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# Phytochemical screening and in vitro evaluation of antibacterial activity of aqueous and ethanolic extracts of root and stem bark of *Bridelia ferruginea*. Benth. (Euphorbiaceae)

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**This study aimed at analysing the phytochemical content and antimicrobial activity of *Bridelia ferrugine* against selected bacteria. Total saponin, alkaloids, tannins, flavonoids and total anthraquinone contents were evaluated using spectrophotometric equivalents of the standards. The antibacterial activity of the plant extracts were determined using Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) assays against selected bacteria. The root and stem revealed the presence of the phytochemicals tested except the stem that lacked anthraquinones. In vitro antimicrobial activity of the plant extracts against the gram-positive bacteria tested showed that *Bacillus cereus* was most susceptible to the plant extract having MIC and MBC of 25 and 50 mg/ml, respectively for the stem-bark and root-bark ethanolic extract, while gram-negative bacteria the plant extracts were most active against *Proteus mirabilis* with MIC and MBC of 50 and 100 mg/ml, respectively. The aqueous extract was most active against *Staphylococcus epidermidis* with MIC and MBC of 50 and 100 mg/ml for stem-bark and 25 and 50 mg/ml for root-bark extract. Concentration dependent study showed the plant extracts were either bacteriostatic or bactericidal. Only the stem-bark aqueous extract showed no primary effect on the control strains. The study confirmed the presence of some phytochemicals which revealed that the plant is of pharmacological importance going by the ability of these phytochemicals to elicit antibacterial activity.**

**Key words:** Antibacterial, phytochemical screening, *Bridelia ferruginea*, plant extracts.

## INTRODUCTION

Traditionally, the use of plants in treating diseases and ailments has its origin in the history of man as it dates

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back to antiquity (Ogunyemi, 1979; Grabley and Thiericke, 1999). The use of plant by different ethnic groups for medicinal purposes prevails among the Nigerian people; even in the developed countries, plant derived drugs may be of some importance. In the United States of America, 25% of drug prescribed in the community pharmacies from 1959 to 1980 contain plant extracts or active ingredients obtain from them (Fransworth, 1999). As pointed out by Baker et al. 1995, plants have contributed significantly in ensuring the health care of about 80% of the world's population. Most of the drugs produced from plant products arise from the traditional use of the plants. For instance, 74% of the drugs derived from plant products listed by WHO arise from studies that isolated the active ingredients that accounted for using the plant in traditional medicine (Fransworth, 1999). Long before now, reports of resistance by pathogenic microorganisms to many synthetic drugs has been alarming (Ozumba, 2003; Aibinu, 2004). The continued increase in strains of microorganisms having resistant to antibiotic result in the development of a more effective antibiotic such as the 3rd and 4th generations of cephalosporins by pharmaceutical industries (Odugbemi, 2006). Several reports showing the potency of plant extract against microorganisms have been published. From these reports, plants became the foundation for synthetic drugs (Evans et al., 2002).

*B. ferruginea* belongs to the family *Euphorbiaceae*. It mostly grows as a shrub but under favourable condition can grow well reaching the size of a tree. The tree is about 6 to 15 m high, and 1.5 m in girth. The bark is dark grey, rough and often scaly (Rashid et al., 2000). Its common names are Kirni (Hausa), Marehi (Fulfulde), Ira lodan (Yoruba), Ola (Igbo); and KensangeAbia (Boki). It's mostly found in the savannah, most especially the moisture regions that extend from Guinea to the Democratic Republic of the Congo and Angola.

*B. ferruginea* has diverse uses. Extract from the bark have been used in the coagulation of milk and lime juice to formulate a traditional gargle The bark extract has been used for the coagulation of milk and also lime juice for the formulation of a traditional gargle "egunefu" (Orafidiya et al., 1990). Reports have also indicated its usage in the treatment of water (Kolawole and Olayemi 2003) In Togo, the bark of the root is used I the remedy of intestinal disorders and for the treatment of skin diseases (De Bruyne et al., 1997). Some other reported activity of the bark extract are trypanocidal (Ekanem et al., 2008), antimicrobial (Adeoye et al., 1988), molluscidal (Iwu, 1984), anti-inflammatory (Olajide et al., 1999). The bark, leaves and roots are ingredients of Yoruba (in Nigeria) infusions chiefly administered to children (Burkil, 1994).

A large proportion of the population of African countries still rely on the use of local herbs in the management of many ailments ranging from surgical to medical either infectious and non-infectious, with different degree of success or claim of beneficial effects. The bark and the bright red infusion from it are commonly sold in Nigerian markets and shops for use as a mouth-wash and remedy for thrush in children. In Congo, a bark decoction is used for toothache and in the Ivory Coast for dysentery and diarrhoea or as a laxative (Gill, 1992). The bark is used as antidote against poison and arrow poison (Burkil, 1994). A leaf extract in saline solution is reported to produce a marked reduction of blood-sugar in laboratory rats and clinical trials have given a drop from 250 mg to the normal less than 120 mg after eight weeks of daily treatment (Iwu, 1980). A bark preparation is used for immunity against arrow poison and syphilis. Extract from the bark is mixed with the stem of *Costus* for the treatment of minor epilepsy (Akubue and Mittal 1982). Root and stem barks are used for skin disease and eruption. They are found to be rich in tannins and are used as chewing sticks/mouth washes (Burkil, 1994). The boiled root and stem bark (boiled water extract) have recorded positive action against gram positive bacteria; *Sarcinalutea* and *Staphylococcus aureus* (Malcolm and Sofowora 1969).

Antimicrobial properties of stem bark of *Bridelia ferruginea* against facultative gram negative rods have been reported by Ndukwe et al., 2007. The activities of the methanol, petroleum ether and chloroform bark extracts of *B. ferruginea* against some potential pathogenic organisms have been extensively investigated (Iwu, 1984; Adeoye et al., 1988; Olajide et al., 1999). *B. ferruginea* had been found to contain various organic compounds according to Sofowora et al., 1982. The plant was presumed to contain alkaloids, tannins, terpenoids, glycosides, flavonoids, saponins, anthraquinones and steroids.

The occurrence of multiple antibiotics resistance developed by microorganisms against the development of resistance to both the old and newer drugs calls for active search for more effective as well as affordable antimicrobial agents. This problem has prompted tremendous effort to explore for more potent antimicrobial agents, especially of natural origin to counter the resistance.

Previous studies have shown that, *B. ferruginea* has tremendous potentials as important sources of remedy for certain bacterial infections and as a source of new compounds for antimicrobial drugs syntheses (Sofowora, 1982).The plants are the sleeping giants of pharmaceutical industry (Hostettmann and Hamburger 1991), may provide natural source of antimicrobial drugs that will provide novel compounds that may be employed in the management some infections caused by microorganism.

Herbal preparations of *B. ferruginea,* have been found to be useful in treating some conditions but the extent of use is often met with a major setback from the fact that little scientific evidence is available for many of such preparations. In addition, the phytochemical properties of

this plant have been found to vary with the habitat or geographical locations (Hostettmann and Hamburger 1991). Therefore, there may be variations in the antibacterial effect of this plant from different part of Nigeria. This study was aimed at finding and establishing a scientific basis for the use of the plant in search of effective and affordable cure for certain bacterial infections. The specific objective is to determine the phytochemical contents and antibacterial activity of the ethanolic and aqueous extracts of the stem and root bark of *B. ferruginea.*

## MATERIALS AND METHODS

### Collection of plant materials

Fresh stem and root bark of *B. ferruginea* were collected from the field between July and October, 2015 and were identified by a botanist from the Federal College of Forestry, Jos, Plateau State.

### Preparation of extracts

The plant materials (fresh stem and root bark of *B. ferruginea*) were dried at room temperature for 14 days followed by further drying in the oven at 50°C for 5 days to enable it dry completely. The dried stem and root bark were then pounded using a pestle and mortar and the powder stored in an air-tight container. The ground stem and root-bark of the plant was extracted using water and ethanol. About 20 g each of powdered root and stem-bark was poured in 120 ml of ethanol and water in a conical flask and the content sealed properly to avoid evaporation. In each case, the solution was filtered using Whatmann No. 1 filter paper after allowing the mixture to stand overnight. The filtrates were evaporated to dryness in an evaporating dish in a water bath at 70°C. The extracts were then scrapped and stored in a sterile container.

### Phytochemical screening

The extracts of the stem and root bark of *B. feruginea* were analysed for the presence of the following phytochemicals; alkaloids, saponins, tannins, anthraquinones, and flavonoids according to standard methods (Sofowora 1982; Ngbede et al., 2008).

### Source of the test organisms

The bacteria used for this study consist of six (6) clinical isolates; *Pseudomonas aeroginosa, P. mirabilis*, *Escherichia coli*, *S. aureus, Bacillus cereus and Stapylococcus epidermidis.* These isolates were obtained from the laboratory stock of central diagnostic, National Veterinary Research Institute, Vom, Jos. The gram positive and gram negative control strains; *E. coli* (NCTC 10418) and *S. aureus* (NCTC 6571) were also obtained from the Institute's Molecular Laboratory. The pure cultures of these isolates were prepared in nutrient broth in test tubes and kept in the refrigerator at 4°C, until needed for use.

### Constitution of the stock concentration of the extracts

About 5 g each of the aqueous stem and root-bark extracts were dissolved in 50 ml of distilled water to constitute a stock solution of 100 mg/ml. In similar manner 5 g of the ethanolic stem and root-bark extracts were dissolved in 50 ml of Dimethyl Sulphuroxide (DMSO) to constitute a stock concentration of 100 mg/ml. DMSO was used for ethanolic extract because it does not dissolve completely in water as in the case of aqueous extracts.

### Determination of minimum inhibitory concentration (MIC)

Tube dilution method described by Scott, 1989) was used. Exactly 8 tubes labelled 1 to 8 (2 sets) with each tube containing 4 ml of nutrient broth. 4 ml of the crude extracts in the stock concentration (100 mg/ml) was introduced to tube 1 and diluted using a double dilution to yield a concentration of 50, 25, 12.5, 6.25, 3.12 and 1.56 mg/ml. Tube 8 contain a standard antibiotic (ciprofloxacin) serving as a positive control. To the first set of tubes, 0.02 ml (200µl) of 24 h broth cultures of the test organisms was added after dilution to yield 0.5 McFarland standard (equivalent to $1.5\times10^8$ Cfu/ml) using a Nephelometric turbidity metre. The tubes were then incubated at 37°C for 24 h after which they were examined for microbial growth. The second set of tube was not inoculated and serves as a control to observe for change in turbidity by comparing with the first set.The MICs of the ethanolic and aqueous extract of the stem and rootbark for each test organism is the smallest concentration of such extract that is capable of inhibiting the growth of specific inoculum of the test organism evidenced by absence of turbidity in the particular tube.

### Determination of the minimum bactericidal concentration

The Minimum Bactericidal Concentrations (MBCs) was determined by identifying the tubes that showed no growth (evident by absence of turbidity) during MIC determination. One loop full from each of these tubes selected was inoculated over the surface of nutrient agar in Petri-dish and incubated for 18 to 24 h at 37°C. Lowest concentration of the extract at which no growth was observed is taken as the MBC.

## RESULTS

The phytochemical evaluation of the aqueous extracts of the root and stem-bark, reveals the presence of some phytochemicals. The stem-bark extract contains alkaloids, saponins, tannins, and flavonoids. While root-bark extract demonstrated the presence of saponins, tannins, alkaloids, flavonoids and anthraquinones (Table 1).

The result of the phytochemical analysis of ethanolic extracts of the root and stem-bark of *B. ferruginea* is shown in Table 2. The analysis of the stem extract revealed the presence of saponins, tannins, flavonoids, alkaloids, while anthraquinones was not present. The analysis of the root-bark extract demonstrated an increased presence of saponins, tanins and alkaloids, while, flavonoids and anthraquinones were present in moderate amounts.

Table 3 shows the MIC and MBC of aqueous extract of the stem and root-bark of *B. ferruginea*. For stem-bark extract, amongst the gram positive bacteria tested, *S. aureus* (NCTC 6571) and *S. aureus* had no MIC and

**Table 1.** Phytochemical constituents from the aqueous extract of the stem- and root-bark of *B. ferruginea.*

| Phytochemicals | Aqueous extract | |
|---|---|---|
| | Stem-bark | Root-bark |
| Saponins | + | + |
| Tannins | + | + |
| Alkaloids | + | + |
| Flavonoids | + | + |
| Anthraquinones | − | + |

Key: + = present ; − = absent.

**Table 2.** Phytochemical component of ethanolic extracts of the stem and root bark of *B. ferruginea.*

| Phytochemicals | Ethanolic extracts | |
|---|---|---|
| | Stem-bark | Root-bark |
| Saponins | + + | + + |
| Tannins | + + | + + |
| Alkaloids | + | + + |
| Flavonoids | + + | + |
| Anthraquinones | − | + |

Key:+ = present ;+ + = present in increased quantity; − = absent.

MBC, while *S. epidermidis* and *B. cereus* both recorded MIC and MBC of 50 and 100 mg/ml, respectively. For gram negative bacteria, only *P. mirabilis* had an MIC of 100 mg/ml. There was no MIC and MBC for all the other gram negative bacteria tested (*E. coli* (NCTC 10418), *E. coli*, and *P. aeruginosa*). In the case of root-bark extract, *S. aureus* (NCTC 6571) and *S. aureus* had MIC of 100 mg/ml but no MBC was recorded. *S. epidermidis* had MIC and MBC of 25 and 50 mg/ml, respectively, while *Bacilluscereus* had MIC and MBC of 50 and 100 mg/ml. Amongst the gram negative bacteria tested, *E. coli* (NCTC 10418) and *P. mirabilis* had MIC and MBC of 50 and 100 mg/ml, respectively, while *E. coli* and *P. aeruginosa* had MIC of 100 mg/ml but no MBC was observed.

Table 4 shows the MIC and MBC of ethanolic extracts of the root- and stem-bark of *B. ferruginea* against selected bacteria. For the stem-bark extract, amongst the gram positive bacteria tested, *S. aureus* (6571), *S. aureus* and *S. epidermidis* recorded MIC and MBC of 50 and 100 mg/ml, respectively, while *B. cereus* recorded MIC and MBC of 25 and 50 mg/ml, respectively. For the gram negative bacteria tested, *E. coli* (NCTC 6571), *E. coli*, and *P. aeruginosa* recorded MIC of 100 mg/ml with no MBC, while *P. mirabilis* had MIC and MBC of 50 and 100 mg/ml, respectively.

For the root-bark extract, amongst the gram positive bacteria tested, *S. aureus* (NCTC 6571) had MIC of 100 mg/ml with no recorded MBC. *S. aureus*, *S. epidermidis* and *B. cereus* had MIC and MBC of 25 and 50 mg/ml, respectively. For the gram negative bacteria, *E. coli* (10418), *E. coli* and *P. mirabilis* had MIC and MBC of 50 and 100 mg/ml, respectively, while *P. aeruginosa* had MIC of 100 mg/ml with no MBC.

Table 5 shows the summary of the primary activity of the root- and stem-bark extract of both the aqueous and ethanolic extract of *B. ferruginea* against the selected bacteria. The result indicates that, aqueous root-bark extract had more activity than aqueous stem-bark extract. On the other hand, the root-bark ethanolic extract had more activity than the stem-bark ethanolic extract. On a general note, the ethanolic root- and stem-bark extract had more activity than the aqueous root- and stem-bark extract with gram positive bacteria been more susceptible than the gram negative bacteria

## DISCUSSIONS

Phytochemical analysis of the aqueous and ethanolic extracts of the root and stem bark of the plant revealed the presence of saponins, tannins, alkaloids, flavonoids and anthraquinones in the root-bark, while the stem-bark also possesses all the phytochemicals analysed, except for anthraquinones(Table 1 and 2).The presence of these phytochemicals reveals that, the extract of the plant is possibly active. The presence of these phytochemicals in the aqueous root-bark extract is in agreement with the findings of Adebayo and Ishola (2009) whereby all the phytochemical elements identified in this study were also found in their study. The absence of anthraquinones in the stem-bark extract, do not agree with the work done by Owoseni et al (2012) in which anthraquinones was present in the stem-bark extract.

The result from this study also revealed that there was no variation in terms of the active components in aqueous stem- and root-bark extract and that of ethanolic stem and root-bark however, there were variation in terms of the amount of the phytochemicals present in each of the extracts(Tables 1 and 2).There was an increase in the amount of saponins, tannins and flavonoids in ethanolic stem-bark extract, while ethanolic root-bark extract revealed an increase in the amount of saponins, tannins and alkaloids. In similar vein there was an increased extraction in the amount of the phytochemicals by ethanol when compared to aqueous agent. This finding is in line with Arya et al (2012) who observed higher yield using ethanol than other solvents such as petroleum ether, chloroform and water because ethanol is a more effective solvent in the extraction of bioactive molecules (Arya et al., 2012).

It has been discovered that the functional property of a plant relies upon the different secondary metabolites it

**Table 3**. Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of the aqueous extracts of the stem and root-bark of *B. ferruginea* against selected bacteria.

| Bacteria | | Aqueous Extracts (mg/ml) | | | |
|---|---|---|---|---|---|
| | | Stem-bark | | Root-bark | |
| | | MIC | MBC | MIC | MBC |
| Gram-positive | *Staphylococcus aureus* (NCTC 6571) | – | – | 100 | – |
| | *Staphylococcus aureus* | – | – | 100 | – |
| | *Staphylococcus epidermidis* | 50 | 100 | 25 | 50 |
| | *Bacillus cereus* | 50 | 100 | 50 | 100 |
| Gram-negative | *Escherichia coli* (NCTC 10418) | – | – | 50 | 100 |
| | *Escherichia coli* | – | – | 100 | – |
| | *Proteus mirabilis* | 100 | – | 50 | 100 |
| | *Pseudomonas aeruginosa* | – | – | 100 | – |

Key: = no MIC/MBC at highest concentration of the extract tested.

**Table 4.** Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of the ethanolic extracts of the stem- and root-bark of *B. ferruginea* against selected bacteria.

| Bacteria | | Ethanolic Extracts (mg/ml) | | | |
|---|---|---|---|---|---|
| | | Stem-bark | | Root-bark | |
| | | MIC | MBC | MIC | MBC |
| Gram-positive | *Staphylococcus aureus*(NCTC 6571) | 50 | 100 | 100 | – |
| | *Staphylococcus aureus* | 50 | 100 | 25 | 50 |
| | *Staphylococcus epidermidis* | 50 | 100 | 25 | 50 |
| | *Bacillus cereus* | 25 | 50 | 25 | 50 |
| Gram-negative | *Escherichia coli* (NCTC 10418) | 100 | – | 50 | 100 |
| | *Escherichia coli* | 100 | – | 50 | 100 |
| | *Proteus mirabilis* | 50 | 100 | 50 | 100 |
| | *Pseudomonas aeruginosa* | 100 | – | 100 | – |

Key = no MIC/MBC at highest concentration of the extract tested.

possesses such as: phenolics, terpenoids, or alkaloids (Murugan and Parimelazhagan 2014). Among the phytochemicals isolated from the plant, flavonoids have been proven to be of more significance because of its ability to assist the body in fighting diseases. Flavonoids act as potent antioxidants but depending on the structure of the molecule and the hydroxyl group in the chemical structure (Iqbal et al., 2015). Phenols, flavonoids and flavonols are polyphenolic compounds of plants which bring about substantial antioxidant activity and several biological activities including: anti-helmintic, analgesic, anti-inflammatory, anti-microbial and anti-allergic properties (Oyedemi et al., 2012; Alabri et al., 2014). The activity of these phytochemicals mainly results from their ability to form a large complex with extracellular protein and the cell walls of bacteria. Flavanoids can also alter the membranes of a bacterial cell (Tsuchiya et al., 1996). The presence of saponins was indicated in *B. ferruginea* extracts which warrant the use of the plant in the management of inflammation. Saponins is known to prevent inflammation and is the main constituents of traditional medicinal plant and thus responsible for majority of the biological effects observed. This support reasons for using the plant in traditional medicine. Just et al., 1998 and Igbinosa et al., 2013 demonstrated the inhibitory effect of saponins on inflamed cells.

The presence of alkaloids is also observed in the extracts. A heterocyclic compound of nitrogen associated with a significant range of antimicrobial activity. Plants containing alkaloids are commonly used in traditional medicine due to their inhibitory effects against protozoa, bacteria and fungi (Kim et al., 2002). The common biological activity of alkaloids is toxicity against the cells of foreign organisms. It has the ability to accumulate in

**Table 5.** Primary effects of the aqueous and ethanolic extracts of the stem- and root-bark of *B. ferruginea* against selected bacteria.

| Bacteria | | Aqueous extracts | | Ethanolic extracts | |
|---|---|---|---|---|---|
| | | Stem-bark | Root-bark | Stem-bark | Root-bark |
| Gram positive | *S. aureus* (NCTC 6571) | – | Static | Cidal | Static |
| | *S. aureus* | – | Static | Cidal | Cidal |
| | *S. epidermidis* | Cidal | Cidal | Cidal | Cidal |
| | *B. cereus* | Cidal | Cidal | Cidal | Cidal |
| Gram negative | *E. coli* (NCTC 10418) | – | Cidal | Static | Cidal |
| | *E. coli* | – | Static | Static | Cidal |
| | *P. mirabilis* | Static | Cidal | Cidal | Cidal |
| | *P. aeruginosa* | – | Static | static | Static |

Key: No effect.

cells due to the variation in membrane potentials and it is a very good DNA introducer (Iwasa et al., 2001) and effective against many microorganisms targeting the RNA polymerase, nucleic acid, RNA gyrase and topoisomerase (Yi et al., 2007).

Plants that have extracts containing tannins are known to be used commonly in traditional medicine for treating haemorrhage, diarrhoea, and detoxification (Okwu and Emenike, 2006). The tannins content as observed in the study especially in the ethanolic extracts justify the use of the plant in traditional medicine for the treatment of diarrhoea. Anthraquinones have been found to have wide range of antibacterial (also anti-mycobacterial) property resulting in loss of function and inactivation of bacterial proteins, cell wall, polypeptides, adhesins and membrane bound organelles with resultant death of the bacterial cell (Kurek et al., 2011).

The antibacterial activity of the plant extracts is tested on gram positive and gram negative bacteria. This is done by determining Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of the aqueous and ethanolic extracts of the stem and root-bark of *B. ferruginea* (Tables 3 and 4). The presence of the phytochemicals is assumed to be responsible for the anti-inflammatory, antioxidant, antibacterial and cytotoxicity activity of the plants. From the results as shown in Table 3 and 4, the extracts have been found to be more active against gram-positive bacteria than gram-negative bacteria.

Among gram-positive bacteria tested, *B. cereus* was most susceptible to the plant extract having MIC and MBC of 25 and 50mg/ml, respectively for the stem-bark and root-bark ethanolic extract. For gram-negative bacteria, the plant extracts were most active against *P. mirabilis* with MIC and MBC of 50 and 100 mg/ml, respectively. The aqueous extract was most active against *S. epidermidis* with MIC and MBC of 50 and 100 mg/ml, respectively for stem-bark and 25 and 50 mg/ml, respectively for root-bark extract. The reason for the difference in sensitivity between gram negative and gram positive could be ascribed to the morphological differences between these microorganisms. As reported by Nostro et al., 2000; Nikaido and Vaara, (1985), gram-negative bacteria are characterized by an outer covering of phospholipidic membrane made up of lipopolysaccharide components, making the cell wall slightly impenetrable, whereas the gram-positive bacteria possessing only an outer peptidoglycan layer (not an effective permeability barriers) are more susceptible.

The level of resistance demonstrated by *P. aeruginosa, E. coli* and *S. aureus* is not strange since the resistances of these organisms to many antibacterial agents have been reported (Kunin, 1993). Also in another study by Dada-Adegbola et al, 2010, on “the activity of crude extract of *B. ferruginea* ” against *P. aeruginosa*, *E. coli* and *P. mirabilis* showed similar results as obtained from this study.

The ethanolic extracts of both the stem- and root-bark demonstrated an increase in activity than that of aqueous stem- and root-bark extracts (Tables 3 and 4). The result from this study is consistent with the study by Owoseni et al. (2010), where the ethanolic extracts of leaves and stem-bark of *B. ferruginea* had an increase antibacterial activity than other extracting solvents used. Also, this result is in tandem with the findings of Olukemi et al. 1997, where ethanolic extract of stem-bark of *Paekia filicoidea* demonstrated ten-fold increase in activity to that of aqueous extracts. This is due to the concentration of active substances responsible for inhibiting the growth of microorganisms which is high in ethanolic extract than aqueous extract of both the root- and stem-bark of the plant. It could also be due to the fact that ethanol as extracting solvent is more effective in extracting the active compounds than aqueous solvent (Arya et al., 2012). The extracts from the root-bark were found to be more effective against the tested pathogens than the stem-bark for both the aqueous and ethanolic extracts (Table 3 and 4). Similar results were obtained by

Adebayo and Ishola (2009) and Owoseni et al. (2012), where the root-bark ethanolic extract had higher activity than stem-bark extract against tested pathogens. The presence of anthraquinones in the roots of both the ethanolic and aqueous extract as against its absence in the stem extract could have been an attribute to its higher antibacterial activity as anthraquinones has been reported to have a wide range of antimicrobial activity against pathogenic organisms.

The primary effects of the aqueous and ethanolic extracts of the root- and stem-bark of the plant against selected bacteria as shown in Table 5 revealed that the antimicrobial activity of the plant is concentration dependent. Within the range of concentrations used for the study, the plant extracts were found to have the primary effect of being bacteriostatic or bactericidal, depending on the concentration against the test organisms. Only the stem-bark aqueous extract showed no primary effect on the control strains, *S. aureus*, *E. coli*, and *P. aeruginosa*. According to Oboh and Abulu (1997) antimicrobial activity is a function of the active ingredient having effect on the target organism.

## Conclusion

Findings from this study confirmed the presence of phytochemicals such as saponins, tannins, alkaloids, flavonoids and anthraquinones which has revealed that the plant is of pharmacological importance going by the ability of these phytochemicals to elicit antibacterial activity.This study has discovered the great potential in *B. ferruginea* as one of the medicinal plant in serving as an alternative in treating human infection with less cost and toxicity.

## CONFLICT OF INTEREST

The authors have not declared any conflict of interests.

### REFERENCES


Ogunyemi AO (1979). The origin of the herbal cure and its spread. In: Proceedings of a conference on African Medicinal Plants. Sofowara. A. (ed); University of Ife Press, Ile-Ife pp. 20-22.

Grabley S, Thiericke R (1999). Drug discovery from Nature. Springer, London pp. 5-7.

Fransworth NR (1999). How can the well be dry when it is filled with water? Economic Botany 38:4-13.

Baker JT, Borris RP, Carte B, Cordell GA, Soejarto SD, Cragg GM, Gupta MP, Iwu MM, Madulid OR, Tyler VE (1995). Natural product drug discovery and development. Journal of Natural Products 58:1325-1357.

Ozumba UC (2003). Antibiotic sensitivity of isolates of *Pseudomonas aeruginosa* in Enugu, Nigeria. African Journal of Clinical and Experimental Microbiolog*,* 4:48-51.

Aibinu I, Adenipekun E, Odugbemi T (2004) Emergence of quinolone resistance among *Escherichia coli* strains isolated from clinical infections in some Lagos State hospitals in Nigeria. Nigerian Journal of Health Biomedical Sciences 3(2):73-78.

Odugbemi T (2006).Outlines and Pictures of Medicinal Plants from Nigeria.University of Lagos Press. pp. 53-64.

Evans CE, Banso A, Samuel OA (2002). Efficacy of some nine medicinal plants against *Salmonella typhi*: an in vitro study. Journal of Ethnopharmacology 80:21-24.

Rashid MA, Gustafson KR, Cardellina JH, Boyd MR (2000). A new Podophyllojoxin Derivative from *Bridelia ferruginea*. Natural Products Letters 14:285-292.

Orafidiya LO, Lamikanra A, Adediji JA (1990). Coagulation of milk as an index of astringency of the bark extract of Bridelia ferruginea Benth and lime juice for the formulation of a traditional gargle 'Ogun Efu'. Phythotherapy Research 4(5):189-194.

Kolawole OM, Olayemi AB (2003). Studies on the efficacy of Bridelia ferruginea benth bark extract for water purification. Nigeria Journal of Pure and Applied Science 18:1387-1394.

De Bruyne T, Cimanga K, Pieters L, Claeys M, Domnusse R, Vlietinck A (1997). Galloctechim(4-0-7) Epigallocatechin. A new Biflavonoid isolated from *Bridelia ferruginea*. Natural Product Letters 11:47-52.

Iwu MM (1984). Proceedings of 4th Annual Conference of Nigeria Society of Pharmacognosy, University of Nigeria, Nsukka. The state of Medicinal plant Research in Nigeria. Sofowora A (ed.).P 57.

Adeoye AO, AbaeliAM, Owowumi C J and Olukoya DK (1988). Antimicrobial activity of *Bridelia ferruginea* in: Book of Abstract of the symposium on drug production from natural products. Drug Research and production Unit, ObafemiAwolowo University, Ile-Ife P 24.

Olajide OA, Makinde JM, Awe SO (1999). Effect of aqueous extract of *Bridellia ferruginea* stem bark on corragenan induced oedema and granuloma tissue formation in rats and mice. Journal of Ethnopharmacology 66(1):113-177.

Ekanem JT, Kolawole OM, Abbah OC (2008). Trypanocidal potential of methanolic extract of Bridelia ferruginea benth bark in *Rattus novergicus*. African Journal of Biochemistry and Research 2(2):045-050.

Burkil HM (1994). The Useful Plants of West Tropical Africa. The Royal Botanic Garden, Kew 2:636.

Gill LS (1992). Ethno-botanical uses of Plants in Nigeria.Univesity of Benin Press.

Iwu MM (1984). Anti-diabetic properties of *Bridelia ferruginea*. Plant Medicine 39:247.

Akubue PI, Mittal GC (1982). Clinical evaluation of a traditional herbal practice in Nigeria: a preliminary report. Journal of Ethnopharmacology 6:355-359.

Malcolm SA, Sofowora EA (1969). Antimicrobial activities of selected Nigerian Folk remedies and their constituent plants. *Lioydia* 32:512-517.

Ndukwe IG, Amupitan JO, Isah Y, Adegoke KS (2007). Phytochemical and antimicrobial screening of the crude extracts from the root, stem bark and leaves of *Vitellaria paradoxa*. African Journal of Biotechnology 6(16):1905-1909.

Shears P (1993). A review article of bacterial resistance to antimicrobial agents in tropical countries. Journal of Annals of Tropical Paediatrics 13:219-226.

Sofowora EA (1982). Medicinal Plants and Traditional medicine in Africa.Spectrum Books Ltd. John Wiley and Sons, Chichester, United Kingdom pp. 159-189.

Hostettmann K, Hamburger M (1991). Medicinal Plants in Tropical West Africa. Phytochemistry 30(12):3864-3874.

Ngbede J, Yakubu RA, Nyam DA (2008). Phytochemical screening for active compounds in *Canarium schweinfurthii* (Atile) leaves from Jos North, plateau state, Nigeria. Research Journal of Biological Sciences 3(9):1076-1078.

Scott AC (1989). Laboratory control of antimicrobial therapy. In: Medical Microbiology (Collee, J. G., Duguid, J. P., Fraser, A. G. and Marmion, B. P., eds.), Churchill Livingstone, New York pp. 9-

180.
Adebayo EA, Ishola OR (2009). Phytochemical and antimicrobial screening of the crude extracts from the root, stem bark and leaves of *Bridelia ferruginea*. African Journal of Biotechnology 8(4):650-653.
Owoseni AA, Ayanbamiji TA, Ajayi YO, Ewegbenro IB (2012). Antimicrobial and phytochemical analysis of leaves and bark extracts from *Bridelia ferruginea*. African Journal of Biotechnology 9(7):1031-1036.
Arya V, Thakur NM, Kashyap C (2012). Preliminary Phytochemical analysis of the Extracts of Psidium Leaves. Journal Pharmacognosy and Phytochemistry 1:1-5.
Murugan R, Parimelazhagan T (2014). Comparative evaluation of different extraction methods for antioxidant and anti-inflammatory properties from Osbeckia parvifolia. – an in vitro approach. Journal King Saud University Science 26(4):267-275.
Iqbal E, Salim KA, Lim LB (2015). Phytochemical screening, total phenolicsand antioxidant activities of bark and leaf extracts of *Goniothalamus velutinus* (Airy Shaw) from Brunei Darussalam. Journal King Saud University Science 27(3):224-232.
Oyedemi SO, Oyedemi BO, Arowosegbe S, Afolayan AJ (2012). Phytochemical analysis and medicinal potentials of hydro alcoholic extract from *Curtisia dentata* (Burm.f) CA Sm stem bark. International Journal Molecular Science 13(5):6189-61203.
Alabri TH, Al Musalami AH, Hossain MA, Weli AM, Al-Riyami Q (2014). Comparative study of phytochemical screening, antioxidantand antimicrobial capacities of fresh and dry leaves crude plant extracts of Daturametel L. Journal King Saud University-Science 26(3):237-243.
Tsuchiya H, Sato M, Miyazaki T, Fujiwara S, Fanigaki S and Ohyama M (1996). Comparative studyon the antibacterial activity of phytochemical flavanones against methicillin-resistant *Staphylococcus aureus*. Journal of Ethnopharmacology 50:27-34.
Just MJ, Recio MC, Giner RM, Cuellar MJ, Manez S, Bilia AR, Rios J (1998). Anti-inflammatory activity of unusual lupine saponins from *Bupleurum fruticescens*. Planta Medica 64(5):404-407.
Igbinosa OI, Edwina OU, Isoken HI, Emmanuel EO, Nicholas OI, Oke AE (2013). In vitro assessment of antioxidant, phytochemical and nutritional Properties of extracts from the leaves of ocimum gratissimum (linn). African Journal Traditional Complementary Alternative Medicine 10(5):292-298.
Kim SH, Lee SJ, Lee JH, Sun WS, Kim JH (2002). Antimicrobial activity of 9-*O*-acyl and 9-*O*-alkylberberrubine derivatives. Plant Medicine 68:277-281.
Iwasa K, Moriyasu M, Yamori T, Turuo T, Lee D, Wiegrebe V (2001). *In vitro* cytotoxicity of the protoberberine-type alkaloids. Journal of Natural Product 64:896-898.
Yi ZB, Yu Y, Liang YZ, Zeng B (2007). Evaluation of the antimicrobial mode of berberine by LC/ESI-MS combined with principal component analysis. Journal of Pharmaceutical and Biomedical Analysis 44:301-304.
Okwu DE, Emenike IN (2006). Evaluation of the phytonutrients and vitamin contents of citrus fruits. International Journal Molecular Medicine in Advanced Science 2:1-6.
Kurek A, Grudniak AM, Kraczkiewicz-Dowjat A, Wolska KI (2011). New antibacterial therapeutics and strategies. Polish Journal of Microbiology 60:3-12.
Nostro A, Germano MP, D'Angelo V, Marino A, Cannatelli MA (2000). Extraction Methods and Bioautography for Evaluation of Medicinal Plant Antimicrobial Activity. Letters of Applied Microbiology 30:379-384.
Nikaido H, Vaara M (1985). Molecular basis of bacterial outer membrane permeability. Microbiology Reviews 19(1):1-32.
Kunin CM (1993). Resistance to antimicrobial drugs-a worldwide calamity. Annals of International Medicine 118(7):557-561.
Dada-Adegbola HO, Oluwatoba OA, Adebiyi OE, Odikagbue AN (2010). In vitro evidence of anti-infective activity of crude aqueous extract obtained by boiling ripe stem-bark of *Bridelia ferruginea* Benth. Journal of Pharmacognosy Phytotherapy 2(4):43-48.
Owoseni AA, Ayanbamiji TA, Ajayi YO, Ewegbenro IB (2010). Antimicrobial and phytochemical analysis of leaves and bark extracts from *Bridelia ferruginea*. African Journal of Biotechnology 9(7):1031-1036
Olukemi MA, Kandakai-Olukemi YT, Bello CSS (1997). Antibacterial activity of the stem-bark of *Paekia filicoidea*. Journal of Pharmaceutical Research and Development 2:64-66.
Oboh PA, Abulu EO (1997).The antimicrobial activities of extracts of *Psidium guajava* and *Citrus auratifolia*. Nigerian Journal of Biotechnology 8:25-27.