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Antimicrobial Activity of *Acacia nilotica* Stem Bark Extract against Bacterial Pathogens Associated with Wound Infections in Jos, Nigeria

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ABSTRACT: The study was carried out to evaluate the *in vitro* antimicrobial activity of crude extracts of *Acacia nilotica* against bacterial isolates from wound of out-patients' at the Plateau Specialist Hospital, Jos, Nigeria using standard microbiological methods. Six bacterial isolates (*Escherichia coli, Proteus mirabilis, Staphylococcus aureus, Streptococcus pyogenes, Pseudomonas aeruginosa* and *Klebsella pneumonia*) were identified. Ethanol and aqueous extraction led to high percentage yields of 23.9% and 22.4% respectively. Phytochemical screening revealed the presence of tannins, saponins, flavonoids, carbohydrates, steroids, anthroquinines, terpenes and cardiac glycosides. The ethanol extract of *A. nilotica* stem bark was equally or more effective than the standard antibiotic (Gentamycin). Ethanol and aqueous stem back extracts of *A. nilotica* exhibited excellent antibacterial activity against all the isolates of wound infections tested, especially against *Streptococcus pneumoniae* which showed the maximum antibacterial activity with mean zones of inhibition (33 and 25mm) in ethanol and aqueous extracts respectively at 200 mg/ml concentration. Overall maximum inhibition zone (22mm) was caused by the ethanol extract against *Streptococcus pneumoniae* while the minimum zone of inhibition (12mm) was caused by the aqueous extract against *Escherichia coli, Staphylococcus aureus* had the lowest MIC (3.125mg/ml) for both aqueous and ethanol extracts. *A. nilotica* aqueous extracts exhibited the greatest antibacterial activities as determined by the MBC which ranged between 6.25 and 50 mg/ml. In the present study, the MIC value of the aqueous and ethanol extracts was lower than the MBC values, suggesting that *A. nilotica* aqueous extracts were bacteriostatic at lower concentrations but bactericidal at higher concentrations. Also, the bacterial zone of inhibition increased with increasing concentration of *A. nilotica* aqueous and ethanol extracts. All the bacterial isolates were susceptible to the plant extract used in this study. This supports the use of *A. nilotica* stem bark as a folklore remedy in the treatment of diseases caused by bacterial isolates in this study. Further research is needed to examine the extracts' *in-vivo* mechanism of action, toxicity, and therapeutic effect.

Keywords: *A. nilotica,* Bacteria, wound infection, antimicrobials, minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC)

INTRODUCTION

Plant based antimicrobials represent a vast untapped source of medicines. Nature has been a source of medicinal agents for thousands of years and since the beginning of man. In Nigeria, almost all plants are medicinal and the application of medicinal plants especially in traditional medicine is currently well acknowledged and established as a viable profession (Kafaru, 1994). Extraction of bioactive compounds from medicinal plants permits the demonstration of their physiological activity. It also facilitates pharmacological studies leading to synthesis of a more potent drug with reduced toxicity (Ebana *et al*., 1991; Williams, 1996; Pamplona–Roger, 1999; Manna and Abalaka, 2000).

Furthermore, the active components of herbal remedies

have the advantage of being combined with many other substances that appear to be inactive. However, these complementary components give the plant as a whole a safety and efficiency much superior to that of its isolated and pure active components (Shariff, 2001). They are potent in the treatment of infectious diseases while simultaneously mitigating many of the side effects of synthetic antimicrobials (Iwu *et al.,* 1999). They may act as lead compounds for the pharmaceutical industry or as the base for the development of new antimicrobials (Aiyelaagbe, 2001; Aiyegoro *et al.,* 2008).

Antibiotics provide the main basis for the therapy against various microbial infections. Since their discovery, antibiotics have completely transformed humanity's approach to infectious diseases and have substantially reduced the threat posed by infectious diseases. However, the increasing resistance of many bacteria and the side effects to the currently used antibiotics are documented (Lancaster and Swart, 1998; Ostier, 1993; Vaughan and Asbury, 1980; Skies *et al.,* 2007). Presently in the developing countries, synthetic drugs are not only expensive and inadequate for the treatment of diseases but are also often with adulterations and side effects (Shariff, 2001).

Moreover, the emergence of drug-resistant microorganisms is swiftly reversing the advances of the previous 50 years of research. These drug-resistant microorganisms have complicated the treatment of infectious diseases in Nigeria. In the 21st century, antibiotic resistance of clinical bacterial isolates is increasing drastically; the search for new and safe anti-bacterial compounds are important and natural medicinal products seem to be a logical and effective source for seeking new antimicrobial agents (Raphael, 2011; El-Ghani, 2016). Excessive irrational use of antibiotics has led to the emergence of various microorganisms with multidrug resistance (Perez *et al.,* 1990) so; there is a need for formulation of new antimicrobial agents. In this context, there is an urgent need to find new antimicrobial agents against resistant microorganisms from different sources, especially of plant origin.

Since ancient times natural products have been used in traditional medicine all over the world and their use predates the introduction of antibiotics and other modern drugs (Raphael, 2011). Scientists from divergent fields are now investigating plants with a new view of their antimicrobial usefulness and as an alternative source to existing drugs (El-Ghani, 2016). Further exploration of plant antimicrobials is needed as antimicrobials of plant origin have enormous therapeutic potential.

Acacia nilotica (L.) Willd. ex Del. also known as Gum Arabic tree, Babul, Bagaruwa in Hausa, "Baani" in Yoruba "Booni" in Igbo. Egyptian thorn or prickly Acacia is a multipurpose nitrogen fixing tree legume (Aliyu, 2006; Saini *et al*., 2008; Kaur *et al.,* 2016). It is a pioneer species, relatively high in bioactive secondary compound and is important for a variety of functions (Aliyu, 2006; Abdulhamid *et al*., 2018). It is economically used as a source of tannins, gums, timber, fuel and fodder. In Nigeria, the plant is traditionally used to treat infections such as diarrhoea, dysentery, oxidative stress, intestinal pains, ulcer, cold, haemorrhages, tuberculosis, congestion, coughs and fever (Aliyu, 2006; Saini *et al*., 2008). Banso (2009) and Mashram (2009) reported the antimicrobial activity of ethanol extracts of the stem bark against human pathogenic microorganisms. Mahesh et al. (2018) and Mohammed et al. (2010) reported the antifungal activity of methanol and aqueous extract of *A. nilotica* (Sati and Joshi 2011). Natural medicinal plants promote self-healing, good health and durability in ayurvedic medicine practices. It has been acknowledged that *A. nilotica* can provide the nutrients and therapeutic ingredients needed to prevent, mitigate or treat many diseases or conditions (Bargali *et al.,* 2004).

Accurate information of the incidence and etiology of wound infections acquired within and outside hospitals is essential for articulation of effective preventive measures (Sanjay *et al.,* 2010; Ogba1 *et al.,* 2014). The need to solve the problems of wound infections has been demonstrated through various researches in the utilization of natural medicinal plants such as *A. nilotica* (Bargali *et al.,* 2004; El-Ghani, 2016). The plant has been reportedly used as medicinal plant in parts of Northern Nigeria, West Africa, North Africa, East Asia and other parts of the world (Aliyu, 2006; Saini *et al*., 2008). *A. nilotica* is an imperative multipurpose plant used in traditional medicine. It still plays an important role in the developing countries where it is valued for being inexpensive, effective, and of natural origin (Aliyu, 2006; Arora and Kaur, 2007; Saini *et al*., 2008; Raphael, 2011; Abdulhamid *et al*., 2018). Against this background, this study was aimed at determining the phytochemical constituents and antimicrobial activity of the aqueous and ethanolic extracts of *A. nilotica* stem bark against aerobic bacteria associated with wound infections of out-patients at the Plateau Specialist Hospital, Jos, Plateau State, Nigeria.

MATERIALS AND METHODS

Collection of plant materials

A. nilotica plant was collected from a forest in Toro Local Government Area of Bauchi State, Nigeria. The plants were duly authenticated at the Herbarium Unit of the Department of Plant Science and Biotechnology, University of Jos, Nigeria where a voucher specimen has been deposited.

Source of culture, identification and maintenance of bacteria isolates

Wound swabs and pus were collected aseptically from 120 male and female volunteer out-patients at the

Plateau State Specialist Hospital, Jos in 2019. The samples were collected using sterile swab sticks. The subjects were recruited upon approval by the Ethical Research Committee of the Jos University Teaching Hospital (JUTH). Written and oral informed consent was obtained from each of the subjects. The bacterial isolates were obtained during parallel clinical studies involving patients with wound infections. Sampling, culturing, isolation and identification were done in the Department of Clinical Microbiology laboratory at the Faculty of Pharmaceutical Sciences, University of Jos using standard microbiology techniques (Collee *et al.,* 1996; Cheesbrough, 2005). The isolates were cultured unto nutrient broth and incubated overnight (8 h) at 37°C after which each isolate was streaked on different media (McConkey agar, Centrimide agar, Mannitol Salt agar and Blood agar) and then sub-cultured unto nutrient agar at 37°C for 24 h. Bacterial pure cultures were grown in Mueller-Hinton agar (MHA) and Mueller-Hinton broth (MHB) in distilled water at 15 lbs psi for 25-30 min and further maintained on the different prepared media at 37°C for 48 h and then stored at 4°C.

Standardization of microorganisms

Exactly 0.2 ml of overnight cultures of each organism was dispensed into 20 ml of sterile nutrient broth and incubated for 3 – 5 h to standardize the culture to 0.5 McFarland standard (1.5×10^8 CFU/ml, 0.5 McFarland standard). A loop full of the standard cultures was used for the antibacterial assay (Collins *et al*., 1995; CLSI, 2010)

Preparation and extraction of plant material

The stem-bark of A. *nilotica* plant was obtained, air dried over a period of three weeks under shade and pulverized with the aid of a pestle and mortar. The method of Okogun, (2000) was used to obtain the plant extracts. Fifty grams (50g) each of the dried stem bark powder was extracted with 200 ml of water and ethanol to get the aqueous and ethanolic extracts respectively. The aqueous and ethanolic extracts were obtained by macerating the stem bark powder in the respective solvents. The extraction was carried out in a rotary shaker for 24 h. The extracts were filtered, centrifuged at 5000 rpm for 15 min and dried under reduced pressure. The air dried extract was stored at 4ºC in airtight bottles. The sterility of the extract was tested before use.

Phytochemical screening of crude extracts

The phytochemical components of the stem bark of *A. nilotica* were screened for using the methods of Harbone, (1984) and Trease and Evans, (1989). The components analyzed for are saponins, saponin glycosides, steroid, glycosides, anthraquinones, tannins, flavonoids alkaloids and phenols.

Determination of *In-vitro* antibacterial activity

Test microorganisms

In vitro antibacterial activity of the crude extracts was studied against six different strains of both Gram positive bacteria *(Streptococcus pneumonia* and *Staphylococcus aureus)* and Gram negative bacteria (*Escherichia coli, Proteus mirabilis, Pseudomonas aeruginosa* and *Klebsiella pneumonia*) for the determination of antibacterial activity.

Antibacterial activity

Antibacterial activity of *A. nilotica* against the clinical bacterial isolates was determined by standard microbiology techniques (Agar well Diffusion and Broth macro-dilution methods) described by Perez *et al.* (1990); Collins *et al*. (1995); Bauer *et al.* (1996); Collee *et al.* (1996); Okogun, (2000) and CLSI, (2010) with slight modifications. The approved guidelines used for dilution antimicrobial susceptibility testing involves the use of MIC and MBC of test bacterial isolates. These standards are recognized and provided by the CLSI and the European Committee on Antimicrobial Susceptibility Testing (EUCAST) (Balouiri *et al*., 2016). Two grams (2g) each of the extract was weighed and dissolved in 10 ml of water each to give a concentration of 200 mg/ml. A two-fold serial dilution was carried out for each extract (aqueous and ethanol) and various concentrations of 100, 50 and 25 mg/ml were obtained. One hundred microliter (100 µl) volumes of standardized inoculum (1.5×10^8 cfu/ml, 0.5 Mac-Farland standards) of each test bacterium were inoculated on molten Mueller-Hinton agar (Oxoid, Hampshire, UK) slant, homogenized and poured into sterile plates. Standard cork borers of various diameter (6, 16 and 20 mm) were used to make uniform wells into which different concentrations (100, 50 and 25 mg/ml) of aqueous and ethanol extracts of *A. nilotica* were added using sterile micropipettes. Standard antibiotic gentamycin 20 µg/ml was used as positive control and 50 mM sodium phosphate buffer alone was used as negative control. The plates were then incubated at 37°C for 24 h. The experiments were carried out in triplicates and the zones of inhibition were measured with the help of a metre-rule and recorded.

Determination of minimum inhibitory concentrations (MIC)

The MIC of *A. nilotica* was determined by macro dilution method (Weckesser *et al*., 2007). Several concentrations

of the aqueous and ethanol extracts (1.563-50mg/ml) and standard antibiotic (Gentamycin 5 mg/disc) were prepared from stock solutions by serial dilution technique. One millilitre of each dilution was mixed properly with 20 ml of sterile molten Muller Hinton agar and poured into 90 mm Petri plates and allowed to cool under laminar air flow for 24 h before streaking with 1.5×10^8 cfu/ml, 0.5 McFarland standards. The lowest concentration which did not show any macroscopic growth of test bacterium was identified as the MIC.

Determination of minimum bactericidal concentration (MBC)

The MBCs of the *A. nilotica* extracts were determined by macro broth dilution method used for quantitative determination of *in vitro* antimicrobial activity against bacterial isolates (Perez *et al.,* 1990). Eight (8) sterile tubes each were provided for the aqueous and ethanolic extract concentrations according to the number of test isolates. Six of the tubes contained the *A. nilotica* extracts at the following concentrations: 50, 25, 12.5, 6.25, 3.125, and 1.563mg/ml while the remaining two tubes contained standard antibiotic; Gentamycin was used as positive control and 50 mM sodium phosphate buffer alone was used as negative control. Six (6) tubes out of eight were inoculated with 1.5×10^8 cfu/ml (0.5 McFarland standards) of a single bacterial species. The eighth plate was left un-inoculated (without the extracts) to serve as control. The plates were then incubated at 37°C overnight and the lowest dilution that caused complete inhibition of bacterial growth was taken as the MBC. Each of the extract was tested in triplicate and the average values were obtained for two repeated experiments.

Statistical analysis

Experimental data were analyzed statistically. Antibacterial activities of the aqueous and ethanolic extracts on the bacterial isolates were expressed as mean ± standard deviation (SD) of growth inhibition zone diameters. Statistical significance was determined by analysis of variance (ANOVA) with the aid of Microsoft Excel Version 2010. P-values < 0.05 were considered significant. Least significant difference (LSD) was used to test for means with significant differences.

RESULTS

Phytochemical screening of crude extracts of *A. nilotica* indicated that the plant had alkaloids, saponins, tannins, carbohydrates, steroid, anthroquinines, terpenes, cardiac glycosides, flavonoids, and phenols (Table 1). The percentage yields of the stem bark of *A. nilotica* crude extracts shows that ethanol extract had 23.9% while the aqueous extract had 22.4% (Table 1).

Antimicrobial activity (Mean zone of inhibition) of the aqueous and ethanol crude extracts

In the present study, all the tested bacteria were sensitive to *A. nilotica* aqueous and ethanol extracts. Among the Gram positive and Gram negative bacteria; *S. pneumonia* and *K. pneumonia* exhibited highest rate of sensitivity to *A. nilotica* ethanol extract with zones of inhibition of 36 mm and 31 mm respectively (Table 3). *S. aureus, a Gram-positive bacterium, and P. mirabilis, a Gram-negative bacterium, exhibited the highest rates of antibacterial activity A. nilotica* aqueous extract with zones of inhibition of 25 mm and 30 mm respectively (Table 4). The zone of inhibition for the *A. nilotica* extracts obtained were either equal or larger than that of the antibiotic (Gentamycin) used to treat wound infections (Tables 3 and 4).

Minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC)

The results showed the broad spectra of antibacterial activity of *A. nilotica* aqueous and ethanol extracts (Figure 1). The MIC and MBC of *A. nilotica* aqueous and ethanol extracts against the clinical isolates has been presented in (Tables 4 and 5). The inhibition of tested bacteria increased with increase in the amount of the *A. nilotica* aqueous and ethanol extracts (Tables 4, 5 and Figure 1). Among the Gram positive bacteria strain, *S. pneumonia* isolates were found to be more sensitive than Gram Negative *P. aeruginosa*. Meanwhile, *S. aureus* was the less sensitive in both aqueous and ethanol extracts (Tables 4 and 5). *Proteus mirabilis, Klebsiella pneumonia* and *E. coli* exhibited the greatest MIC and MBC of 25mg/ml each in ethanol extract (Table 5). The lowest MIC value was observed towards *Staphylococcus aureus* followed by *K. pneumonia* (3.125mg/ml and 6.25mg/ml) in both aqueous and ethanol extracts. *A. nilotica* aqueous extracts exhibited the greatest antibacterial activities as determined by the MBC which ranged between 12.5-50 mg/ml. The lowest MBC value was recorded for *S. aureus, P. aeruginosa* and *K. pneumonia* (12.5 mg/ml each) (Table 5).

DISCUSSION

The plant materials used in this study was initially extracted with ethanol and water; the choice of ethanol as a solvent for extraction was based on the earlier observation that an organic solvent, especially ethanol was a better solvent for consistent extraction of antimicrobial compounds from medicinal plants in

Table 1: Phytochemical constituents of stem bark of *Acacia nilotica*.

Active Constituent	Ethanol Extract	Aqueous Extract
Alkaloids	-	-
Tannins	+++	++
Saponins	+++	+++
Flavonoids	+++	++
Carbohydrates	+	+
Steriods	++	-
Anthroquinines	+++	++
Terpenes	-	-
Cardiac glycosides	++	+

% yield = $\frac{wt\ of\ Extract}{wt\ of\ crude\ powder} X100$ $\frac{19.1}{80} X100 = 23.9\%$ $\frac{17.9}{80} X100 = 22.4\%$

Key: + = Present
- = Absent
++ = Moderately present
+++ = Highly present

Table 2: Mean zones of inhibition (mm) of aqueous extract of stem back of *A. nilotica* against bacterial isolates in comparison with standard antibiotic.

Organism	Standard (Gentamycin 5 mg/disc)	Mean zone of inhibition (mm) (mean ± SD) Concentration of Aqueous extract (mg/ml)			
		200	100	50	25
Pseudomonas aeruginosa	26± 1.52	21± 1.00	19± 1.00	18± 1.00	15± 0.57
Streptococcus pneumonia	23± 1.00	25± 1.52	22 ± 1.00	20 ± 0.57	18± 0.57
Proteus mirabilis	30± 1.52	23± 1.00	21± 1.00	20± 0.57	17± 0.57
Klebsiella pneumonia	24± 1.00	21± 1.00	18± 1.00	16± 0.57	13 ± 0.57
Staphylococcus aureus	25± 1.52	22± 1.00	19± 0.57	16± 0.57	14± 0.57
Escherichia coli	21± 1.00	21± 1.00	18± 0.57	17± 1.00	12± 0.57

Table 3: Mean zones of inhibition (mm) of ethanolic extract of stem back of *A. nilotica* against bacterial isolates in comparison with standard antibiotic.

Organism	Standard (Gentamycin 5 mg/disc)	Mean zone of inhibition (mm) (mean ± SD) Concentration of Aqueous extract (mg/ml)			
		200	100	50	25
Pseudomonas aeruginosa	26± 1.00	26± 1.52	24± 1.00.	22± 1.00.	20± 1.00.
Streptococcus pneumonia	36± 1.52	33± 1.52	30± 1.52	26 ± 1.00	24± 0.57
Proteus mirabilis	30± 1.52	24± 0.57	21± 1.00.	18± 1.00	15± 0.57
Klebsiella pneumonia	31± 1.52	31± 1.52	28± 1.52	26± 1.52	23± 1.00
Staphylococcus aureus	24± 1.00.	25± 0.57	22± 1.00.	19± 1.00	17± 1.00
Escherichia coli	28± 1.00	21± 1.00.	18± 1.00	16 ± 1.00	13± 0.57

Table 4: Minimum inhibitory concentration and maximum bactericidal concentrations of aqueous extracts of *A. nilotica* against bacteria isolates from wounds.

Organisms	Minimum Inhibitory Concentration (MIC) mg/ml	Minimum Bactericidal Concentrations (MBC) mg/ml
Pseudomonas aeruginosa	6.25	12.5
Streptococcus pneumonia	25	50
Proteus mirabilis	12.5	25
Klebsiella pneumonia	6.25	12.5
Staphylococcus aureus	3.125	12.5
Escherichia coli	12.5	25

Table 5: Minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) of ethanol extracts of stem back of *A. nilotica* against bacterial isolates from wounds.

Organisms	Minimum Inhibitory Concentration (MIC) mg/ml	Minimum Bactericidal Concentration (MBC) mg/ml
Pseudomonas aeruginosa	6.25	12.5
Streptococcus pneumonia	6.25	12.5
Proteus mirabilis	12.5	25
Klebsiella pneumonia	12.5	25
Staphylococcus aureus	3.125	6.25
Escherichia coli	12.5	25

Figure 1. Antibacterial activities of aqueous and ethanolic extracts of Accacia nilotica stem bark as shown by zones of inhibition against bacterial isolates

comparison to other solvents such as water, hexane and ethanol (Nebedum *et al.,* 2009; Rojas *et al*., 2006). The ethanolic and aqueous extracts of the stem bark of *A. nilotica* studied were found to contain the following phytochemical compounds: steroids, tanins, saponins, flavonoid, cardiac glycosides, carbohydrates, alkaloids, anthroquinines flavonoid and tarpenes (Table 1). The results of the present study also showed the absence of glycosides and balsams from the plant extract, although they were originally present in the crude extract. The loss of these phytochemical components may be due to fractionation. Harbone (1984) reported that the activity of plant extracts can sometimes change after fractionation and a pure crystalline compound may eventually be obtained which lacks the activity of the original extract. Crude ethanol and aqueous extracts of *A. nilotica* had high percentage yields of 23.9% and 22.4% respectively. This result does not agree with the study by Abdulhamid *et al*. (2018) who reported a lower percentage yield of (9.72%) in the same plant parts extracted even though they used methanol as solvent of extraction while this study used ethanol and water.

Several other studies have reported similar phytochemicals from this plant (Banso, 2009; Okoro *et al.,* 2014); these support the data reported in this research. These compounds are known to be biologically active (Bruce *et al*., 2000; Ververidis *et al.,* 2007) and thus may contribute to the observed antibacterial activities in the plant (Raphael, 2011). The inhibitory effects of these medicinal plants on the bacterial isolates may therefore be due to the presence of the above phytochemical components. Phytochemicals exert antimicrobial activity through different mechanisms. For instance, flavonoids possess a wide range of biological activities which include antimicrobial, anti-inflammatory, analgesic, anti-allergic effects, cytostatic and antioxidant properties (Maikai *et al*., 2009). The antibacterial activity of flavonoids had been shown to be a result of their ability to form complexes with bacterial cell walls' extracellular and soluble proteins (Scalbert, 1991). This also agrees with the findings of a similar research by Okoro *et al.* (2014). Carbohydratewas present in both ethanolic and aqueous extracts. On the other hand, aqueous extract of the plant had high content of saponins while tanins, flavonoids and anthroquinines are moderately present. Cardiac glycosides were also present. This is in tandem with the research conducted by Banso (2009). Herbs that have tannin as their component are astringent in nature and are used for treating intestinal disorders such as diarrhoea and dysentery thus exhibiting antimicrobial activity (Dharmananda, 2003). Tannins have been reported to prevent the development of microorganisms by precipitating microbial protein and making nutritional protein unavailable for them (Dharmananda, 2003). Saponins are known to produce inhibitory effects on inflammatory processes. They were also reported to possess antibacterial property.

Alkaloids are another kind of phytochemicals detected in most of the plant extracts tested. Alkaloids have been associated with medicinal uses for centuries. One of the most common biological properties of alkaloids is their toxicity against cells of foreign organisms (Banso, 2009). Another important phytochemical detected in the plant extracts tested is cardiac glycosides. Cardiac glycosides are an important class of naturally occurring compounds whose actions help in the treatment of congestive heart failure (Banso, 2009). Taken together all these facts support the utilization of this plant (*Acacia nilotica*) in various African countries such as Nigeria, Mali, Niger, Republic of Chad, Benin and Cote d"Ivoire in the preparation of local medications for the treatment of diseases (Abdulhamid *et al.,* 2018).

In the present study, all the tested bacteria isolates were sensitive to the aqueous and ethanol extracts of *A. nilotica* compared well with the standard (Gentamycin). Among the Gram positive and Gram negative bacteria; *S. pneumonia* and *K. pneumonia* exhibited highest sensitivity to *A. nilotica* ethanol extract than aqueous extract on *S. aureus* and *P. mirabilis* (Tables 3 and 4). The extracts tested displayed a varying degree of antibacterial activity against the bacterial isolates. The extract at a concentration of 200 mg/mL was found to inhibit the growth of most of the test bacterial isolates comprising both Gram-positive and Gram-negative organisms. These findings support previous reports on the antimicrobial activity of these plants (Banso, 2009; Okoro *et al.,* 2014).

The results of the present study showed that lowest MICs (the lowest concentration of the assayed antimicrobial agent that inhibits the visible growth of the microorganism tested) and MBCs value in both aqueous and ethanol extract of *A. nilotica* merely inhibited the growth of *Pseudomonas aeruginosa*, *Klebsiella pneumonia* and *Staphylococcus aureus* compared to the other bacterial isolates. In other words, the minimum inhibitory concentration (MIC) for *S. pneumonia, E. coli K. pneumonia, P. mirabilis, P. aeruginosa* are higher than that of *S. aureus* for the plant, *A. nilotica*, meaning that higher doses of antimicrobial agents will be required in infections where these bacterial isolates are the aetiologic agents. The MIC value for *S. aureus* was greater than 3.125mg/ml suggesting that very large amount of the drug is required to inhibit the growth of the organism. This means that the extract has no effect on these organisms. The MIC values of the active ethanol extract were lower than the MBC aqueous extract values suggesting that, the *A. nilotica* ethanol extracts were bacteriostatic at lower concentration but bactericidal at higher concentration (Tables 4 and 5). This agreed with the study by Akinpelu and Onakoya, (2006) who reported that the pace of development of new antimicrobial drugs has slowed down, while prevalence of resistance has increased multi-fold. This also had been reported by Arora and Kaur, (2007), Gurudeeban *et al.* (2010),

Pavithra *et al*. (2010) and Aldebasi *et al*. (2013).

The mean zone of inhibition as shown in (Tables 2, 3 and Figure 1) increased with increase in the concentration of the *A. nilotica* aqueous and ethanol extracts. The findings of this study are similar to several reports by scientists on antimicrobial studies of some medicinal plants (Yogesh and Mohan, 2006; Maji *et al*., 2010; Gurudeeban *et al*., 2010; Aldebasi *et al.,* 2013; Abdulhamid *et al*. 2018). A moderate level of resistance was exhibited by some of the bacterial isolates (*S. aureus, K. pneumonia* and *Pseudomonas aeruginosa*) to *A. nilotica* aqueous and ethanol extracts when compared with gentamycin which served as the positive control. This may be attributed to the fact that gentamycin and its derivatives have been widely abused and frequently implicated in self-medication in Nigeria. It could also be due to the fact that the amount of the components in the crude extract may be little or diluted and when fractionated, the components become concentrated and therefore exhibit activity on the organisms that were initially resistant to the crude extract. Pondei *et al.* (2013) also reported that high levels of antibiotic abuse in Nigeria arose from self-medication which is associated with inadequate dosage and failure to comply with treatment regimen. These antibiotics are being sold over the counter with or without prescription (Anguzu and Olila, 2007). The bacteria isolates used in this study include pathogens such as *E. coli* known to cause urinary tract infections; *K. pneumoniae* known to be the causative agent of pneumonia (Dromigny *et al.,* 2005). All the bacterial isolates were susceptible to the plant extract used in this study, thus supporting its use in folklore remedies in the treatment of diseases caused by these pathogens. Moreover, the antibacterial activity and zone of inhibition of *Acacia nilotica* against the bacterial isolates used in this study is relatively higher or lower than the one reported by Abdulai *et al.* (2018) on the same bacterial isolates.

Conclusion

The results from this study show that *A. nilotica* aqueous and ethanol extracts possess antibacterial activity against the Gram positive and Gram negative bacteria isolated from wound infections at levels comparable with that of the standard antibiotic (Gentamycin) used. *A. nilotica* is an edible plant which is currently being used traditionally for treatment of a number of ailments. It contains bioactive compounds which confer significant antibacterial activity to it. These facts make *A. nilotica* an important plant that should be explored for use as alternative therapeutic drug for the control of wound infections. Furthermore, the bacterial species isolated in this study are known to be associated with various infectious diseases. The antibacterial activities exhibited by the extracts against these bacteria provide scientific justification for the ethno- medicinal uses of the plant. Further research is needed to examine the *in-vivo* mechanism of action, toxicity, and therapeutic effect of the plant.

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