



Research Paper

Phytochemical screening of *Parkia Biglobosa* (Jacq.) Benth and its antimicrobial activity against selected bacteria strains

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ABSTRACT

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The therapeutic roles of plant materials in multi-disease conditions necessitated its continued exploration and consumption. This led us to evaluate the phytochemical properties and antimicrobial activity of extracts of leaf and bark of *Parkia biglobosa*. Phytochemical screening and antimicrobial activity of hexane, chloroform, ethanol and aqueous (control) extracts of *P. biglobosa* leaf and bark was carried out using standard protocols. The antimicrobial activity exhibited on clinical pathogens indicated the inhibitory potentials of the extracts against the test organisms. The observed antimicrobial activity of the plant parts is indicative of the therapeutic potentials of the secondary metabolites inherent in these plants.

Keywords: Bacteriocidal, extracts, sensitivity, strains, therapeutic.

INTRODUCTION

The quest for solutions to the global problems of antibiotic resistance necessitated the need for a continued search for new antimicrobial compounds. Crude extracts of medicinal plants notwithstanding stand out as veritable sources of potential resistance agents and the African biosphere promises to be a potential source of such compounds owing to its rich plant species diversity (Sibanda and Okoh, 2007; Tijani et al., 2009). Many plants have been shown to possess antioxidant properties (Sala et al., 2002; Ivanišová et al., 2013). This has thus raised interest in the investigation of commonly consumed plants for their phytochemicals with nutritional and chemotherapeutic potentials. Therefore, the need to argument synthetic chemotherapeutic compounds with natural products is the drive for the exploitation of natural products from plants as they may have little or no side effects yet meeting the nutritional, chemotherapeutic and economic needs (Iwu et al., 1999; Hazra et al., 2008).

Moreover, despite the efforts of pharmaceutical companies in the production of synthetic antibiotics, there yet exists a marked increase in pathogen population exacerbated by multi-drug resistant micro-organisms (Nino et al., 2006). Consequently, there is increased research into

phytochemicals for the effective therapeutic combat of this menace. The therapeutic effects of plant-based drugs have been documented to be due to the phytochemicals that constitute the plants. These constituents selectively target toxins and pathogens without significant detrimental effect on the human host (Kumar et al., 2012).

Parkia biglobosa (African Locust Bean) is found in many countries of the world especially along the West African coast where the seeds are fermented into 'iru' or 'dawadawa' (daddawa), a popular food seasoning known to be rich in protein and vitamin B₂. Among a wide range of uses which includes apiculture, fodder, tanning and food, etc, this plant has been used extensively for medicinal purposes by the Hausa people of Northern Nigeria and other parts of West Africa. A decoction of the stem bark is used as a mouthwash to steam and relieve toothache as well as, a bath for fever (Ajaiyeoba, 2002). The bark is also used with lemon for wounds and ulcers. In Cote d'Ivoire and Nigeria, a bark infusion is used as a tonic for diarrhoea and as an enema (Duker-Eshun et al., 2001; Agunu et al., 2005). Among the Hausa people of Northern Nigeria, *P. biglobosa* is used against bronchitis, pneumonia, diarrhoea, violent colic, vomiting, sores and ulcers (Mallam Abbas,

Samaru-Zaria, personal communication). The leaves are also used for burns and toothache as well as, for sore eyes in Gambia (Banwo et al., 2004). The root of *P. biglobosa* has been reported to be used in lotions for sore eyes when combined with leaves; they are active against bronchitis, pile, cough, amoebiasis, dental carries and conjunctivitis (Millogo-Kone et al., 2006)

Despite the nutritional benefits of the seeds of African locust bean coupled with its antioxidant potentials, there has been dearth of information on the phytochemical and antimicrobial investigations of the leaf and bark of *P. biglobosa*. In addition, the continued explorations on the therapeutic potentials of medicinal plants cannot be overemphasized because it elicits a lot of information. Hence, this work attempts to investigate the phytochemical and antimicrobial properties of the leaf and bark of *P. biglobosa* against selected strains of bacteria.

MATERIALS AND METHODS

Collection and authentication of plant materials

The leaf and bark of *P. biglobosa* was collected from Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria. The plant materials were identified and authenticated by a taxonomist at the Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba-Akoko.

Preparation and extraction of plant samples

Each plant material was washed and air dried for five days on the laboratory bench (Okoh, 2013) and thereafter, grounded into powder in a mortar. About 50 g each of the plant material were then extracted with hexane, chloroform, ethanol and water using a Soxhlet apparatus. The solvents were later removed and the extracts obtained stored in a desiccator for future use.

Fractionation of extract

Leaf and bark extracts were fractionated using N hexane, chloroform, ethanol and water. About 20 g of each dried extract was ground in a mortar and dissolved in 200 ml of water and later filtered through a Whatmann No. 1 filter paper. 200 ml of N hexane was added to the mixture, shaken vigorously and allowed to settle. The ether fractions were removed and concentrated while another 200 ml of chloroform was added to the aqueous layer and vigorously shaken and allowed to settle. The aqueous and the chloroform layers were further separated while the

chloroform portion was concentrated to dryness by allowing standing on the laboratory bench while the solvent evaporated.

Preparation of the medium

30 g of potato dextrose agar powder were weighed into conical (Cleaned) flask and 100 ml of sterilized distilled dispensed into the conical flask to form homogenized solution and later sterilized in an autoclave at 121°C for 15 min. It was later cooled in water bath at 45°C and 500 mg of antibiotics (Chloramphenicol) added.

Phytochemical analysis

All the fractions from the extracts were subjected to phytochemical screening to test for the presence of saponin, alkaloids, flavonoids, glycosides, tanins, phenol, carbohydrates, phytosterols, quinone, steroids and phytosteroids, terpenoids, cardiac glycosides, coumarins and anthraquinone among other secondary metabolites (Sofowora, 1984; Trease and Evans, 1989).

Test organisms

Source of micro-organisms

Gram positive bacteria (*Bacillus subtilis*, *Staphylococcus aureus* and *Salmonella typhi*) and gram negative bacteria (*Streptococcus pneumoniae*, *Escherichia coli* and *Klebsiella pneumoniae*) were obtained from the Department of Microbiology, Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria.

Purification of test organisms

The purity of the test organisms were confirmed by sub-culturing into nutrient broth incubated at 37°C for 18 h. Thereafter, they were streaked unto sterile nutrient agar plate and later incubated. The developed colonies were observed under the microscope after simple staining and later sub-cultured.

Standardization of inoculum

The inocula were prepared from the stock cultures which were maintained in nutrient agar at 4°C and sub-cultured in nutrient broth using a sterilized wire loop. The density of suspension inoculated unto the media for susceptibility test was determined by comparison with 0.5 McFarland

Table 1: Qualitative phytochemical analysis of *Parkia biglobosa* leaf extract in different solvents.

Phytochemicals	HE	CE	EE	AE
Saponin	-	-	++	+++
Alkaloids	+	-	-	-
Flavonoids	+	+	-	-
Glycosides	-	-	-	-
Tannins	-	-	+	-
Phenol	-	-	-	-
Carbohydrates	-	++	-	++
Phytosterols	++	-	-	-
Quinone	-	-	++	-
Steroids	+	-	+	-
Terpenoids	-	+	++	+
Cardiac glycosides	+	++	++	+++
Coumarins	-	+	-	+++
Anthraquinone	-	-	-	++
Protein	-	-	-	-

Key: + = present, - = absent; HE = Hexane extract; CH = Chloroform extract; EE = Ethanol extract; AQ = Aqueous extract; +++ = 25% inhibition; ++ = 50% inhibition; + = 75% inhibition; - = 100% inhibition.

standard of Barium sulphate solution (Cheesbrough, 2002).

Susceptibility test

Agar well diffusion method was employed for antibacterial assay following established protocols. The preparation was incubated at appropriate temperature. The zone of inhibition diameter formed in the medium was measured to determine antibacterial effectiveness of the different concentrations of the extracts.

Determination of minimum inhibitory concentration (MIC)

The minimum inhibitory concentration for bacterial isolates was carried out using tube dilution as described by Akinyemi et al. (2005). Stock solution of 80,000 µg in 10 ml sterilized distilled water was serially diluted to arrive at concentrations of 500, 1000, 2000 and 4000 µg/ml, respectively.

Statistical analysis

The program, Statistical Package for Social Science (SPSS) version 20 was used in the analysis of the data. For descriptive purposes, arithmetic mean and standard deviation (SD) were generated as appropriate. Data

generated were also subjected to analysis of variance. P values of ≤0.05 were regarded as statistically significant.

RESULTS AND DISCUSSION

Table 1 shows the quantitative phytochemical analysis of *P. biglobosa* leaf extracts in different solvents. Most of the isolates tested showed varying degree of susceptibility to the activity of the extract. Saponins, cardiac glycosides and coumarins showed 25% inhibition with aqueous extract as against hexane extract. Tannins, quinones and terpenoids were observed to vary between 25 to 100% inhibition. However, Glycosides, phenols and proteins were not susceptible to the bacterial isolates.

Table 2 shows the quantitative phytochemical analysis of *P. biglobosa* barks extracts in different solvents. Most of the secondary metabolites investigated were more deposited in the bark than in the leaf with ethanolic and aqueous extract having the highest zone of inhibition as against chloroform and hexane extract. Only cardiac glycosides are present in the extracts.

Table 3 shows the antibacterial activity of the extracts of the leaf of *P. biglobosa* against the test bacterial isolates. The highest zone of inhibition of 310 mm was observed in hexane extract for *K. pneumoniae* as against 1.16 in aqueous extract for *B. subtilis*. In gram positive bacteria, the highest inhibition zone of 2.97 mm was observed in ethanolic extract for *B. subtilis*, *S. aureus* and *S. typhi* while *E. coli* showed zones of inhibition between (1.85 to 2.85) mm,

Table 2: Qualitative phytochemical analysis of *P. biglobosa* bark extract in different solvents.

Phytochemicals	HE	CE	EE	AE
Saponin	-	-	++	++
Alkaloids	+	-	-	-
Flavonoids	+	++	-	-
Glycosides	-	-	-	-
Tannins	-	-	+	-
Phenol	-	-	+	+
Carbohydrates	-	+	++	+++
Phytosterols	-	-	-	-
Quinone	+	++	++	-
Steroids & Phytosteroids	-	-	+	+
Terpenoids	-	++	++	++
Cardiac glycosides	+	+++	++	+++
Coumarins	-	+	-	++
Anthraquinone	-	-	++	++
Protein	-	-	-	-

Key: + = present; - = absent; HE = Hexane extract; CH = Chloroform extract; EE = Ethanol extract; AQ = Aqueous extract; +++ = 25% inhibition; ++ = 50% inhibition; + = 75% inhibition; - = 100% inhibition.

Table 3: Antibacterial activity of the extracts of the leaf of *P. biglobosa* against the test bacterial isolates.

Variable	Zone of inhibition (mm)			
	HE	CE	EE	AQ
Bacteria strain (Gram positive)				
<i>Bacillus subtilis</i>	2.45 ^a	2.15 ^a	2.97 ^a	1.16 ^a
<i>Staphylococcus aureus</i>	2.60 ^a	2.85 ^a	2.75 ^a	1.86 ^a
<i>Salmonella typhi</i>	2.26 ^a	2.56 ^a	2.56 ^a	1.96 ^a
Bacteria strain (Gram negative)				
<i>Streptococcus pneumonia</i>	1.17 ^c	1.27 ^c	1.20 ^c	1.10 ^c
<i>Escherichia coli</i>	2.03 ^b	1.86 ^b	1.85 ^b	1.85 ^b
<i>Klebsiella pneumonia</i>	3.10 ^a	2.65 ^a	2.45 ^a	2.80 ^a
LSD (0.55)				

Key: HE = Hexane extract, CH = Chloroform extract, EE = Ethanol extract, AQ = Aqueous extract. Means with the same letter in superscript along the same column are not significantly different at $P > 0.05$.

respectively among the various extracts.

Table 4 shows antibacterial sensitivity pattern of the extracts of the bark of the *P. biglobosa*. Similar trend in their zone of inhibition and susceptibility pattern is also observed with *K. pneumoniae* having the highest zone of inhibition of 3.15 mm in hexane extract in contrast to aqueous extract with 1.32 mm. *S. typhi* and *E. coli* had inhibition range of (2.36 to 2.73) mm in ethanolic extract.

There are different mechanisms by which phytochemicals exerts antimicrobial activities. Flavonoids exhibit a wide range of biological activities which include anti-microbial, anti-inflammatory, analgesic, anti-allergic effects and anti-

oxidant properties (Maikai et al., 2009). Also, flavonoids in the human diet many reduce the risk of various cancers as well as, preventing menopausal symptoms (Scalbert, 1991). The antibacterial activity of flavonoids was repeated as a result of their ability to form complexes with bacterial cell walls, extracellular and soluble proteins (Scalbert, 1991).

Tannins act by iron deprivation, hydrogen bonding or specific interaction with protein such as enzymes, cell envelopes and complex formulations with polysaccharides (Scalbert, 1991; Hisanori et al., 2001; Dharmananda, 2003).

Cardiac glycosides are an important class of naturally occurring drugs where actions help in the treatment of

Table 4: Antibacterial activity of the extracts of the bark of *P. biglobosa* against the test bacterial isolates.

Variable	Zone of inhibition (mm)			
	HE	CE	EE	AQ
Bacteria strain (Gram positive)				
<i>Bacillus subtilis</i>	2.72 ^a	2.82 ^a	2.17 ^a	1.86 ^a
<i>Staphylococcus aureus</i>	2.57 ^a	2.55 ^a	1.85 ^b	1.56 ^a
<i>Salmonella typhi</i>	2.18 ^a	2.36 ^a	2.40 ^a	1.32 ^a
Bacteria strain (Gram negative)				
<i>Streptococcus pneumonia</i>	2.54 ^b	2.67 ^b	2.60 ^b	2.20 ^a
<i>Escherichia coli</i>	1.86 ^c	2.36 ^b	2.73 ^b	1.58 ^b
<i>Klebsiella pneumonia</i>	3.15 ^a	3.10 ^a	3.27 ^a	2.76 ^a
LSD (0.55)				

Key: HE = Hexane extract, CH = Chloroform extract, EE = Ethanol extract, AQ = Aqueous extract. Means with the same letter in superscript along the same column are not significantly different at $P > 0.05$.

congestive health failure (Ikeda et al., 1995). The noticeable presence of this phytochemical compound especially in the bark of *P. biglobosa* extract gave credence to its cardiac infections dental caries and cough among the Yoruba extraction of southern Nigeria.

Simultaneous comparison of the MIC values exhibited by n-hexane, chloroform, ethanoic and aqueous fractions against tested bacterial isolates showed that MIC values of bark extract were highest than in the leaf. This shows that there might be synergistic antibacterial enhancing interactions between different bioactive components of the bark and leaf extracts. This trend was also supported by Abioye et al. (2013).

Potential therapeutic roles of plant materials has not only validated their efficacies in combating various diseases but also identified the pharmacological roles of active components of these plant materials. The results of phytochemical analysis of the leaf and bark of *P. biglobosa* showed the presence of a number of secondary metabolites including saponins, alkaloids, flavonoids, tannins, phytosterols, glycosides, coumarins and antraquinones among others (Tables 1 and 2).

Saponins were detected in both the leaf and bark of *P. biglobosa* in ethanol and aqueous extract respectively. Varying presence of other metabolites including steroids, terpenoids, tannins and phenols, etc are noticeable in either the leaf and/or bark of *P. biglobosa*. Findings from this study are not in agreement with the work of Ajaiyeoba (2002) who reported the presence of tannins in two leaves extracts (water and ethanol) and absence of saponins in both leaf extracts. The noticeable presence of saponins in the bark than in the leaf revealed the potent activity of the bark extract in therapeutic roles as against the leaf (Udobi and Onaolapo, 2009; Bukar et al., 2010; Igwo-Ezikpe, 2013).

Similar phytochemicals have been reported by studies on

other vegetative parts such as the leaves, stem bark and root bark (Ajaiyeoba, 2002, Abioye et al., 2013). The presence of these secondary metabolites give credence to *P. biglobosa* therapeutic application in the treatment of diseases such as cardiac infirmity (Ajaiyeoba, 2002), intestinal disorders and other bacterial infections (Millogo-Kone et al., 2008). It was earlier suggested that the presence of flavonoids in the leaf and stem bark of *P. biglobosa* might account for its relatively high radical scavenging activity (Adaramola et al., 2012).

The presences of these phytochemicals in plants are linked to the antimicrobial activities of the plants (Lewis and Ausubel, 2006). The alarming increase in the pathogenic resistance to orthodox medicine had hitherto being unabated. Also, the quest for antidote to this health scourge necessitated increased interest in the field of traditional medicine.

The susceptibility of the bacteria isolates investigated to the ethanol extract of *P. biglobosa* suggested the extract possesses antibacterial potential (Igwo-Ezikpe et al., 2013). The result of the antimicrobial activity confirmed that N-hexane leaf extract had the highest antimicrobial activity against *K. pneumoniae* with zone of inhibition of 3.10 mm as against *S. typhi* with 2.26 mm inhibition zone (Table 3). This is a clear indication that the extract may have very high potent efficacy against multi-bacterial infections.

Antibiotic sensitivity patterns of the extracts of *P. biglobosa* bark in different solvents relative to the control showed that the aqueous fractions of the ethanol extract displayed reasonable activity against the tested organisms (Table 4). The observed zones of inhibition due to the aqueous fraction of the bark extract were clearer and more distinct for *Klebsiella* spp (3.27 mm), *Streptococcus* spp (2.60 mm), *E. coli* (2.73 mm) as against *Bacillus* spp (2.17 mm) and *Salmonella* (2.40 mm) relative to the control. This

contradicts the findings of Udobi and Onaolapo (2009) who reported *S. aureus*, *P. aureginosa* and *E. coli* to be sensitive to Parkia leaf water (PLW) at 200 mg/ml.

Differences in the sensitivity patterns of bacterial isolates on the extracts might be attributed to the differences in the strains utilized for the research as Udobi and Onaolapo (2009) used clinical strains from patients while Igwo-Ezikpe et al. (2013) used strains from food samples collected from Kuto market in Abeokuta, Ogun State, Nigeria.

Conclusion

Hexane extracts showed greater antimicrobial activity against *K. Pneumoniae* bacteria. This suggests it has a broader spectrum of activity on gram negative than on gram positive bacteria. The bark extracts also showed better bactericidal property than the leaf. This suggests that potent secondary metabolites are inherent in the bark as against the leaf. The production of ameliorated traditional drug which will be cost effective using prepared concoctions from the leaf and bark of *P. biglobosa* is recommended. However, an investigation into the antifungal potency of the extracts is however recommended for further study.

REFERENCES

- Abioye EO, Akinpelu DA, Aiyegoro OA, Okoh MFAI (2013). Preliminary phytochemical screening and antibacterial properties of crude stem bark extracts and fractions of *Parkia biglobosa* (Jacq.). *Molecules*. 18(7): 8485-8499.
- Adaramola TF, Ariwaodo JO, Adeniji KA (2012). Distribution, Phytochemistry and Antioxidant Properties of the Genus *Parkia* R.Br. (Mimosaceae) in Nigeria. *Int. J. Pharmacogn. Phytochem. Res.* 4(4): 172-178.
- Agunu A, Yusuf S, Andrew GO, Abdulrahman EM (2005). Evaluation of five medicinal plants used in diarrhea treatment in Nigeria. *J. Ethnopharmacol.* 101(1-3): 27-30.
- Ajaiyeoba EO (2002). Phytochemical and antibacterial properties of *Parkia biglobosa* and *Parkia bicolor* leaf extracts. *Afr. J. Biomed. Res.* 5: 125 - 129.
- Akinyemi KO, Oladapo O, Okwara CE, Ibe CC, Fasura KA (2005). Screening of crude extracts of six medicinal plants used in South-West Nigerian unorthodox medicine for antimethicillin resistant *S. aureus* activity. *BMC Complement. Altern. Med.* 5: 6. <https://doi.org/10.1186/1472-6882-5-6>
- Banwo GO, Abdullahi I, Duguryil M (2004). The antimicrobial activity of the stem bark of *Parkia clappertoniana* keay family Leguminosae against selected microorganisms. *Nig. J. Pharm. Res.* 3(1): 16-22.
- Bukar A, Uba A, Oyeyi TI (2010). Antimicrobial Profile of *Moringa oleifera* Lam. Extracts against some Food-Borne Microorganisms. *Bayero J. Pure Appl. Sci.* 3(1): 43-48.
- Cheesbrough M (2002). Medical laboratory manual for tropical countries. ELBS edition. Tropical health technology publications. UK. 2: 2-392.
- Dharmananda S (2003). Gallnuts and the uses of tannins in Chinese medicine. Proceedings of inst. for Trad. Med. Portland. OR, USA.
- Duker-Eshun GD, Beni CT, Asonaming WA, Akwamoah RA (2001). Chemical investigation of the stem bark of *Parkia clappertoniana* Keay. *J. of Ghana Sci. Assoc.* 3(2): 95-100
- Hazra B, Biswas S, Mandal N (2008). Antioxidant and free radical scavenging activity of *Spondias pinnata*. *BMC Complement. Altern. Med.* 8: 63.
- Hisanori A, Kazuyasu F, Osamu Y, Takashi O, Keiji I (2001). Antibacterial action of several tannins against *Staphylococcus aureus*. *J. Antimicrob. Chemother.* 48(4): 487-491.
- Igwo-Ezikpe (2013). Methanolic extract of parts of *Parkia biglobosa*. *Afr. J. Biotechnol.* 8: 4993-4998.
- Ikeda Y, Fujii Y, Nakaya I, Yamazaki M (1995). Quantitative HPLC analysis of cardiac glycosides in *Digitalis purpurea* leaves. *J. Nat. Prod.* 58(6): 897-901.
- Ivanišová E, Tokár M, Mocko K, Bojňanská T, Mareček J, Mendelova A (2013). Antioxidant activity of selected plant products. *J. Microbiol. Biotechnol. Food Sci.* 2 (Special issue 1): 1692-1703
- Iwu MM, Duncan RA, Okunji CO (1999). New antimicrobials of plant origin. In: Perspective on new crops and new uses, Janick, J. (Ed.). ASHS Press, Alexandria, Virginia. pp. 457-462.
- Kumar S, Sharma UK, Sharma AK, Pandey AK (2012). Protective efficacy of *solanum xanthocarpum* root extracts against free radical damage: phytochemical analysis and antioxidant effect. *Cell. Mol. Biol.* 58(1): 174-181.
- Lewis K, Ausubel FM (2006). Prospects for plant-derived antibacterials. *Nat. Biotechnol.* 24(12):1504-1507.
- Maikai VA, Maikai BV, Kobo PI (2009). Antimicrobial properties of stem bark extract of *Ximenia Americana*. *J. Agric. Sci.* 1(2): 30-34.
- Millogo-Kone H, Guisson IP, Nacoulma O, Traore AS (2006). Study of the antibacterial activity of the stem bark and leaf extracts of *Parkia biglobosa* (Jacq) Benth on *Staphylococcus aureus*. *Afr. J. Trad. Comp. Altern. Med.* 3(2): 74- 78.
- Millogo-Kone H, I.P. Guissou IP, O. Nacoulma O, Traore A (2008). Comparative Study of Leaf and Stem Bark Extracts of *Parkia biglobosa* against Enterobacteria. *Afr. J. Trad. Com.* 5(3): 238-243.
- Nino J, Navaez DM, Mosquera OM, Correa YM (2006). Antifungal and cytotoxic activities of eight Asteraceae and two Rubiaceae plants from Colombian biodiversity. *Braz. J. Microbiol.* 37(4): 566-570.
- Okoh AI (2013). Preliminary phytochemical screening and antibacterial properties of crude stem bark extracts and fractions of *Parkia biglobosa* (Jacq.). *Molecules*. 18(7): 8485-8499.
- Sala A, Recio M, Giner RM, Máñez S, Tournier H, Schinella G, Ríos JL (2002). Antiinflammatory and antioxidant properties of *Helichrysum italicum*. *J. Pharm. Pharmacol.* 54(3): 365-371.
- Scalbert A (1991). Antimicrobial properties of tannins. *Phytochem.* 30(12): 3875-3883.
- Sibanda T, Okoh AI (2007). The challenges of overcoming antibiotic resistance; plant extracts as potential sources of antimicrobial and resistance modifying agents. *Afr. J. Biotechnol.* 6(25): 2886-2896.
- Sofowora EA (1984). Medicinal and Traditional Medicine in Africa. John Wiley and Sons, London. pp. 249.
- Tijani AY, Okhale SE, Salawu TA, Onigbanjo HO, Obianodo LA, J.A. Akingbasote JA, Salawu OA, Okogun JE, Kunle FO, Emeje M (2009). Anti diarrheal and antibacterial properties of crude aqueous stem bark extract and fractions of *Parkia biglobosa* (Jacq) R.Br Ex G. Don. *Afr. J. Pharm Pharmacol.* 7(3): 347-353.
- Trease GE, Evans WC (1989). Pharmacognosy. 15th edn. Brailliar Tridel can, Macmillan Publishers.
- Udobi CE, Onaolapo JA (2009). Phytochemical analysis and antibacterial evaluation of the leaf, stembark and root of *Parkia biglobosa*. *J. Med. Plants Res.* 3(5): 338-344.