

Antibacterial Activity of Four Nigerian Medicinal Plants

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Abstract: The Antibiotics properties of the aqueous leaf extracts of *A. spinosus*, *A. hybridus*, *C. esculenta* and *C. bicolor* on four human pathogens, *S. aureus*, *E. coli*, *Salmonella typhi* and *Candida albicans* was studied using further paper disc diffusion techniques. The minimum inhibitory concentration (MIC) was evaluated for each of the plant extracts on the test organisms. Result showed that there were significant variations in the levels of activity against the test organisms. Finding showed that the inhibition of *staphylococcus aureus* was in the range of 11.67 ± 1.53^d mm in *A. hybridus* to 18.3 ± 1.16^b mm in *C. bicolor* while the activity against *E.coli* was in the range of 10.33 ± 0.58^d mm in *A. hybridus* to 16.67 ± 1.53^b mm in *C. bicolor*. *Salmonella typhi* was inhibited within the range of 10.33 ± 0.58^c .mm in *A. hybridus* and 14.00 ± 1.00^b mm in *B. bicolor* and the inhibition was between 11.67 ± 0.58^c in *C. esculenta* and 21.00 ± 2.65^b for *Candida albican*. The results show that the aqueous extract of *C. bicolor* was the most potent while *A. hybridus* extract was the least potent. All the test extracts had activities lower than that of standard antibiotics. The minimum inhibition concentration (MIC) showed that the extracts possess antimicrobial properties at concentrations ranging from ≥ 12.50 mg/ml to ≥ 200 mg/ml respectively. The result obtained in this study suggests that the aqueous leaf extracts of the plants possessed antimicrobial activities against the bacterial isolates at different concentrations. The minimum inhibition concentration was between 12.50 mg/ml and 50 mg/ml against all the test organisms. There were variations in the lowest concentrations of the different plant extracts that caused inhibitions against the different test organisms.

Keywords: Antibacterial, plant extracts, medicinal plants, Nigerian plants

INTRODUCTION

Antimicrobial agents are essentially important in reducing the global burden of infectious diseases. However, as resistant pathogens develop and spread, the effectiveness of the antibiotics is diminished. This type of bacterial resistance to the antimicrobial agents poses a very serious threat to public health [1, 2]. Bacterial resistance to antibiotics increases mortality likelihood and length of stay in the hospital [3].

In recent years, drug resistance to human pathogenic bacteria has been commonly reported from all over the world [4, 5, 6, 7, 8]. However, the situation is alarming in developing as well as developed countries due to indiscriminate use of antibiotics. Therefore, alternative antimicrobial strategies are urgently needed, and thus this situation has led to a re-evaluation of the therapeutic use of remedies from plants [1, 9]. According to [10], medicinal plants would be the best source to obtain a variety of drugs. Medicinal plants are the richest bio-resource of drugs, modern medicine, food supplements, folk's medicine, pharmaceutical intermediates and chemical entities [11]. The medicinal values of these plants lie on some chemical active substances that produce definite physiological actions on the human body. The most important of these bio-active constituents of plants are

alkaloids, tannins, flavonoids, saponins, steroids and phenolic compounds [12].

Natural products of some tropical plants may possess a new source of antimicrobial agents with possible novel mechanism of action [13]. They are effective in treatment of infectious diseases, while simultaneously mitigating many of the side effects that are often associates with the synthetic antimicrobials [14]. Medicinal plants contain accumulated natural products, biologically active materials and ingredients, which has various effects. [15] have reported that antimicrobial effect of leaf extracts of *Ocimum gratissimum* on several species of bacteria and fungi such as *E.coli*, *Salmonella typhi* and *S.aureus*. Approximately 80% of the world's population currently depends on traditional system of health care that incorporates natural food [16]. Many studies have been undertaken with the aim of determining the different antimicrobial and phytochemical constituents of medicinal plants and using them for the treatment of both topical and systemic microbial infections as possible alternatives to chemical synthetic drugs to which many infectious microorganisms have become resistant [17,18]. Because of the emerging development of drug resistance by pathogenic microorganisms against synthetic antibiotics; attention has now shifted to extracts of biologically active components isolated

from plant species used as herbal medicine. The potential antimicrobial properties of plants are related to their ability to synthesize several chemical compounds of relatively complex structures with antimicrobial activity. These compounds include tannins, alkaloids, coumarins, cardiac glycosides, terpenes, phenylpropanes, organic acids, flavonoids, isoflavonoids and saponins [16, 19].

Plant based antimicrobials represent a vast untapped source. The use of plant extract for medicinal treatment has become popular since people realized that over prescription and misuse of traditional antibiotics are causing microbial resistance [20]. Traditionally used medicinal plants produce a variety of compounds of known therapeutic properties [21, 22]. In recent years, antimicrobial properties of medicinal plants are being increasingly reported from different parts of the world [23, 24, 25, 26, 27, 28, 29]. At present, nearly 30% or more of the modern pharmacological drugs are derived directly or indirectly from plants [30, 31, 32]. Considering the vast potentiality of plants as sources for antimicrobial drugs, this study aimed to detect the antimicrobial activities of some natural plant extracts.

BOTANY OF AMARANTHUS HYBRIDUS

Amaranthus hybridus is usually a short-lived annual crop that grown up to 1m in height, the stem is erect, often thick and fleshy, sometimes grooved. The leaves are often green or purple, normally alternate petiolate. *Amaranthus hybridus* belong to the family of Amaranthaceae. There are four different kinds of *amaranthus* that are widely grown in Nigeria and these are small leafy *amaranthus*, large leafy *amaranthus*, white *amaranthus* and red *amaranthus*.

Amaranthus, collectively known as ‘‘amaranth’’ is a cosmopolitan genus of herbs. Approximately 60 species are recognized with inflorescence and foliage ranging in colour from purple and red to green or gold. Although several species are often considered as weeds. *Amaranthus* response to soil with high inorganic content, with adequate mineral reserve. It is tolerant to relatively high temperature range of 22-30°C. [33]. It is grown during both wet and dry season; the dry season requires irrigation system or wetting device. As a traditional food plant in Africa, *amaranth* has a potential to improve nutrition, boost food security, foster rural development and support sustainable land care. The most widely consumed of the more than 100 different indigenous leafy vegetable species occurring in South Africa are *amaranthus* species, melons and cowpeas [34, 35]. The main use of *Amaranthus hybridus* is as a leaf vegetable (vegetable *amaranth*) prepared by cooking and consumed as a vegetable dish or as an ingredient in sauces. Dishes with amaranth are eaten with the main dish of cereals or tubers [36]. *Amaranthus* leaves contain 17.5 -38.3% protein of which 5% is lysine; an essential amino acid that is lacking in most diets based on cereals and tubers

[37, 38]. In South Africa *Amaranthus hybridus* is grown commercially for canning and sold in supermarkets [39]. Those with large bright red inflorescences are widely grown as ornamentals. A red dye can be obtained from the inflorescences. Vegetable amaranths are recommended as a good food with medicinal properties for young children, lactating mothers and for patients with constipation, fever, haemorrhage, anaemia or kidney complaints.

In Senegal the roots are boiled with honey as a laxative for infants. In Ghana the water of macerated plants is used as a wash to treat pains in the limbs. In Ethiopia *Amaranthus hybridus* is used as a tapeworm expellant. In Sudan the ash from the stems is used for wound dressing [40]. Several studies have shown that amaranth seed or oil may benefit those with hypertension and cardiovascular disease; regular consumption reduces blood pressure and cholesterol levels, while improving antioxidant status and some immune parameters. In traditional medicine amaranth is specially recommended for people with low red blood cell count [41].

BOTANY OF AMARANTHUS SPINOSUS

Amaranthus spinosus is an annual weed that is widely distributed in the humid zone of the tropics. The weed has been reported to have some pharmacological properties. Extracts of the leaf have also been used in the treatment of menstrual disorders in women. The plant is recommended for fevers, the leaves are considered a good emollient. Externally, the bruised leaves are applied locally to treat eczema. Furthermore, it is used to treat several ailments such as malaria, hepatic disorders, jaundice, and scanty urine and to cure wounds. The wild *Amaranthus spinosus* L. is used as a depurative against venereal diseases and as dressing on boils. The leaves and roots are applied as poultice to relief bruises, abscesses, burns, gonorrhoea and inflammatory swelling. *A. spinosus* is used to treat diarrhea, the root is used for toothache [42, 43]. The plant sap is used as an eye wash to treat ophthalmia and convulsion in children. The leaves are also used for gastroenteritis, gall bladder inflammation, abscesses, colic menorrhagia, arthritis and diabetes. *Amaranthus spinosus* is also used as anti-inflammatory, antimalarial, antibacterial, antidiuretic and antiviral agents.[44]

The plant has several active constituents like alkaloids, flavonoids, glycosides, phenolic acids, steroids, amino acids, terpenoids, lipids, saponins, betalains, spinoside, hydroxycinnamates, quercetin, betaxanthin, betacyanin, amaranthine, isoamaranthine and gomphrenin. Other compounds include b-sitosterol, stigmasterol, linoleic acid, rutin, and carotenoids. It also contains amaranthoside, lignin glycoside, coumaroyl adenosine along with stigmasterol glycoside [45, 46].

BOTANY OF COLOCASIA ESCULENTA

Cocoyam, *Colocasia esculenta* (L.) Scholt constitutes one of the basic food crops of major economic importance in the south eastern Nigeria. It ranks the third after cassava and yam, in terms of total production, land area under crop and consumption [47]. There are two main edible types of cocoyam in Nigeria *Colocasia esculenta* (L.) Scholt, otherwise known as 'taro' and *Xanthosoma sagittifolium* also known as 'tannia' [48]The former is by far more popular than the later. Taro requires heavy fertile upland soil and plentiful rainfall for good yield. It does well also in a fertile low land environment [49, 50] and commonly grown in South Eastern zone of Nigeria. On the other hand, tannia (*Xanthosoma sagittifolium*) is well cultivated in the South Western zone of Nigeria [51]. Currently, *Colocasia esculenta* (taro) is seriously threatened to extinction in south eastern Nigeria as a result of its high susceptibility to bacterial leaf blight disease.

BOTANY OF CALADIUM BICOLOR

Caladium is an ornamental foliage plant grown from tubers and planted extensively in landscape, especially in the southeastern U.S.A. *Caladium* is indigenous to South and Central America and belongs to the family *Araceace*. The colouration of this plant makes the environment in which it is found beautiful and adoring. The ornamental value of *caladium* use as pot or landscape plants is determined primarily by leaf characteristics [52]. They are grown for their colorful leaves that have a combination of green and white, green and red, white with red blotches or green veins and some have lavender spots. The size of the heart-shaped leaves may vary from 6 inches to 2 feet in length. Most *Caladium* varieties prefer fertile, moist, humus-rich but well drained soils in partially or fully shaded places [53]. Cultivar development in *caladium* has a history of some 150 years. However, about fifty one cultivars of *caladium* have gone to extinction due to lack of conservation [54]. *Caladium bicolor* has evolved due to its ornamental importance throughout the world.



Plate 1: *Amaranthus spinosus*



Plate 2: *Amaranthus hybridus*



Plate 3: *Colocasia esculenta*



Plate 4: *Caladium bicolor*

MATERIALS AND METHODS

SOURCES AND IDENTIFICATION OF PLANT MATERIALS

Four fresh plant samples of *Amaranthus spinosus*, *Amaranthus hybridus*, *Colocasia esculenta* and *Caladium bicolor* were collected from the forest strip of the Forestry Department in Michael Okpara University of Agriculture, Umudike, Abia State and identified by Mr. N. Ibe of the Forestry Department.

PREPARATION OF PLANT EXTRACTS

Freshly collected leaves of the various plants were oven-dried and then powdered using a Thomas Willey milling machine and then stored in air tight containers for analysis.

10 g of the dry grounded leaf samples of each plant was dispensed in a labeled beaker, 200 ml of distilled water was added and the mixture was shaken well and allowed to stand for 3 days (72hours). They

were filtered with Whatman 41 filter paper into another sterilized beaker and allowed to evaporate to dryness over a steam bath. The resulting dry extracts were used for the tests.

PREPARATION OF ANTIBIOTIC STOCK SOLUTION

The antibiotics used for this investigation were ciprofloxacin (500 mg) and ketoconazole (300 mg). A tablet of the antibiotic was dissolved in 5 ml of distilled water (500 mg/5 ml) in a sterile test tube and was used for the antimicrobial susceptibility test on each of the bacteria isolates.

MEDIUM PREPARATION

The medium used in the culture of bacteria and fungi was Nutrient Agar and Sabouraud Dextrose Agar. These were prepared in accordance with the manufacture's directives. Accordingly 28 g of Nutrient Agar was weight into separate flask and dispensed into

distilled water to make a total volume of 1 liter while the Saboraud Dextrose Agar (SDA) of 65g was weighted into separate flask and dispensed into distilled water to make a total volume of 1 liter. The mixture was heated in an electric water bath (GFC, 1083, Germany) until the Agar melted to form a homogenous solution. The prepared medium was separately transferred to Durum medium bottle and sterilized by autoclaving at 12°C for 15 minutes. The sterile medium was allowed to cool to about 45°C before being poured aseptically in an inoculation chamber (Ceslab England) in 15 ml portions, into sterile petri dishes to cool and gel into solids.

THE ANTIMICROBIAL SUSCEPTIBILITY STUDIES

The antimicrobial susceptibility studies of the extract were carried out using 5 mm diameter paper disc diffusion techniques described by [55]. 5 mm diameter paper discs were cut out from absorbent paper (Whatman filter paper No 1.) using office paper perforator. The discs were boiled for 30 minutes in a beaker containing 50 ml of distilled water. The water was decanted and the disc transferred to a clean universal bottle. They were sterilized by autoclaving at 121°C for 15 minutes. The paper discs remained in the capped bottle, labeled and stored in the refrigerator until they were ready for use.

Each test microorganism from 48 hours broth culture was inoculated onto a solid agar plate using spread plate technique. With the help of sterile forceps, the leaf extract discs were collected and placed carefully on each inoculated culture plates at the same distance from each other and for each organism. The agar plates containing inoculated organisms were incubated at 37°C for 24 hours to 48 hours in the incubator. They were examined daily for growth. On establishment of growth the paper discs containing the extracts were examined for a clear zone surrounding each disc. The diameters of such zones of inhibition were measured (mm) with the aid of transparent ruler

and recorded. Triplicate measurements were made for each test and the mean value was taken. The potency of each positive activity of extract against each organism was calculated relative to that of the standard antibiotic. This was determined using the formula below:

$$\% \text{ Relative potency} = \frac{DT \times 100}{DS \quad I}$$

Where DT = Diameter of inhibition zone of test extract.

DS = Diameter of inhibition zone of standard antibiotic.

DETERMINATION OF MINIMUM INHIBITION CONCENTRATION

The minimum inhibition concentration was determined as the least concentration of the plant extract to cause inhibition on each of the test microorganisms. In this regards, each extract was diluted in series to certain varying concentrations of mg/ml in the range of 6.25 mg/ml, 12.5 mg/ml, 50 mg/ml, 100 mg/ml, 150 mg/ml and 200 mg/ml. Each of the diluents was tested for antimicrobial activity against each of the test organisms. A standard antibiotics, Ciprofloxacin and ketoconazole were also tested at the conventional dose of 30 mg/ml. After inoculation and subsequent placement of the discs bearing the different diluents of the extract, the plates were incubated and observed. The lowest concentration to cause inhibition that is visible was recorded as the minimum inhibition concentration (MIC).

RESULTS

The Results of analysis of the antimicrobial activity of the aqueous test plant extracts are shown in Tables-1 to 5.

Table 1 shows the activities of the different extracts against the test organisms while Table 2 to 5 presents the minimum inhibition concentration of the extracts against the specific organisms.

Table 1: Mean zone of inhibition of the aqueous leaf extract of *A. spinosus*, *A. hybridus*, *C. esculenta* and *C. bicolor*.

Test organisms	Plant extracts and their zones of inhibitions (mm)			
	<i>S. aureus</i>	<i>E. coli</i>	<i>S. typhi</i>	<i>C. albican</i>
<i>A. spinosus</i>	15.6 ± 0.58 ^c	14.67 ± 0.58 ^c	12.33 ± 1.16 ^b	18.00 ± 1.73 ^{bc}
<i>A. hybridus</i>	11.67 ± 1.53 ^d	10.33 ± 0.58 ^d	10.33 ± 0.58 ^c	14.33 ± 0.58 ^c
<i>C. esculenta</i>	12.33 ± 0.58 ^d	16.33 ± 1.16 ^c	10.67 ± 1.16 ^c	11.67 ± 0.58 ^c
<i>C. bicolor</i>	18.3 ± 1.16 ^b	16.67 ± 1.53 ^b	14.00 ± 1.00 ^b	21.00 ± 2.65 ^b
STD	22.33 ± 1.53 ^a	21.67 ± 0.58 ^a	19.5 ± 2.12 ^a	26.0 ± 1.0 ^a

Table-2: Minimum inhibitory concentration of plants extracts on *Staphylococcus aureus*

Extract concentration (mg/ml)						
Plant extracts	6.25	12.50	50	100	150	200
<i>A. spinosus</i>	0.00±0.00	0.00±0.00	8.87±0.32	10.33±0.58	11.67±0.58	12.33±0.58
<i>A. hybridus</i>	0.00±0.00	0.00±0.00	6.90±0.17	8.83±0.29	9.20±0.17	10.77±0.40
<i>C. esculenta</i>	0.00±0.00	0.00±0.00	7.33±0.58	9.89±0.19	10.43±0.51	12.67±0.58
<i>C. bicolor</i>	0.00±0.00	6.33±0.58	9.67±0.58	11.33±0.58	12.33±0.58	11.68±0.97

Table-3: Minimum inhibitory concentration of plant extracts on *E. coli*

Extract concentration (mg/ml)						
Plant extracts	6.25	12.50	50	100	150	200
<i>A. spinosus</i>	0.00±0.00	0.00±0.00	9.33±0.58	10.00±1.00	10.67±0.58	11.67±0.58
<i>A. hybridus</i>	0.00±0.00	0.00±0.00	6.67±0.58	7.67±0.58	8.67±0.15	9.67±0.58
<i>C. esculenta</i>	0.00±0.00	6.33±0.58	9.67±0.58	11.10±0.17	11.30±0.30	11.17±0.46
<i>C. bicolor</i>	0.00±0.00	8.17±0.29	9.67±0.58	11.33±0.58	11.73±0.67	12.33±0.58

Table -4: Minimum inhibition concentration of plant extracts on *Salmonella typhi*

Extract concentration (mg/ml)						
Plant extracts	6.25	12.50	50	100	150	200
<i>A. spinosus</i>	0.00±0.00	0.00±0.00	12.67±0.58	14.00±0.50	13.50±0.50	13.83±1.04
<i>A. hybridus</i>	0.00±0.00	8.33±0.29	10.17±0.29	11.20±0.17	11.55±0.48	12.37±0.32
<i>C. esculenta</i>	0.00±0.00	9.33±0.58	11.67±0.58	12.00±1.00	12.33±1.16	13.00±1.00
<i>C. bicolor</i>	0.00±0.00	0.00±0.00	10.67±0.58	12.00±1.00	12.67±0.58	12.67±0.58

Table-5: Minimum inhibition concentration of plant extracts on *Candida albican*

Extract concentration (mg/ml)						
Plant extracts	6.25	12.50	50	100	150	200
<i>A. spinosus</i>	0.00±0.00	9.10±0.17	10.20±0.17	11.33±0.58	12.33±0.58	13.00±1.00
<i>A. hybridus</i>	0.00±0.00	0.00±0.00	6.33±0.56	8.33±0.58	8.67±0.58	9.33±0.58
<i>C. esculenta</i>	0.00±0.00	0.00±0.00	0.00±0.00	8.33±0.58	10.67±0.58	11.33±0.58
<i>C. bicolor</i>	0.00±0.00	10.67±0.56	10.67±0.56	11.10±0.17	12.17±0.29	12.07±0.58

Table 1 shows the ability of the plant aqueous extracts against the organisms. The diameter of inhibition zones against *Staphylococcus aureus* varied between 11.67±1.53^d mm in *A. hybridus* and 18.3±1.16^b mm in *C. bicolor*. *Staphylococcus aureus* is one of the most encountered pathogen in health concern and is known to have strong resistances against many conventional antibiotics. However, the potency of the extracts were lower than the activity of the standard antibiotic which had an inhibition diameter of 22.33 mm. Relatively the activity of extracts ranged between 52.26% in *A. hybridus* and 82.06% in *C. bicolor*. The activity of the plant extract against *E. coli* varied with significant difference. Extracts of *C. bicolor* and *C. esculenta* had higher activity against *E. coli* having diameter of 16.67 ± 1.53^b mm and 16.33 ± 1.16^c mm respectively as against 10.33 ± 0.58^d mm and 14.67 ± 0.58^c mm recorded for *A. hybridus* and *A. spinosus* respectively. The activities of the two plant extracts *C. bicolor* and *C. esculenta* against *E. coli* compared relatively with that of the standard antibiotic (21.67 ± 0.58^a mm). The relative potency were 76.93% for *C.*

biolor and 75.36% for *C. esculenta*. *E. coli* is a pathogen that is associated with diarrhea and dysentery and is implicated in many cases of food borne diseases [56]. The potentials of using the test plant extracts in the control of *E. coli* based ailments exist.

Salmonella typhi was inhibited by the plant extracts to a lesser extent than *Staphylococcus aureus* and *E. coli*. The diameter of inhibition zones were between 10.33 ± 0.58^c mm in *A. hybridus* and 14.00± 1.00^b mm in *C. bicolor*. *A. spinosus* had 12.33 mm ± 1.16^b mm while *C. esculenta* had 10.67mm ± 1.16^c mm. The low levels of activity against *Salmonella typhi* show resistance on the side of the organisms. The activities of the plant extracts were higher against the fungi *Candida albican* with inhibition diameter of 11.67±0.58^c mm to 21.00±2.65^b mm whereas the standard antibiotic recorded 26.0±1.0^a mm. *C. bicolor* had the highest activity (21.00±2.65^b mm) with a relative potency of 80.77 %, 21/26 while *C. esculenta* had the least activity (11.67±0.58^c mm) with a relative potency of 44.88 % 11.67/26. *Candida albicans* is a

normal flora of the female genitalia but also causes vaginal candidiasis under certain conditions.

Table 2 showed the result of test on the minimum inhibitory concentration of the plant extracts against *Staphylococcus aureus* at different concentration ranging from 6.25 mg/ml to 200 mg/ml, the result showed that there were variations in the activity of the different plant extracts against the organism. The MIC of aqueous extracts of *A. spinosus*, *A. hybridus* and *C. esculenta* were 50 mg/ml with inhibition zone of diameter 8.87 ± 0.32 mm, 6.9 ± 6.17 mm and 7.33 ± 0.58 mm respectively while *C. bicolor* inhibited the organism at a concentration of 12.5 mg/ml with a diameter of 6.33 ± 0.58 mm.

Table 3 showed the MIC test on *E.coli*. The lowest concentration which inhibited *E.coli* was 50 mg/ml (9.33 ± 0.58 mm) in *A. spinosus*, 50 mg/ml (6.67 ± 0.58 mm) in *A. hybridus*, 12.5 mg/ml (6.33 ± 0.58 mm) in *C. esculenta* and 12.5 mg/ml (8.17 ± 0.29 mm) in *C. bicolor*. Table 4 showed the susceptibility of *Salmonella typhi* to the plant extracts. At concentrations of 6.25 mg/ml and 12.5 mg/ml the extracts of *A. spinosus* and *C. bicolor* were not active against *Salmonella typhi*. They were active at concentration of 50 mg/ml while *C. esculenta* and *A. hybridus* at concentration of 12.5 mg/ml with inhibition zones of 9.33 ± 0.58 mm and 8.33 ± 0.29 mm respectively. In Table 5, the minimum inhibitory concentration (MIC) test against *Candida albican* was 12.50 mg/ml (9.10 ± 0.17 mm) and (10.67 ± 0.56 mm) for *A. spinosus* and *C. bicolor* respectively, 50 mg/ml (6.33 ± 0.56 mm) for *A. hybridus* and 100 mg/ml (8.33 ± 0.58 mm) for *C. esculenta*.

DISCUSSION

The activities exhibited by these plant extracts suggest the possibility of using them to control such infections. The level of inhibition of the pathogen by the test extracts shows the extracts to be appreciably potent. Generally, the activity of plant extracts against disease causing microorganisms and their use in traditional remedies is considered to be a function of the phytochemicals in the plants [57]. These bioactive compounds are known to act by different mechanism and exert antimicrobial action. Tannins bind to proline rich proteins and interfere with the protein synthesis [58]. Flavonoids are hydroxylated phenolic substance known to be synthesized by plants in response to microbial infection and it should not be surprising that they have been found in vitro to be effective antimicrobial substances against a wide array of microorganisms. Their activity is probably due to their ability to complex with extracellular and soluble proteins and to complex with bacterial cell walls [59]. Antimicrobial property of saponin is due to its ability to cause leakage of proteins and certain enzymes from the cell [60]. While observing the potentials of the plant extracts for use against the clinical isolates, it is on

record that medicinal plants can be poisonous if wrong plant parts or concentrations are used [61]. In this regard, a good knowledge of the phytochemical composition of the plants is necessary in selecting and applying them in controlling ailments.

Plant essential oils and extracts have been used for several thousands of years, in food preservation, pharmaceuticals, alternative medicine and natural therapies. It is necessary to investigate those plants scientifically which have been used in traditional medicine to improve the quality of healthcare. Plant extracts remain potential sources of novel antimicrobial compounds especially against bacterial pathogens.

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