

Phytochemical, Antioxidant and Antimicrobial activities of the Hydroalcoholic Extract of the Roots of *Adenodolichos paniculatus* against selected Pathogenic Microorganisms

Njinga S.N.^{1*}, Lawal B.A.², David S.M.³, Eniayewu I.O.¹, Bellol N.⁴, Abiodun O. S.⁵, Kolawole A.J.⁶, Ene O.C.⁷, Bamidele O.D.¹, Saka K.L.⁸, Kayode M. S.², Rahimat O. O.⁹

¹ Department of Pharmaceutical and Medicinal Chemistry, University of Ilorin, Ilorin, Nigeria.

² Department of Pharmacognosy and Drug Development, University of Ilorin, Ilorin, Nigeria.

³ Department of pharmaceutical Microbiology and Biotechnology, University of Ilorin, Ilorin, Nigeria.

⁴ Department of Clinical Sciences and Pharmacy Practice, Faculty of Pharmaceutical Sciences, University of Ilorin, Ilorin, Nigeria.

⁵ Department of pharmaceuticals and Industrial Pharmacy, Faculty of Pharmaceutical Sciences, University of Ilorin, Ilorin, Nigeria.

⁶ Department of Pharmaceutical and Medicinal Chemistry, Faculty of Pharmaceutical Sciences, University of Jos, Jos, Nigeria.

⁷ Department of Chemistry, College of Science, Federal University of Petroleum Resources Effurun, Delta State, Nigeria.

⁸ Department of Pharmaceutical & Medicinal Chemistry, Faculty of Pharmacy, Olabisi Onabanjo University Sagamu, Ogun State, Nigeria.

⁹ Faculty of Pharmaceutical Sciences, University of Ilorin, Ilorin, Nigeria.

*Corresponding author: ngastanjin@yahoo.com / njinga.ns@unilorin.edu.ng.

Abstract

Drugs derived from natural sources present a significant alternative therapy in the management of infectious diseases. The increasing resistance of pathogenic microorganisms to orthodox medicine has necessitated the search for alternative means of treatment. This study aimed at evaluating the phytochemicals, antioxidant and antimicrobial activities of the hydroalcoholic extract of the roots of *Adenodolichos paniculatus* against selected pathogenic microorganisms. Evaluation of phytochemical constituents was done using standard procedures and the antioxidant activity was evaluated using 2,2-diphenyl-2-picryl-hydrazyl. Antimicrobial activity was investigated using fifteen pathogenic organisms, which included five gram-positive and seven gram-negative bacterial strains and three fungal strains using Agar diffusion method. The zones of inhibition of the extract against the test organisms, their minimum inhibitory concentrations (MIC) as well as the minimum bactericidal/fungicidal concentrations (MBC/MFC) were determined. The extract was found to contain steroids, flavonoids, alkaloids and saponins. The total phenols, flavonoids, alkaloids and saponins were found to be 1.427 ± 0.02 mg/g gallic acid, 0.4239 ± 0.19 mg/g quercetin, 5% and 75.23% respectively. The antioxidant activity at concentrations of 7.53 and 15.51 $\mu\text{g/mL}$ were not statistically different from that of vitamin C ($P < 0.05$) and the IC₅₀ (Half-maximal inhibitory concentration) found to be 4.906

$\mu\text{g/mL}$. The zones of inhibition ranged from 22 – 47 mm while the MIC and MBC/MFC was observed to be 5 to 10 mg/mL, and 10 to 40 mg/mL respectively. The availability of phytochemicals with remarkable antioxidant activities and the demonstration of antimicrobial activity against gram-positive, gram-negative bacteria and fungi strains show that *A. paniculata* root is a potential source for the production of antioxidants as well as antimicrobial drugs.

Key Words: *Adenodolichos paniculatus*, antimicrobial activity, antioxidant activity, Phytochemical, zone of inhibition, hydroalcoholic extract.

Introduction

The search for new drugs from natural sources is attracting increasing scientific interest around the world, especially because of the growing incidence of drug-resistant strains of micro-organisms which limit the use of currently available anti-microbial agents and the wide margin of safety associated with plant-derived drugs. Plants contain a variety of secondary metabolites, such as tannins, alkaloids, quinones, simple phenols and flavonoids, which have been found *in-vitro* to have antimicrobial properties, therefore, making them viable sources of new arsenal of antimicrobial drugs [1,2]. This thus sets the stage for further search of more readily available and accessible natural sources of antimicrobial drugs from plants.

Adenodolichos paniculatus (HUA) (Leguminosae) is a

perennial woody multi-purpose shrub that grows up to 4m high in savanna region of Northern Nigeria, Guinea and across to Sudan. The stems are flattened with a velvety red-brown colour when young, and smooth when mature. The leaves are foliate with 3-5 leaflets. The lower surface of leaflets is glandular [3]. *A. paniculatus* is commonly called "wáákénwuta" or "fire bean" in Hausa [4]. The root-decoction is used for blennorrhoea and liver problems in Central Africa Republic [5]. The leaf is applied topically with butter oil for dressing burns in Nigeria and also for toothache in Ubangi [5]. The methanolic leaf extract of *A. paniculatus* have been demonstrated to possess both anti-inflammatory and analgesic activities [6]. Similarly, the methanolic leaf extract of the plant has been reported to have no harmful effect on the liver in sub-chronic toxicity test [6, 7].

Following the plant anti-inflammatory and analgesic activities which have been reported, and the series of its traditional uses, the present study is aimed at evaluating the phytochemicals, antioxidant and antimicrobial activities of the hydroalcoholic extract of the roots of *Adenodolichos paniculatus* against the selected pathogenic microorganisms in the effort to discover new and effective antimicrobial agents.

Methodology

Chemicals and Equipment

Methanol, gallic acid, aluminium chloride, Folin-Ciocalteu's phenol reagent, quercetin, sodium carbonate, sodium chloride, 1,1-diphenyl-2-picrylhydrazyl (DPPH), potassium ferricyanide, iron (III) chloride, tannic acid, sulphuric acid, acetic anhydride, sodium hydroxide, hydrochloric acid, magnesium ribbon, chloroform, glacial acetic acid, Mayer's and Wagner's reagents were from Sigma Aldrich (Gillingham, UK). Other reagents used include Mueller Hinton agar, Sabouraud's dextrose agar and nutrient agar were obtained from Oxoid (Basingstoke, UK).

Equipment used were Electro-Heating Standing Temperature Air Dry Oven, water bath (Fisher Scientific Company, USA), UV-visible Spectrophotometer (Hewlett Packard), analytical weighing balance (Ohaus, USA), Autoclave (Cole Parmer, England) and Incubator (Microfield, SM9052, England).

Collection and Preparation of Plant Sample

The root of *A. paniculata* was collected in Jos in July 2012. It was authenticated at the department of plant science and technology, University of Jos. The roots were dried under shed for two weeks, pulverized and transferred into an extraction bottle. The extraction was carried out using known standard procedures [8]. The pulverized plant material (580g) was macerated using 70% methanol in distilled water for 3 days. The extract was filtered using Whatman filter paper (No. 1) and concentrated in vacuo at 40°C. The hydroalcoholic extract yielded a solid residue weighing 41.13g (7.1% w/w). The extract was then kept in sterile bottles, under refrigerated conditions, until further use. The crude hydroalcoholic extract was used for further investigation for potential of antimicrobial properties.

Qualitative Phytochemical Analysis of hydroalcoholic root extracts

The hydroalcoholic root extracts was subjected to preliminary phytochemical screening to identify the chemical constituents using the standard procedures with some modifications [8, 9]. A stock solution of the extract (10 mg/mL) was prepared and tested for phenols and tannins, steroids, saponins, flavonoids, cardiac glycosides, terpenoids and alkaloids.

Quantitative Phytochemical Analysis

Determination of total phenolics

Total phenolic contents of the hydroalcoholic root extracts were evaluated on each extract with Folin-Ciocalteu's phenol reagent [10, 11]. The extract solution in methanol (2.0 mg/mL) was mixed with 2.0 mL Folin-Ciocalteu reagent previously diluted with water (1:9 v/v). After 5 minutes, 1.6 mL of 7% Na₂CO₃ solution was added with mixing. The tubes were shaken for 5 seconds and allowed to stand for 30 min at 40°C in an oven for color development. Absorbance was then measured at 765 nm using UV-Vis spectrophotometer. Samples of extract were evaluated at a final concentration of 0.01 mg/mL. Gallic acid at different concentrations of 0.01 to 0.07 mg/mL was used as standard. All tests were performed in triplicates. Total phenolic content was expressed as mg/g Gallic acid equivalent using the following equation based on the calibration curve: $y = 1.6232x$, $R^2 = 0.6658$, where y was the absorbance and x was the concentration.

Determination of total flavonoids

Colorimetric aluminum chloride method was used for flavonoid determination of each extract according to the methods of Nabavi et al. [11] with some modifications. 3.0 mL solution of each extract dissolved in methanol was separately mixed with 3.0 mL of 2.0% aluminum chloride. After one hour at room temperature, the absorbance was measured at 420 nm. Extracts were evaluated at a final concentration of 0.1 mg/mL. Quercetin was used as a standard. All tests were performed in triplicates. Total flavonoid content was calculated as quercetin equivalents (mg/g) using the following equation based on the calibration curve: $y = 0.0.23x$, $R^2 = 0.9424$, where y was the absorbance and x was the concentration.

Alkaloids determination

The method of Obadoni and Ochuko [12] was used in which 3 g of the powdered sample was weighed into 150 mL of 20 % acetic acid in ethanol and allowed for 4 h. The mixture was filtered and the filtrate concentrated using a water bath at 55°C to one-quarter of its original volume. Concentrated NH₄OH was added drop wise into the extract until precipitation was complete. The whole solution was allowed to settle and then filtered. The precipitate which is the crude alkaloid was washed with dilute NH₄OH solution. The crude alkaloid was weighed and calculated according to the equation:

$$\% \text{ amount of alkaloid (mg/g)} = \frac{\text{weight of precipitate}}{\text{weight of sample}} \times 100$$

Saponin determination

The saponin content in the plant extracts was estimated as described in literature [13]. Ten grams of the powdered sample was placed in 200 mL of 20% ethanol in water. The suspension was heated in a water bath at 55°C for 4 hours with continuous stirring. The mixture was filtered and the residue was re-extracted as above. The combined extracts were reduced to 40 mL over a water bath at 90°C. The concentrate was transferred into a 250 mL separatory funnel and 20 mL diethyl ether was added and shaken vigorously. The ether layer was discarded, while the purification process was repeated three times. 60 mL of n-butanol was added and the extracts were washed twice with 10 mL of 5% aqueous sodium chloride. The remaining solution was heated in a water bath. After evaporation, the sample was dried at 90°C in the oven to a constant weight. The saponin content was calculated according to the equation:

$$\% \text{ amount of alkaloid (mg/g)} = \frac{\text{weight of residue}}{\text{weight of sample}} \times 100$$

Antioxidant activity: DPPH scavenging activity

The DPPH radical-scavenging activity of the test extracts was examined as described by Kumarasamy et al. [14] with some modifications. Different concentrations (0.03- 0.1 µg/ml) of each extract were separately added, to an equal volume of hydroalcoholic solution of DPPH (100 µM). The mixture was allowed to react at room temperature in the dark for 30 minutes. Vitamin C was used as standard control while a mixture without the extract was taken as blank. After 30 minutes, the absorbance (A) was measured at 518 nm. Each test was carried out in duplicates converted into the percentage antioxidant activity using the following equation:

$$\% \text{ scavenged} = \frac{\text{Absorbance (DPPH)} - \text{Absorbance (Extract)}}{\text{Absorbance (DPPH)}} \times 100$$

The IC₅₀ values of each fraction were calculated by nonlinear regression using graph pad prism. Where the abscissa represented the concentration of fractionated extract and the ordinate represented the average percent of scavenging capacity from the triplicates.

Antimicrobial activities

Test Microorganisms and Culture Media

The test microorganisms used were collected from the department of Pharmaceutical Microbiology and biotechnology, University of Ilorin. The bacteria isolates used were: Methicillin resistant *Staphylococcus aureus* (MRSA), *Staphylococcus aureus*, *Streptococcus pyogenes*, *Bacillus subtilis*, *Corynebacterium ulcerans*, *Escherichia coli*, *Proteus mirabilis*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, *Salmonella typhii*, *Shigella dysenteriae*, *Klebsiella pneumonia*.

The fungi test micro-organisms used are: *Candida albicans*, *Candida krusei*, and *Candida tropicalis*. The bacterial strains were grown in the nutrient broth at 37°C and maintained on nutrient agar slants at 4°C, whereas the fungal strains were grown in Sabouraud dextrose agar (SDA) and Potato dextrose agar (PDA) media, respectively at 28°C. The stock cultures were maintained at 4°C.

Determination of Zone of Inhibition

The antimicrobial activities of crude hydroalcoholic extract were determined against bacterial and fungal isolates. About 0.4 g of the AP extract was dissolved in 10ml DMSO to obtain a concentration of 40 mg/ml of the extract; this was the initial concentration of the extracts used to check the antimicrobial activities of the extracts.

Mueller Hinton agar was selected as the growth medium to the microbes. The medium was prepared according to the manufacturers' instruction, sterilized at 121°C for 15 minutes; the sterilized medium was then poured into sterile petri dishes and was allowed to cool and solidify. Agar diffusion method was the method used to screen the extracts according to the standard procedures [15]. The sterile Mueller Hinton agar plates were seeded with 0.1 ml of standardized inoculum of the test microorganisms, the inoculum was spread evenly over the surface of the medium by the use of a sterile swab.

By the use of a standard cork borer of 6 mm in diameters, a well was cut at the center of each inoculated medium and base sealed with molten agar. 0.1 ml of the extract at different concentrations was then introduced into each well on the inoculated medium. Dimethyl sulfoxide was used as negative control while ciprofloxacin and Fluconazole were used as positive controls for bacterial and fungi respectively. The inoculated medium were then incubated at 37°C for 24 h (bacteria) and 48 h (fungi) respectively, after which each plate of medium was observed for the zones of inhibition of growth.

Determination of Minimum Inhibition Concentration (MIC)

The minimum inhibitory concentration of the extract was carried out using the macro broth dilution method [16, 17]. Two-fold serial dilutions of the extract in the broth was prepared and 2mls aliquots of different concentrations of the solutions were added to 18ml of sterile molten nutrient agar and Sabouraud dextrose agar for bacteria and fungi respectively to obtain the following concentrations of the plant extract at 40, 20, 10, 5 and 2.5 mg/ml. The initial concentration of the plant was obtained by dissolving 0.4g of the extract in 10 mL of the sterile broth. Having obtained the different concentrations of the extract in the broth, 0.1 ml of the standardized inoculum was inoculated into the different concentrations of the extract in the broth; the incubation was made at 37°C for 24hrs. for bacterial strains and 28°C for 48hrs. for the fungal strains. Thereafter each test-tube was observed for turbidity (presence or absence of growth); the lowest concentration of the extract in the broth

which showed no turbidity (growth) was recorded as the minimum inhibition concentration. A test tube with sterile nutrient broth/ potato dextrose media and 1mL suspension of test organisms each (for bacteria and fungi) without the extract and another tube with nutrient broth and 1mL of the extract without the test organisms were provided as positive and negative controls.

Determination of Minimum Bactericidal / Fungicidal Concentration (MBC/MFC)

Minimum Bactericidal/ Fungicidal Concentration was carried out to check whether the test organisms were killed or only their growth was inhibited. Mueller Hinton agar and Sabouraud dextrose agar were prepared, sterilized and poured into sterile petri dishes, the plates were allowed to cool and solidify. The contents of the MIC in the serial dilution were then sub-cultured onto the prepared media, plates were then incubated at 37°C for 24hours for bacteria and at 28°C for 48hrs after which the plates were observed for colony growth. The MBC/MFC were the plates with lowest concentrations of the extract without colony growth [16, 17].

Statistical Analysis

The data were presented as mean $\pm$ standard error of mean and the IC₅₀ analysed using Graph Pad prism 6 (Graph Pad prism 6 software. Inc, USA). Differences of P<0.05 was taken as statistically significant

Results

Qualitative Phytochemistry

Phytochemical constituents present in the hydroalcoholic extract of the roots of *A. paniculatus* were steroids, flavonoids, alkaloids, tannins and saponins as shown in table 1.

Table 1. Phytochemical constituents present in the hydroalcoholic extract of the roots of *A. paniculatus*

Phytochemical constituent	Test	hydroalcoholic extract
Alkaloids	Wagners' Test	+
Cardiac glycosides	Keller-kilani Test	-
Flavonoids	NaOH, Shinoda	+
Saponins	Frothing Test	+
Steroids	Acetic anhydride + Conc. H ₂ SO ₄	+
Tannins	FeCl ₃	-
Terpenoids	CHCl ₃ + H ₂ SO ₄	-

+ (presence of phytochemical) - (Absence of phytochemical)

Quantitative phytochemistry

The level of these phenolic and flavonoid compounds in the methanol extract of the roots of *A. paniculatus* was considerable as shown in Figure 1. The total phenolic and flavonoid contents of the extract were 1.427 $\pm$ 0.02 mg/g gallic acid and 0.4239 $\pm$ 0.19 mg/g quercetin respectively (figure1a). The alkaloids and saponins contents were 5 % and 75.23 % respectively as shown in Figure 1b.

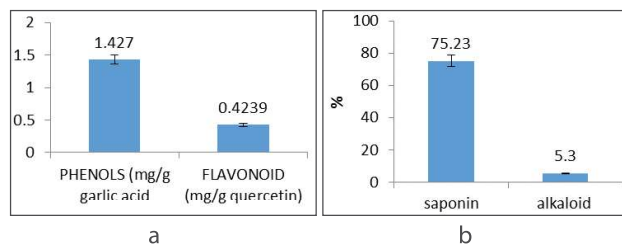


Figure 1. Total phenolic and flavonoid constituents (a) and Percentage saponins and alkaloids (b) in methanol extract of *A. paniculatus*

Antioxidant Activity

The scavenging activity was expressed as percentage inhibition of DPPH free radical (Figure 2). The results of the DPPH assay also showed a dose dependent scavenging activity. As shown in Figure 3, the DPPH radical-scavenging activity at 15.51 and 7.53 μ g/mL was not significantly different (P<0.05) from that of vitamin C (5 μ g/mL). The IC₅₀ was found to be 4.906 μ g/ml

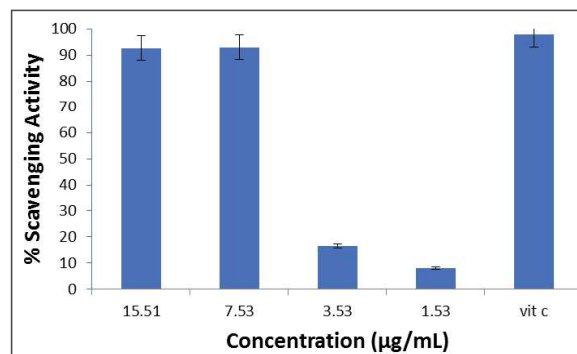


Figure 2. DPPH Scavenging activity of *A. paniculatus* at different concentrations

Antimicrobial activity

The antimicrobial activity of the hydroalcoholic extract of *A. paniculatus* was studied at different concentrations (40, 20, 10, 5 and 2.5 mg/ml) against twelve pathogenic bacterial strains: five gram-positive (Methicillin resistant *Staphylococcus aureus*; *Staphylococcus aureus*; *Streptococcus pyogenes*; *Bacillus subtilis*, *Corynebacterium ulcerans*), seven Gram-negative (*Escherichia coli*; *Proteus mirabilis*; *Proteus vulgaris*; *Pseudomonas aeruginosa*; *Salmonella typhi*; *Shigella dysenteriae*; *Klebsiella pneumonia*), and three fungal strains (*Candida albicans*; *Candida krusei* and *Candida tropicalis*). The results of the antibacterial and antifungal activities are presented in Table 2. The antimicrobial profile of the hydroalcoholic root extract of *A. paniculatus* are presented in Tables 3 to 5. (See tables overleaf)

Table 2. Zones of inhibition of the hydroalcoholic extract and standard drug against the Test Microorganisms

Zones of inhibition (mm)			
Test Organisms	Hydroalcoholic extract(200 mg/mL)	*Ciprofloxacin (5 µg/mL)	*Fluconazole (5 µg/mL)
MRSA	0.0	0.0	
<i>S. aureus</i>	25.0	42.0	
<i>S. pyogenes</i>	27.0	47.0	
<i>B. subtilis</i>	27.0	47.0	
<i>C. ulcerans</i>	0.0	37.0	
<i>E. coli</i>	0.0	34.0	
<i>P. mirabilis</i>	23.0	30.0	
<i>P. vulgaris</i>	27.0	24.0	
<i>P. aeruginosa</i>	22.0	0.0	
<i>S. typhii</i>	0.0	24.0	
<i>S. dysenteriae</i>	0.0	27.0	
<i>K. pneumoniae</i>	28.0	30.0	
<i>C. albicans</i>	0.0		32.0
<i>C. krusei</i>	24.0		30.0
<i>C. tropicalis</i>	0.0		29.0

Table 3. The Antimicrobial profile of *A. paniculata* plant extract.

Test Organisms	Gram +ve or -ve	Plant Extract	Ciprofloxacin	Fluconazole
MRSA	+ve	R	R	R
<i>S. aureus</i>	+ve	S	S	R
<i>S. pyogenes</i>	+ve	S	S	R
<i>B. subtilis</i>	+ve	S	S	R
<i>C. ulcerans</i>	+ve	R	S	R
<i>E. coli</i>	-ve	R	S	R
<i>P. mirabilis</i>	-ve	S	S	R
<i>P. vulgaris</i>	-ve	S	S	R
<i>P. aeruginosa</i>	-ve	S	R	R
<i>S. typhii</i>	-ve	R	S	R
<i>S. dysenteriae</i>	-ve	R	S	R
<i>K. pneumoniae</i>	-ve	S	S	R
<i>C. albicans</i>	Fungus	R	R	S
<i>C. krusei</i>	Fungus	S	R	S
<i>C. tropicalis</i>	Fungus	R	R	S

Key: +ve = Gram positive, -ve = Gram negative, R = Resistant strain, S = Susceptible strain.

Table 4. Minimum inhibitory concentration (MIC) of the extract against the micro-organisms.

Test Organisms	40 mg/mL	20 mg/mL	10 mg/mL	5 mg/mL	2.5 mg/mL
<i>S. aureus</i>	-	-	**	+	+
<i>S. pyogenes</i>	-	-	**	+	+
<i>B. subtilis</i>	-	-	-	**	+
<i>P. mirabilis</i>	-	-	**	+	++
<i>P. vulgaris</i>	-	-	-	**	+
<i>P. aeruginosa</i>	-	-	**	+	++
<i>K. pneumoniae</i>	-	-	-	**	+
<i>C. krusei</i>	-	-	**	+	++

Key: - = No turbidity (no growth), ** = Minimum inhibitory concentration, + = Turbid (light growth), ++ = Moderate turbidity, +++ = High turbidity

Table 5. Minimum bactericidal/fungicidal concentration of the extract against the micro-organisms

Test Organisms	40 mg/mL	20 mg/mL	10 mg/mL	5 mg/mL	2.5 mg/mL
<i>S. aureus</i>	-	**	+	++	+++
<i>S. pyogenes</i>	-	-	**	+	++
<i>B. subtilis</i>	-	**	+	++	+++
<i>P. mirabilis</i>	**	+	++	+++	++++
<i>P. vulgaris</i>	-	-	**	+	++
<i>P. aeruginosa</i>	**	+	++	+++	++++
<i>K. pneumoniae</i>	-	-	**	+	++
<i>C. krusei</i>	-	**	+	++	+++

Key: - = No colony growth, ** = Minimum bactericidal/fungicidal concentration, + = Scanty colony growth, ++ = Moderate colony growth, +++ = Heavy colony growth

Discussion

The results in the present study revealed the presence of low level of hydroalcoholic soluble phytochemicals as extractive values (7.1% w/w). From the phytochemistry, the extract contained mostly flavonoids, alkaloids and saponins. The results also revealed a considerable high level of the phenolics. Reports on phytochemistry on the leaves show the presence of flavonoids, tannins, steroids, carbohydrates, glycosides, alkaloids, anthraquinones and cardiac glycosides [6].

Attention of antioxidants derived from natural sources has increased and efforts in screening and characterization have been put into identifying antioxidant compounds suitable to replace synthetic ones [18]. Thus, there is continued search for phytochemicals with potent antioxidant for remedies against free radical mediated diseases prevention of oxidative stress, oxidative reaction in food, protection against DNA damage and carcinogenesis [19, 20].

Flavonoids is one of the several categories of phenolic compounds which have potent antioxidant activities [21]. Flavonoids reduce free radicals by chelating, up-regulating and quenching radical intermediate compounds [22]. DPPH is used to measure the electron donation ability of extracts through decolorization of DPPH solution by antioxidant or a radical species [21]. Free radical scavenging activity of the extract is indicated by decrease in the absorbance of the reaction mixture between DPPH and the extract [23]. In this study, the hydroalcoholic extract of *A. paniculata* showed highest antioxidant activity at 15.51 and 7.53 µg/mL which was statistically significant ($P < 0.05$) compared to that of vitamin C. The high presence of flavonoids in this extract justifies its high antioxidant activity. The antioxidant and antimicrobial activities of other members in this family as well as this plant species is scarce in the literature.

All the tested microorganisms were susceptible to ciprofloxacin except for MRSA (gram +ve) and *P. aeruginosa* (gram -ve) that demonstrated resistant strains toward ciprofloxacin. In like manner, two-gram positive (MRSA and *C. ulcerans*) and three- gram negative (*P. aeruginosa*, *E. coli* and *S. dysenteriae*) strains demonstrated resistant to the

plant extract. Also, the three fungi strains used were susceptible to fluconazole while only *C. krusei* was susceptible to the plant extract.

For the minimum inhibitory concentration (MIC) experiment, only the microorganisms which were susceptible to the plant extract were selected and the plant extract at 5mg/mL was able to inhibit the growth of *B. subtilis*, *P. vulgaris* and *K. pneumoniae* while the growth of *S. aureus*, *S. pyogenes*, *P. mirabilis*, *P. aeruginosa* and *C. krusei* were inhibited at higher concentration of the plant extract (10mg/mL). No inhibition was observed when 2.5mg/mL of the plant extract was used. However, all the test micro-organisms had no growth at 20mg/mL and 40mg/mL of the plant extract. This result shows that the inhibitory activities of the plant extract was concentration dependent with higher potency observed on *B. subtilis*, *P. vulgaris* and *K. pneumoniae*.

The bactericidal and fungicidal activities result of the plant extract showed that the plant extract had a bactericidal effect on *B. subtilis*, *P. vulgaris* and *K. pneumoniae* at 10mg/mL while the bactericidal effect was at 20mg/mL for *S. aureus* and *S. pyogenes*. Only at a higher concentration of 40mg/mL was bactericidal effect of the plant extract observed for *P. mirabilis* and *P. aeruginosa*. The plant extract also demonstrated fungicidal activity on *C. krusei* at 20mg/mL.

Flavonoid and its derivatives have shown a wide range of antimicrobial, antiviral, anti-inflammatory, as well as anticancer activities [24]. Antifungal activity of saponins have also been reported [25]. Results from these studies show a good level of antimicrobial activity of the extract as the same was observed to inhibit the growth of three out of the four (75%) gram positive organisms tested and four out of seven (57.14%) of the gram-negative organisms tested with pronounced activity against *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*. These two-gram negative organisms are known pathogenic organisms which are mostly resistant to antibiotics commonly prescribed. Aqueous and hydroalcoholic extracts have been reported to be more effective against gram positive than gram negative bacteria [26]. However, the antifungal properties are not as broad as the antibacterial properties as 33% of the fungal isolates were observed to be susceptible to the extract while the standard antifungal drug gave 100% inhibition of the isolates. The presence of flavonoids and saponins could therefore have accounted for the broad-spectrum antimicrobial activity of the hydroalcoholic extract of *A. paniculata*.

Limitation of the study

The limitation of this study is the utilization of "one-dimensional" character of methods used to evaluate antioxidant activity. Also, the percentage yield was too low and prevented further investigations.

Conclusion

A. paniculata contains phenolic compounds as well as alkaloids with antioxidant and wide spectrum antimicrobial

activity which serve as scientific basis for the use of this plant in traditional medicine.

Conflict of Interest

There is no conflict of interest with the data contained in this manuscript.

Source of Funding

This research was not funded by any organization.

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