; *Staphylococcus aureus* and *Bacillus subtilis* and two Gram negative organisms; *Escherichia coli* and *Pseudomonas aeruginosa*. Results obtained confirmed a broad spectrum of activity as all the organisms used were inhibited by the extracts and their aqueous fractions.	[97]
	Ethanolic extract of the stem bark	Agar well diffusion method	The extract had a concentration-dependent antimicrobial effect on *Pseudomonas aeruginosa*, *Escherichia coli*, *Klebsiella pnuemoniae*, *Proteus mirabilis*, *Aspergillus flavus* and *Aspergillus fumigatus.*	[98]
Antihypertensive	Aqueous extract of bark of trunk	Ludwig manometer principle	The extracts decreased the rabbit blood pressure in a dose-depend manner and the effect was similar to that produced by propranolol	[99]
	Fermented seeds	Clinical, biochemical and anthropometrical, analyses in two types of people (consumption or no consumption of seeds condiment)	Significantly decreased blood pressure and heart beat was detected in the group where the condiment is highly consumed when compared to the non-consumption group	[100]
	An alcoholic extract of crude seeds of *P. biglobosa*		An alcoholic extract of crude seeds of *P. biglobosa* showed anti-hypertensive activity and contractile effect on smooth muscles of the intestine, and increased the tonus and mobility of the uterus. Ichthyotoxic and molluscicidal activities have been recorded for the seeds due to the presence of saponins.	[5]
Anti-diarrhoeal	Aqueous stem bark extract of *P. biglobosa*	Aqueous stem bark extract of *P. biglobosa* and its fractions designated PF1 PF4 investigated in mice	Anti-diarrhoeal activities of the aqueous stem bark extract of *P. biglobosa* and its fractions designated PF1 PF4 were investigated in Mice, were indicated that the extract and its column chromatographic fraction F3 significantly ($p < 0.05$) and dose-dependently reduced the frequency of stooling in castor-oil induced diarrhoea, castor-oil-induced intestinal fluid accumulation and intestinal transit.	[101]
Anthelmintic effect	Aqueous extracts of seeds and leaves	Egg hatch assay	Produced a high hatching egg inhibition against *Haemonchus, Trichostrongylus, Oesophagostomum* and *Bunostomum* species.	[102]
	Aqueous and methanol extracts of both leaves and seeds	*In vitro* study using adult and infective larvae stage of *H. contortus*	The aqueous and methanol extracts of leaves and seed of *P. biglobosa* have higher adulticidal activity for 12 hours post exposure but lower larvicidal activity against *H. contortus*.	[103]

(Table 3). Continued.

Biological Activity	Part Tested	Bioassay Models	Results	Reference
Antimicrobial Activities	Aqueous extract of leaves	WHO method test (Mark III) *in vitro* micro	There was a dose dependent inhibition of parasitemia in the *in vivo* tests, with maximum effect at 600 mg/kg and *in vitro* a weak and concentration-dependent activity against *P. falciparum*	[104]
	bark ethanolic and ethyl acetate extracts and leaves ethyl acetate	*In vitro* antibacterial assay using disc diffusion method	The bark ethanolic and ethyl acetate extracts and the leaves ethyl acetate showed activity against *S. epidermidis, P. vulgaris, S. oralis* and *S. aureus*	[105]
Analgesic and anti inflammatory activities.	Hexane fraction of bark	The abdominal writhing test in mice and the hot-plate method	The extract has a marked analgesic activity when evaluated with the abdominal writhing test in mice, but, like paracetamol, was ineffective with the hot-plate method.	[106]
	Methanolic extracts of the stalk		Methanolic extracts of *P.biglobosa* stalk significantly antagonized the formation of croton pellet granuloma in a dose-dependent manner. The extract also showed a dose-dependent inhibition of the croton oil ear inflammation in test animals, there was also appreciable inhibition of carrageenin-induced rat paw oedema compared with controls. The extracts of *P.biglobosa* further inhibited the arachidonic acid induced paw oedema in a dose-dependent manner comparable to the dual blocker, phenidone. Thus, suggesting that the observed anti-inflammatory activities may be produced by the inhibition of the lipo-oxygenase pathways, the cyclooxygenase pathways or both, which are involved in metabolism of arachidonic acid .	[107]
Anti-diabetic activity	Aqueous and methanolic extracts of fermented seeds	Determination of fasting plasma glucose, total cholesterol, triglyceride, high density lipoprotein and low density lipoprotein	Extracts exert a hypoglycaemic effect and ameliorated the loss of bodyweight usually associated with diabetes.	[108]
Antiplasmodial	Methanol extract and methanol fraction of the stem bark	The antiplasmodial activity of the leaves of *P. biglobosa* was evaluated *in vivo* and *in vitro* against *Plasmodium berghei* and clinical isolates of *Plasmodium falciparum,* respectively.	The crude extract and methanol fraction exhibited dose dependent reduction of parasitaemia at the different doses administered. Methanol fraction showed higher reduction of parasitaemia.	[82]
Antioxidant	Methanol extract and methanol fraction of the leaves and stem barks	1,1diphenyl-2-picrylhydrazyl (DPPH) assay	The result of the antioxidant activities of the methanol extract and methanol fraction indicated that the sensitivity of the antioxidant activity of the methanol fraction is higher than that of crude un-fractionated methanol extract. Study on the antioxidant properties of the stem bark of *P.biglobosa* showed that the radical- scavenging potential of *P.biglobosa* was dose-dependent; this activity was higher than that of standards (rutin, ascorbic acid, butylated hydro-anisole (BHA) and alphatocopherol). The stalk of *P. biglobosa* also showed *in vitro* anti-oxidant activities using the DPPH.	[14,21,107,109]

(Table 3). Continued.

Biological Activity	Part Tested	Bioassay Models	Results	Reference
Hypolipidemia	Methanolic extract and aqueous fractions of the leaf.	The hypolipidemic effect and the improvement in serum lipid profile of triton-induced hyperlipidemic rats by *Parkia biglobosa* saponins were investigated.	The result indicated that *P. biglobosa*-mediated therapeutic effects may be associated with its hypolipidemic components.	[20]
Antidiabetic and antihyperlipidaemic effect	Aqueous and methanolic extract	Fasting plasma glucose (FPG), total cholesterol, triglyceride, high-density lipoprotein (HDL) and low-density lipoprotein (LDL) were determined.	Both the aqueous and methanolic extracts of fermented seeds exert a hypoglycaemic effect; hence, has an antidiabetic property. The aqueous extract has a favourable lipid profile, which is an indication of its possible anti-arteriogenic property. The methanolic extract shows possible contraindication to ischaemic heart diseases.	[35]
Antipyretic properties	Crude extract and methanol fraction	The effect of yeast-induced pyrexia on albino Wistar rats was evaluated by determining the body temperatures of the rats by measuring Rectal Temperature (RT) at predetermined intervals	Antipyretic properties of the reduction in yeast induced hyperpyrexia were produced by the extract and the fractions. The methanol fraction exhibited a significant reduction in the yeast induced elevated temperature.	[82]
Anti-venom	A water-methanol extract of P. *biglobosa* stem bark	*In vivo* experiment using Wistar mice	*P biglobosa* stem bark had been shown to possess antisnake venom activity. This extract also reduced the loss of responses to acetylcholine (Ach), carbachol and KCl, which are normally blocked by *N. nigricollis* venom, and significantly reduced the contractures of the preparation induced by venom.	[110]
Termiticidal activity	Aqueous, alcoholic, and acetone extracts	*In vitro* analysis using *Coptotermes intermedius*	Termiticidal activity of aqueous and alcoholic extracts of raw seeds of *P. biglobosa* increases as the concentration levels increase while significant termiticidal activity for acetone extract was obtained only at higher concentrations. The acetone extracts showed termiticidal activity at higher concentration levels while no significant activity was detected at the lower concentration. Aqueous, alcoholic, and acetone extracts of boiled seeds showed no termiticidal effect on the termite workers.	[111]

induced by isoproterenol. Builder *et al*. [89] determined the effect of *Parkia biglobosa* methanolic stem barks extract on open wound healing in dexamethasone induced hyperglycaemia. The study revealed that different doses of *P. biglobosa* extract decreased the serum glucose concentration in pre and post-treatment dexamethasone-induced hyperglycaemic animals. Also, the histological evaluation showed that the pre-treated group of animals had higher performance scores on the grading scale and improved healing when compared with the post-treated groups, thus, established the wound healing activity of *P. biglobosa* extract. Jean *et al*. [90] reported that aqueous extract of *Parkia biglobosa* showed anxiolytic properties in the mice model tests.

A study by Fred-Jaiyesimi and Abo [91] showed that the methanol seed extract of this plant administered to

glucose-loaded diabetic rats exhibited a decrease in the blood glucose levels of the animals, with a peak decrease of 64% at 5 hr. Similarly, Kassi *et al*. [92] evaluated the effect of aqueous bark trunk extracts on blood glucose levels in normoglycemic rats and reported a 17.37% reduction of glycemia at a dose of 1000 mg/kg bw. Yomalan *et al*., [93] reported that the aqueous extract of *Parkia biglobosa* contains cardio depressant active principles. However, the study suggested that the extract action was not mediated by cholinergic muscarinic receptors, but may imply an adrenergic β-blocker.

Tokoudagba *et al.* [35] have reported that *Parkia biglobosa* leaf crude extract induced a redox-sensitive endothelium dependent relaxation mediated by both nitric oxide and endothelium-derived hyperpolarizing factor in porcine coronary artery rings. Airaodion *et al.* [94] reported that the methanolic extract of *P. biglobosa* was able to remedy the effect of ethanol by regulating the oxidative stress biomarkers in the Wistar rats, thus possesses prophylactic efficacy against ethanol-induced oxidative stress and can protect the liver against free radicals arising from oxidative stress. According to Ogunyinka *et al*. [95], a *Parkia biglobosa* protein isolate protects the brain and testicular tissues against oxidative stress induced by streptozotocin, via modulation of serum testosterone concentration and also by enhancing antioxidant defence system in streptozotocin-diabetic rats. The *P. biglobosa* leaf displays significant ACE inhibitory effects and affects mitochondrial redox chemistry, hence the use of the plant in indigenous medicinal systems [96].

Plant secondary metabolites present in *Parkia biglobosa* exhibit antibacterial activity against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Escherichia coli* and *Shigella dysenteriae* responsible for urinary tract and digestive system infections [1,21].

Threats to the ALBT

The main threats to the ALBT in Africa are overexploitation, overgrazing, bush fires, cotton production, mining, and habitat degradation leading to fragmentation of tree populations and climate change. Globally, *P. biglobosa* is of least concern [112] though in some parts of Africa, it is considered near threatened (endangered species) [32,113].

Local use and trade of *P. biglobosa* products in West Africa makes the tree vulnerable due to unsustainable harvesting [1,10,32] without taking into account the regeneration potential of the species [29,114,115]. In Nigeria, studies have shown that there are poor conservation and poor management of its genetic resources, yet there is increased demand for its use and derivable products [116]. The area of cultivation and production of the species is on the decline without reforestation strategies in most countries. Overgrazing by domestic animals causes a lack of regeneration and an over-ageing of tree individuals in the parklands. There has also been a decline or absence of pollinators [117-119].

A case study of Benin showed that climate change is one of the main factors affecting *P. biglobosa* populations [2]. The populations of *P. biglobosa* species are in decline and they remain semi- or undomesticated [31]. Climate change could alter the area of distribution of the ALBT. Previous studies had noted that *P. biglobosa* is genetically diverse, therefore there is great potential for domestication through selection and breeding [16,120-122]. In order to derive maximum benefits from *P. biglobosa*, it is imperative to know the evolutionary history of tree species for the management of their genetic resources, to prevent extinction and to preserve the germplasm [123]. *Parkia biglobosa* can be propagated mainly by seeds or vegetative propagation but the natural regeneration of the species is very low [124,125].

CONCLUSIONS

Parkia biglobosa is an important agroforestry tree species that improves the quality of life of resource-poor farmers, reducing poverty and promoting sustainability of the natural resources base and economic growth. It has nutritional and protective potentials, as it is rich in protein and has some beneficial health components. There is need for future research to characterize the tannins in the leaves of the ALBT in order to identify those that are nutritionally important to improve livestock productivity and to initiate industrial processing of the seeds and pulp. The tree is also under threat from climate change and over-exploitation in some parts of Africa.

AUTHORS' CONTRIBUTIONS

CM wrote the first draft and supervised the research, while EBA, SMM and CK assisted with writing the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors have not declared any conflict of interest.

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REFERENCES

[1] Millogo-Kone H, Guissou I, Nacoulma O, Traore A. Antimicrobial effects of the stem bark extracts of *Parkia biglobosa* (jacq.) Benth. on Shigellae. Afr J Tradit Complement Altern Med 2008; 4(4): 392-396. https://doi.org/10.4314/ajtcam.v4i4.31234

[2] Dotchamou FT, Atindogbe G, Sode AI, Fonton HN. Density and spatial pattern of *Parkia biglobosa* under climate change: the case of Benin. J Agric Environ Int Dev 2016; 110(1): 173-94.

[3] Hall JB, Tomlinson HF, Oni PI, Buchy M, Aebischer DP. *Parkia biglobosa*. A Monograph. School of Agricultural and Forest Sciences, University of Wales, Bangor, U.K 1997.

[4] Fafioye OO. Plants with piscicidal activities in Southwestern Nigeria. Turk J Fish Aquat Sci 2005; 5: 91-97.

[5] Sina *et al*. In: Oyen, L.P.A.; Lemmens, R.H.M.J. (eds), PROTA (Plant Resources of Tropical Africa/Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands 2002.

[6] Emmanuel SD, Adamu IK, Mohammed SY, Ejila A, Ja'afaru MI, Amos Y, Bobai M, Agbor O. Effect of industrial tannery effluent on soil fungi and fungal protease/cellulase activity on modified rice husk/modified sawdust medium (MRHM/MSDM). Scientific Research and Essays 2014; 9(21): 894-905.

[7] CABI. Invasive species compendium *Parkia biglobosa* (ne're'). CAB International, Wallingford. https://www.cabi.org/isc/datasheet/44162 2019. (Retrieved February 6, 2020).

[8] Wada NI, Njidda AA, Olafadehan OA, Bello B. Effect of Graded Levels of *Parkia biglobosa* in a Concentrate Diet on Growth Performance, Digestibility and Nitrogen Utilization of Yankasa Rams. Global J Biol Aric Health Sci 2014; 3(4): 65-70.

[9] Tropical Plants Database. Ken Fern. tropical.theferns.info. <tropical.theferns.info/viewtropical.php?id=Parkia+biglobosa> 2020 (Accessed 2020-02-26).

[10] Koura K, Ganglo JC, Assogbadjo AE, Agbangla C. Ethnic differences in use values and use patterns of Parkia biglobosa in Northern Benin. J Ethnobiol Ethnomed 2011; 7: 42. https://doi.org/10.1186/1746-4269-7-42

[11] Shao M. Parkia biglobosa: Changes in resource allocation in Kandiga, Ghana. Msc thesis Michigan Technological University 2002.

[12] Ajayi OA. Bacteriology and Qualitative Study of African Locust Bean (Parkia biglobosa). Open J Soc Sci 2014; 2: 73-78. https://doi.org/10.4236/jss.2014.211010

[13] Gernah DI, Atolagbe MO, Echegwo CC. Nutritional composition of the African locust bean (Parkia biglobosa) fruit pulp. Niger Food J 2007; 25(1): 190-196. https://doi.org/10.4314/nifoj.v25i1.33669

[14] Builders M, Wannang N, Aguiyi J. Antiplasmodial activities of Parkia biglobosa leaves: *In vivo* and *In vitro* studies. Ann Biol Res 2011; 2(4): 8-20.

[15] Bello OS, Adegoke KA, Sarumia OO, Lameed OS. Functionalized locust bean pod (Parkia biglobosa) activated carbon for Rhodamine B dye removal. Heliyon 2019; 5:1-11. https://doi.org/10.1016/j.heliyon.2019.e02323

[16] Teklehaimanot Z. Exploiting the potential of indigenous agroforestry trees: Parkia biglobosa and Vitellaria paradoxa in sub-Saharan Africa. Agrofo Syst 2004; 61-62(1-3): 207-220. https://doi.org/10.1023/B:AGFO.0000029000.22293.d1

[17] Ntui VO, Uyoh EA, Urua IS, Ogbu U, Okpako EC. Regeneration of *Parkia biglobosa* Benth.: An important tree species of Africa. J Microbiol Biotech Res 2012; 2(1): 169-177.

[18] Orwa C, Mutua A, Kindt R, Jamnadass R, Anthony S. Agroforestry Database:a tree reference and selection guide version 4.0. 2009. (http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp).

[19] Agroforestree Database. International Centre for Research in Agroforestry (ICRAF) 2008.

[20] Komolafe K, Olaleye MT, Fasan TI, Elekofehinti OO, Saliu JA, Akindahunsi AA. Lipid-Lowering Effect of *Parkia biglobosa* Leaf Saponins in Triton-X 1339-Induced Hyperlipidemic Rats. Res J Pharm Biol Chem Sci 2013; 4(1):576.

[21] Ajaiyeoba EO. Phytochemical and antibacterial properties of *P.biglobosa* and *P.bicolor* leaf extract. Afr J Biomed Res 2002; 5:125-129. https://doi.org/10.4314/ajbr.v5i3.54000

[22] Tybirk K. Planting trees in Sahel - doomed to failure? In: Poulsen, E. and Lawesson, J. (eds.) Dryland degradation: Causes and consequences 1991; pp. 22-28. Aarhus University Press, Aarh.

[23] Sina S, Traoré SA. *Parkia biglobosa* (Jacq.) R.Br. ex G.Don. In: Oyen, L.P.A. and Lemmens, R.H.M.J. (Editors). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands 2002. Accessed 7 October 2019.

[24] Ouédraogo AS. *Parkia biglobosa* (Leguminosae) en Afrique de l'Ouest: biosystématique et amélioration. Thèse de Doctorat Université Agronomique de Wageningen 1995.

[25] Djakpo O. Fermentation contrôlée des graines de néré (Parkia biglobosa) pour la production d'un condiment béninois de type afitin: effets de l'utilisation des souches sélectionnées de Bacillus subtilis sur la qualité du produit. Thèse d'ingénieur Agronome Université d'Abomey-Calavi, Faculté des Sciences Agronomiques 2005.

[26] Hassan LG, Umar KJ. Protein and Amino Acids Composition of Locust Bean (*Parkia biglobosa*). Trop Subtrop Agroecosyst 2005; 5: 45-50.

[27] Bayala J, Sanou J, Teklehaimanot Z, Kalinganire A, Ouédraogo SJ. Parklands for buffering climate risk and sustaining agricultural production in the Sahel of West Africa. Curr Opin Environ Sustain 2014; 6:28–34. https://doi.org/10.1016/j.cosust.2013.10.004

[28] Dimobe K, Tondoh JE, Weber JC, Bayala J, Ouédraogo K, Greenough K. Farmers' preferred tree species and their potential carbon stocks in southern Burkina Faso: Implications for biocarbon initiatives. PLoS ONE 2018; 13(12): e0199488. https://doi.org/10.1371/journal.pone.0199488

[29] In Réseau « Espèces Ligneuses Alimentaires ». Compte rendu de la première réunion du Réseau: 11-13 décembre 2000; CNSF Ouagadougou, Burkina Faso. Edited by: Eyog-Matig O, Gaoué OG, and Dossou B. Institut International des Ressources Phytogénétiques 2002.

[30] Dukku UH. Plants for Bees. *Parkia biglobosa*. An important honeybee forage in the Savanna. Bee World 2010; 87:28-29. https://doi.org/10.1080/0005772X.2010.11417363

[31] AbdulRahaman AA, Oladele FA, Babalola AO. Conservation Status of *Vitellaria paradoxa, Parkia biglobosa and Daniellia oliveri* in Ilorin Environ Kwara State Nigeria, Int J Appl Sci 2016; 1(1): 29-32.

[32] Obiozoba IC. Fermentation of African locust bean. Text on nutritional quality of plant fruit. (Edn) Osagie, Eka 2000. Post-

Harvest Research Unit. Dept. Biochem. Uniben. Nigeria 1998; pp 160-198.

[33] Udobi CE, Onaolapo JA. Bioactive Compounds of the stem bark of *Parkia biglobosa*. J Appl Pharm Sci 2012; 02(07): 133-137. https://doi.org/10.7324/JAPS.2012.2718

[34] Odetola AA, Akinloye O, Egunjobi C, Adekunle WA, Ayoola AO. Possible antidiabetic and antihyperlipidaemic effect of fermented *Parkia biglobosa* (Jacq) extract in alloxan-induced diabetic rats. Clin Exp Pharmacol Physiol 2006; 33: 808–812. https://doi.org/10.1111/j.1440-1681.2006.04444.x

[35] Tokoudagba J, Auger C, Bréant L, N'Gom S, Chabert P, Idris-Khodja N, Gba-guidi F, Gbenou J, Moudachirou M, Lobstein A. Procyanidin-rich fractions from *Parkia biglobosa* (Mimosaceae) leaves cause redox-sensitive endothelium-de-pendent relaxation involving NO and EDHF in porcine coronary artery. J Ethnopharmacol 2010; 132(1): 246-250. https://doi.org/10.1016/j.jep.2010.08.031

[36] Banwo GO, Abdullahi I, Duguryil M. The antimicrobial activity of the stem bark of *Parkia clappertoniana Keay* family Leguminosae against selected microorganisms. Nig J Pharm Res 2004; 3(1): 16-22. https://doi.org/10.4314/njpr.v3i1.35379

[37] El-Mahmood A M, Ameh J M. *In vitro* antibacterial activity of *Parkia biglobosa* (Jacq.) root bark extract against some microorganisms associated with urinary tract infections. Afr J Biotechnol 2007; 6(11): 1272-1275.

[38] Duker-Eshun GD, Beni CT, Asonaming WA, Akwamoah RA. Chemical investigation of the stem bark of *Parkia clappertoniana Keay*. Journal of Ghana Science Assoc 2001; 3:2. https://doi.org/10.4314/jgsa.v3i2.17925

[39] Irvine FR. Wood Plants of Ghana Oxford University Press, London 1961.

[40] Dedehou VFGN, Olounladé PA, Adenile DA, Alowanou GG, Azando EVB, Hounzangbe-Adote MS. A review on medicinal plants of *Parkia biglobosa* (Mimosaceae -Fabaceae) and *Pterocarpus Erinaceus* (Leguminosae – Papilionoidea). J Med Plants Stud 2016; 4(6): 132-137.

[41] Asuzu IU, Harvey AL. The antisnake venom activities of Parkia biglobosa (Mimosaceae) stem bark extract. Toxicon 2003; 42(7): 763-768. https://doi.org/10.1016/j.toxicon.2003.10.004

[42] Olugbemi B. Termiticidal activity of *Parkia biglobosa* (Jacq) Benth seed extracts on the termite Coptotermes intermedius Silvestri (Isoptera: Rhinotermitidae), Psyche 2012; pp. 1-5. https://doi.org/10.1155/2012/869415

[43] Teklehaimanot Z. Germplasm Conservation and Improvement of *Parkia biglobosa* (Jacq.) Benth. for Multipurpose Use. EU/INCO Project Contract TS3*-CT92-0072, Final Report, University of Wales Bangor, UK 1997; 166 pp.

[44] Bonkoungou EG. Monographic Study of Nere: *Parkia biglobosa* (Jacq) Benth. (Leguminosae, Mimosoideae). Burkina Faso: Institute of Research and Biology and Tropical Ecology, National Center for Scientific and Technological Research, Ministry of Higher Education and Scientific Research 1986.

[45] Bawa-Allah KA, Akinnuoye BO. Acute toxicity and adverse effects of aqueous and ethanol extracts of *Parkia biglobosa* pods on biochemical parameters of *Clarias gariepinus*. Afr J Aquat Sci 2019; 44(1): 89–95. https://doi.org/10.2989/16085914.2018.1559794

[46] Fafioye OO, Adebisi AA, Fagade SO. Toxicity of *Parkia biglobosa* and *Raphia vinifera* extracts on *Clarias gariepinus* juveniles. Afr J Biotechnol 2004; 3(11): 627-630.

[47] Omitoyin BO, Ajani EK, Adesina BT, Okuagu CNF. Toxicity of lindane (gamma hexachloro-cyclohexane) to *Clarias gariepinus* (Burchell 1822). World J Zool 2006; 1(1): 57–63.

[48] Alinde OBL, Esterhuyse AJ, Oguntibeju OO. Potential Role of *Parkia biglobosa* in the Management and Treatment of Cardiovascular Diseases 2014. https://doi.org/10.5772/57229

[49] Akwaji PI, Eyam EO, Bassey RA. Ethnobotanical survey of commonly used medicinal plants in Northern Cross River State, Nigeria. World Sci News 2017; 70(2): 140-157.

[50] Adi K, Metowogo K, Mouzou A, Lawson-Evi P, Eklu-Gadegbeku K, Agbonon A, Lamboni C, Essien K , Aklikokou K, Gbeassor M. Evaluation of cardioprotective effects of *Parkia biglobosa* (Jacq. Benth) Mimosaceae stem bark. J Appl Pharm Sci 2013; 3(02): 060-064. https://doi.org/10.7324/JAPS.2013.30210

[51] Lehman AD, Dunkel FV, Klein RA, Ouattara S, Diallo D, Gamby KT, N'Diaye M. Insect management products from Malian traditional medicine—Establishing systematic criteria for their identification. J Ethnopharmacol 2007; 110: 235–249. https://doi.org/10.1016/j.jep.2006.06.016

[52] Builders MI. *Parkia biglobosa* (African Locust Bean Tree). World J Pharm Res 2014; 3(2):1672-1682.

[53] Osho I, Lajide L. Prescreening evaluation of some plant extracts used in ethno-veterinary practices as antitrypanosomal agents. J Med Plant Res 2012; 6(11): 2056-2060. https://doi.org/10.5897/JMPR10.045

[54] Ognatan K, Adi K, Lamboni C, Damorou JM, Aklikokou KA, Gbeassor M, Guilland JC. Effect of Dietary Intake of Fermented Seeds of *Parkia biglobosa* (Jacq) Benth (African Locust Bean) on Hypertension in Bogou and Goumou-kope Areas of Togo. Trop J Pharm Res 2011; 10(5): 603-609. https://doi.org/10.4314/tjpr.v10i5.9

[55] Agunu A, Yusuf S, Andrew GO, Zezi AU, Abdurahman EM. Evaluation of five medicinal plants used in diarrhoea treatment in Nigeria. J. Ethnopharmacol 2005; 101:27–30. https://doi.org/10.1016/j.jep.2005.03.025

[56] Gbolade A. Ethnobotanical study of plants used in treating hypertension in Edo State of Nigeria. J Ethnopharmacol 2012; 144: 1–10. https://doi.org/10.1016/j.jep.2012.07.018

[57] Tapsoba H, Deschamps JP. Use of medicinal plants for the treatment of oral diseases in Burkina Faso. J Ethnopharmacol 2006; 104:68–78. https://doi.org/10.1016/j.jep.2005.08.047

[58] Muhammad S, Amusa NA. The Important Food Crops and Medicinal Plants of North-western Nigeria. Res J Agric Biol Sci 2005; 1(3): 254-260.

[59] Adjanohoun E, Adjakidjè V, Ahyi MRA, Akpagana K, Chibon P, El - Hadji A. Contribution aux études ethnobotaniques et floristiques au Togo. Agence de coopération culturelle et technique (ACCT), Paris 1986; pp. 671.

[60] Adjanohoun E, Adjakidje V, Ahyi MRA, Ake Assi L, Akoegninou A, d'Almeida J. Contribution aux études ethnobotaniques et floristiques en République populaire du Bénin. Médecine Traditionnelle et pharmacopée. Agence de Coopération Culturelle et Technique, Paris 1989; pp. 895.

[61] Grøn.haug TE, Glæserud S, Skogsrud M, Ballo N, Bah S, Diallo D. Ethnopharmacological survey of six medicinal plants from Mali, West-Africa. J Ethnobiol Ethnomed 2008; 4(26). https://doi.org/10.1186/1746-4269-4-26

[62] Belem B, Nacoulma BMI, Gbangou R, Kambou S, Hansen HH, Lund S, Raebild A, Lompo D, Ouedraogo M, Theilade I, Boussim IJ. Use of Non Wood Forest Products by local people bordering the "Parc National Kaboré Tambi", Burkina Faso. "J Transdiscipl Environ Stud 2007; 6(1).

[63] Tamboura H, Kaboré H, Yaméogo SM. Ethnomédecine vétérinaire et pharmacopée traditionnelle dans le plateau central du Burkina Faso : cas de la province du Passoré. Biotechnol Agron Soc Environ 1998; 2(3): 181–191.

[64] Adjanohoun E, Ake Assi L. Aux contributions des plantes médicinales census de Côte d'Ivoire. Centre Nat Fleuriste Univ Abidjan 1979; pp. 358.

[65] Abubakar MS, Musa AM, Ahmed A, Hussaini IM. The perception and practice of traditional medicine in the treatment of cancers and inflammations by the Hausa and Fulani tribes of Northern Nigeria. J Ethnopharmacol 2007; 111: 625–629. https://doi.org/10.1016/j.jep.2007.01.011

[66] Erakhrumen AA, Ogunsanwo OY, Ajewole OI. Assessment of some other traditional uses of accepted agroforestry fuelwood species in Akinyele and Ido local government areas, Oyo state, Nigeria. International Journal of Social Forestry (IJSF) 2010; 3(1): 49-65.

[67] Akande OA, Buochuama A, Alaye SA, Shuaib AB, Mohammed AM. Ethnobotanical Survey of Medicinal Plants amongst Kanti Community in Mashegu Local Government Area of Niger State, Nigeria. Int J Innovative Biosciences Res 2018; 6(1): 20-27.

[68] Nordeng H, Al-Zayadi W, Diallo D, Ballo N, Paulsen BS. Traditional medicine practitioners' knowledge and views on treatment of pregnant women in three regions of Mali. J Ethnobiol Ethnomed 2013; 9:67. https://doi.org/10.1186/1746-4269-9-67

[69] Asase A, Oteng-Yeboah AA, Odamtten GT, Simmonds MSJ. Ethnobotanical study of some Ghanaian anti-malarial plants. J Ethnopharmacol 2005; 99:273–279. https://doi.org/10.1016/j.jep.2005.02.020

[70] Inngjerdingen K, Nergård CS, Diallo D, Mounkoro PP, Paulsen BS. An ethnopharmacological survey of plants used for wound healing in Dogonland, Mali, West Africa. J Ethnopharmacol 2004; 92: 233–244. https://doi.org/10.1016/j.jep.2004.02.021

[71] Inngjerdingen K, Nergard CS, Diallo D, Mounkoro PP, Paulsen BS, Zerbo P. Plantes médicinales et pratiques médicales au Burkina Faso. cas des Sanan. Bois et Forêts des Tropiques 2011; 307(1): 41-53. https://doi.org/10.19182/bft2011.307.a20481

[72] Djoueché CM, Azebaze AB, Dongmo AB. Investigation of Plants Used for the Ethnoveterinary Control of Gastrointestinal Parasites in Bénoué Region, Cameroon. Tropicultura 2011; 29(4): 205-211.

[73] Sourabie TS, Kinda D, Yaro B, Nikiema JB. Ethnobotanical Survey of Medicinal Plants Used By the Traditional Medical Healers in the Villages of Bérégadougou and Fabédougou (Cascades Region, Burkina Faso). J Pharm 2013; 3(7): 38-45. https://doi.org/10.9790/3013-0371038-45

[74] Soetan KO, Lasisi OT, Agboluaje AK. Comparative assessment of in-vitro anthelmintic effects of the aqueous extracts of the seeds and leaves of the African locust bean (Parkia biglobosa) on bovine nematode eggs. J Cell Anim Biol 2011; 5(6): 109-112.

[75] Tchacondo T, Karou SD, Batawil K, Agban A, Ouro-Bang'na K, Anani KT, Gbeassor M, de Souza C. Herbal remedies and theie adverse effects in Tem tribe traditional medicine in Togo. Afr J Tradit Complement Altern Med 2011; 8(1): 45-60. https://doi.org/10.4314/ajtcam.v8i1.60522

[76] Udobi CE, Onaolapo JA. Phytochemical analysis and antibacterial evaluation of the leaf stem bark and root of the African locust bean (*Parkia biglobosa*). J Med Plant Res 2009; 3(5): 338-344.

[77] Assogba MN. Quelques enquêtes sur la pharmacopée traditionnelle vétérinaire en République du Bénin. 13e Conférence de la Société Ouest Africaine de Pharmacologie 1984; 23-25.

[78] Ampitan TA. Ethnobotanical survey of medicinal plants in Biu local government area of Borno state, Nigeria. Comprehensive Journal of Herbs and Medicinal Plants 2013; 2(1):7-11.

[79] Kassi Y, Aka KJ, Abo KJ-C, Méa A, Néné Bi SA, Ehilé EE. Effet antihypertensif d'un extrait aqueux d'écorce de tronc de *Parkia biglobosa* (Mimosaceae) sur la pression artérielle de lapin. Sciences and Nature 2008; 5(2):133-143. https://doi.org/10.4314/scinat.v5i2.42159

[80] Pare D, Hilou A, Quedraogo N and Guenne S (2016). Ethnobotanical study of medicinal plants used as anti-obesity remedies in the nomad and hunter communities of Burkina Faso. Medicines (Basel) 2016; 3(2):9. https://doi.org/10.3390/medicines3020009

[81] Femi-Ola TO, Ajibade VA, Afolabi A. Chemical composition and termicidal properties of *Parkia biglobosa* (Jacq) Benth. J Biol Sci 2008; 8(2): 494-497. https://doi.org/10.3923/jbs.2008.494.497

[82] Builders MI, Tarfa F, Aguiyi JC. The potency of African locust bean tree as an antimalarial. J Pharmacol Toxicol 2012; 7: 274-287. https://doi.org/10.3923/jpt.2012.274.287

[83] Tringali C, Sparafora C, Longo, OD. Bioactive constituents of the bark of *Parkia biglobosa*. Fitoterapia 2000; 71: 118-125. https://doi.org/10.1016/S0367-326X(99)00137-9

[84] Bello MO, Falade OS, Adewusi RA, Olawore NO. Studies on the chemical composition and anti-nutrient of some lesser known Nigeria fruits. Afr J Biotechnol 2008; 7(21): 3972-3979.

[85] Campbell-Platt G. African Locust Bean (Parkia Species) and Its West African fermented food product, Dawadawa. Ecol Food Nutr 1980; 9: 123-132. https://doi.org/10.1080/03670244.1980.9990590

[86] Alabi DA, Akinsulire OR, Sanyaolu MA. Qualitative determination of chemical and nutritional composition of *Parkia biglobosa* (Jacq.) Afri J Biotechnol 2005; 4 (8): 812-815.

[87] Kouadio F, Kanko C, Juge M, Grimaud N, Jean A, N.'Guessan YT, Petit JY. Analgesic and antiinflammatory activities of an extract from *Parkia biglobosa* used in traditional medicine in the Ivory Coast. Phytother Res 2000; 14: 635-637. https://doi.org/10.1002/1099-1573(200012)14:8<635::AID-PTR427>3.0.CO;2-T

[88] Lamien-Meda A, Lamien CE, Compaoré MM, Meda RN, Kiendrebeogo M, Zeba B, Millogo JF, Nacoulma OG. Polyphenol content and antioxidant activity of fourteen wild edible fruits from Burkina Faso. Molecules 2008; 13(3): 581-594. https://doi.org/10.3390/molecules13030581

[89] Builders MI, Joseph OS, Vhriterhire AR. Effect of *Parkia biglobosa* extract on open skin wound healing in dexamethasone-induced hyperglycaemia and histological assessment in rats. Afr J Pharm Pharmacol 2019; 13(8), pp. 84-89. https://doi.org/10.5897/AJPP2019.5043

[90] Omam JPO, Mbomo RA, Kavaye AK, Ze Minkoulou MD, Kameni SJN, Okomolo FCM, Bum EN. GABA-A receptor complex in the anxiolytic properties of *Parkia biglobosa* in mice, Int J Brain Cogn Sci 2017; 6(2): 26-33. doi: 10.5923/j.ijbcs.20170602.02.

[91] Fred-Jaiyesimi A A, Abo KA. Hypoglycaemic effects of *Parkia biglobosa* (Jacq) Benth seed extract in glucose-loaded and NIDDM rats. Int J Biol Chem Sci 2009; 3(3): 545–550. https://doi.org/10.4314/ijbcs.v3i3.45340

[92] Kassi Y, Toto KN, Golé NGGC, Anthelme NBS, Traoré F. Assessment of the effects of an aqueous trunk bark extract of *Parkia biglobosa* (mimosaceae) on blood sugar levels in rats. World J Pharm Pharm Sci 2018; 7(10).

[93] Yomalan K, Bi SA.N, Konaté K, Yaya T. Cardiodepressor effects of an aqueous trunk bark extract of *Parkia Biglobosa* (Jacq. Benth (Mimosaceae) on the spontaneous contractile activity of the isolated heart of rat. IOSR J Pharm Biol Sci 2018; 13(5) Ver. III: 11-16.

[94] Airaodion AI, Ogbuagu EO, Ogbuagu U, Adeniji AR, Agunbiade AP, Airaodion EO. Hepatoprotective effect of *Parkia biglobosa* on acute ethanol-induced oxidative stress in wistar rats. International Research Journal of Gastroenterology and Hepatology 2019; pp.1-11. https://doi.org/10.9734/ajrb/2019/v5i230084

[95] Ogunyinka BI, Oyinloye BE, Osunsanmi FO, Opoku AR, Kappo AP. Modulatory influence of *Parkia biglobosa* protein isolate on testosterone and biomarkers of oxidative stress in brain and testes of streptozotocin-induced diabetic male rats. Int J Physiol Pathophysiol Pharmacol 2016; 8(3): 78.

[96] Komolafe K, Akinmoladun KC, Komolafe TR, Olaleye MT, Akindahunsi AA, Rocha JBT. African locust bean (*Parkia biglobosa*, Jacq Benth) leaf extract affects mitochondrial redox chemistry and inhibits angiotensinconverting enzyme *in vitro*. Clin Phytosci 2017; 3:19. https://doi.org/10.1186/s40816-017-0057-4

[97] Udobi CE, Onaolapo JA. Cell kill pattern and acute toxicity studies of the aqueous fraction of the methanolic extract of parts of *Parkia biglobosa*. Afr J Biotechnol 2010; 8 (31):4993-4998.

[98] Akintobi OA, Adejuwon AO, Olawale AK. Antimicrobial evaluation of the stem bark extracts of Parkia biglobosa (Jacq.) Benth. Ex G. Don. Report and Opinion 2013; 5 (10): 41-45.

[99] Gabriel AF, Onigbanjo HO. Phytochemical and antimicrobial screening of the stem bark extracts of *Pterocarpus erina*ceus (Poir). Nig J Basic Appl Sci 2010; 18(1):1-5. https://doi.org/10.4314/njbas.v18i1.56835

[100] Konaté K, Kiendrébéogo M, Ouattara MB, Souza A, Lamien-Meda A, Nongasida Y. Antibacterial potential of aqueous acetone extracts from five medicinal plants used traditionally to treat infectious diseases in Burkina Faso. Curr Res J Biol Sci 2011; 23(5): 435-442.

[101] Tijani AY, Okhale SE, Salawu TA, Onigbanjo HO, Obianodo LA, Akingbasote JA, Salawu OA, Okogun JE, Kunle FO, Emeje M. Anti-diarrhoeal and antibacterial properties of crude aqueous stem bark extract and fractions of *P.biglobosa* (Jacq) R. Br Ex G. Don. African J Pharm Pharmacol 2009; 7: 347-353.

[102] Ezeja MI, Ezeigbo II, Madubuike KG, Udeh NE, Ukweni IA, Akomas SC. Antidiarrheal activity of *Pterocarpus erinaceus* methanol leaf extract in experimentally-induced diarrhoea. Asian Pac J Trop Med 2012; pp. 147-150. https://doi.org/10.1016/S1995-7645(12)60014-5

[103] Josiah JG, Omalu IC, Adama JY, Ejima IA, Obi OA. Evaluation of anthelmintic potential of *Parkia biglobosa* leaves and seeds extracts against infective larvae and adult of Haemonchus contortus of goats. Journal of Animal Science and Veterinary Medicine 2018; 3(1): 6-17. https://doi.org/10.31248/JASVM2017.079

[104] Karou D, Dicko MH, Sanon S, Simpore J, Traore AS. Antimalarial activity of Sida acuta Burm. f. (Malvaceae) and *Pterocarpus erinaceus* Poir. (Fabaceae). J Ethnopharmacol 2003; 89: 291-294. https://doi.org/10.1016/j.jep.2003.09.010

[105] Nounagnon M, Dah-Nouvlessounon D, N'tcha C, Nanoukon C, Assogba F, Lalèyè FOA, Noumavo P, Gbénou DJ, Baba-Moussa L. Phytochemical composition, antimicrobial and cytotoxicity activities of *Parkia biglobosa* (Jacq) benth extracts from Benin. J Pharmacogn Phytochem 2017; 6(2).

[106] Hage S, Kienlen-Campard P, Octave JN, Quetin-Leclercq J. *In vitro* screening on amyloid peptide production of plants used in traditional medicine for cognitive disorders. J Ethnopharmacol 2010; 131: 585-591. https://doi.org/10.1016/j.jep.2010.07.044

[107] Nwaehujor CO, Ezeigbo I, Udeh NE, Ezeja MI, Asuzu IU. Anti-inflammatory and antioxidant activities of the methanolic extracts of the stalk of *Parkia biglobosa* (jacq.) Benth. Hygeia Journal for Drugs and Medicine 2011; 3(1): 34-40.

[108] Ouédraogo N, Sawadogo RW, Tibiri A, Bayet C, Lompo M, Hay AE. Pharmacological properties and related constituents of stem bark of *Pterocarpus erinaceus* Poir (Fabaceae). Asian Pac J Trop Med 2011; pp. 412-420.

[109] Millogo-Kone H, Lompo M, Kini F, Asimi S, Guissou IP, Naucoulma O. Evaluation of flavonoids and total phenolics content of stem bark and leaves of *P. biglobosa* (Jacq) Benth (Mimosaceae)-free radical scavenging and antimicrobial activities. Phytother Res 2009; 8: 635-642.

[110] Asuzu IU, Harvey AL. The antisnake venom activities of *Parkia biglobosa* (Mimosaceae) stem bark extract. Toxicon 2003; 42(7): 763–768. https://doi.org/10.1016/j.toxicon.2003.10.004

[111] Olugbemi B. Termiticidal activity of *Parkia biglobosa* (Jacq) Benth seed extracts on the termite *Coptotermes intermedius Silvestri* (Isoptera: Rhinotermitidae). Psyche 2012; p. 5. https://doi.org/10.1155/2012/869415

[112] IUCN 2012. The IUCN Red List of threatened species version 2012-3. http://www.iucnredlist.org

[113] Danjuma MN, Abubakar SM. Conservation Status of Vegetation in the Dryland of Northwestern Nigeria. International Journal of Agriculture, Forestry and Fisheries 2017; 5(2): 18-24.

[114] Eyog Matig O, Gaoué OG, Dossou B. Réseau « Espèces Ligneuses Alimentaires ». Compte rendu de la première réunion du Réseau tenue 11-13 décembre 2000 au CNSF Ouagadougou, Burkina Faso. Institut International des Ressources Phytogénétiques 2002; 235.

[115] Sina S. Reproduction et Diversité Génétique chez Parkia biglobosa (Jacq.) G. Don [thesis]. Wageningen Agricultural University, Wageningen, The Netherlands 2006.

[116] Gaisberger H, Kindt R, Loo J, Schmidt M, Bognounou F, Da SS, Diallo OB, Ganaba S, Gnoumou A, Lompo D *et al*. Spatially explicit multi-threat assessment of food tree species in Burkina Faso: a fine scale approach. PloS One 2017; 12, p.e0188457. https://doi.org/10.1371/journal.pone.0184457

[117] Ouedraogo S, Some N, Ouattara S, Kini FB, Traore A, Bucher B, Guissou IP. Acute toxicity and vascular properties of seed of *Parkia biglobosa* (JACQ) R. Br Gift (Mimosaceae) on rat aorta. Afr J Tradit Complement Altern Med 2012; 9: 260-265. https://doi.org/10.4314/ajtcam.v9i2.12

[118] Amusa O, Adesoye A, Ogunkanmi A, Omoche O, Olowe O, Akinyosoye S, Omodele T. 2014. Genetic diversity of *Parkia biglobosa* from different agroecological zones of Nigeria using RAPD Markers. International Journal of Biodiversity 2014: 1 - 9. https://doi.org/10.1155/2014/457309

[119] Lompo D, Vinceti B, Gaisberger H, Konrad H, Duminil J, Ouedraogo M, Sina S, Geburek T. Genetic conservation in *Parkia biglobosa* (Fabaceae: Mimosoideae)-what do we know? Silvae Genetica 2017; 66: 1 - 8. https://doi.org/10.1515/sg-2017-0001

[120] Sabiiti EN, Cobbina J. Initial agronomic evaluation of *Parkia biglobosa* in the humid zone of Nigeria. Agrofo Syst 1992; 17(3): 271-279. https://doi.org/10.1007/BF00054152

[121] Lovett PN, Haq N. Evidence for anthropic selection of the Sheanut tree (*Vitellaria paradoxa*). Agrofo Syst 2000a; 48(3): 273-288. https://doi.org/10.1023/A:1006379217851

[122] Lovett PN, Haq N. Diversity of the Sheanut tree (*Vitellaria para*doxa C.F. Gaertn.) in Ghana. Genet Resour Crop Evo 2000b; 47(3): 293-304.

[123] Lompo D, Vinceti B, Konrad H, Gaisberger H, Gebure T. Phylogeography of African Locust Bean (*Parkia biglobosa*) Reveals Genetic Divergence and Spatially Structured Populations in West and Central Africa. J Hered 2018; pp. 811-824. https://doi.org/10.1093/jhered/esy047

[124] Bonkoungou EG. Monographie du néré, *Parkia biglobosa* (jacq.) Benth., espèce agroforestière à usages multiples Institut de Recherche en Biologie et Ecologie Tropicale: IRBET/CNRST, Ouagadougou, Burkina Faso 1987.

[125] Gbédji EK. Caractérisation morphologique et structurale des parcs à néré *(Parkia biglobosa* (Jack.) R. Br. Ex. G. Don.) au Bénin. Thèse d'Ingénieur Agronome Université d'Abomey-Calavi, Faculté des Sciences Agronomiques 2003.

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