



Comparative Phytochemicals Screening, Antibacterial and Antioxidant Properties of Some Selected Medicinal Plants in Nigeria

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Abstract

Background: Antibiotics resistance poses serious health threats globally, necessitating the search and development of an efficient environmentally friendly antibiotics. Evaluation of medicinal plants possessing antioxidant and antimicrobial chemicals is essential for solving this problem and improves human health.

Aims: This research was done to assess the phytochemical status, antioxidant and antibacterial potentials of the leaf extracts of four medicinal plants (*Moringa oleifera*, *Linus usitatissimum*, *Vernonia amygdalina*, and *Anacardium occidentale*) cultivated in Nigeria.

Methods: Standard methods were used to screen the phytochemicals; agar well diffusion and DPPH radical scavenging assays were employed to evaluate the antibacterial and antioxidant properties of the extracts.

Results: The results showed that the medicinal plants tested possessed significant phytochemicals including alkaloids, flavonoids, phenolics, terpenoids, tannins, saponins, among others. The plants showed effective antibacterial properties, with *Moringa oleifera* showing highest antibacterial activities against *Staphylococcus aureus* and *Escherichia coli*, followed by *Vernonia amygdalina*, *Linus usitatissimum*, and *anacardium occidentale*. The medicinal plants also showed powerful antioxidant potentials with lower IC₅₀ values. *moringa oleifera* being the most powerful has an IC₅₀ value of 41.95 µg/ml, followed by *Linus usitatissimum* (IC₅₀ = 43.09 µg/ml), *Vernonia amygdalina* (IC₅₀ = 54.64 µg/ml), and *anacardium occidentale* (IC₅₀ = 66.85 µg/ml), compared with the standard ascorbic acid (IC₅₀ = 14.14 µg/ml).

Conclusion: The medicinal plants tested in this study possess significant bioactive compounds and could serve as an effective potential agent against pathogenic bacteria, suppress oxidative stress thereby improving the human health quality.

Keywords: Antioxidant Activity; Antimicrobial Resistance; Extracts; Medicinal Plants; Phytochemicals

1. INTRODUCTION

Microbial diseases continue to pose serious worldwide threats despite significant advancements in modern medicine (Tufa et al., 2023). This is primarily due to a decline in the introduction of new antimicrobial medications and a rise in the ratio of antimicrobial

resistance to synthetic drugs. According to Rather et al. (2017), bacteria that are resistant to one or more of the antibiotics used to treat illnesses causes serious infections in at least 2 million people in the United State of America annually. In low-income nations, the situation is made more worrisome by a lack of laboratory tests, efficient surveillance systems, and affordable access to the right antimicrobials. This dire situation necessitates the search for new, innovative, and reasonably affordable antibiotics, particularly in underdeveloped nations where infectious diseases account for half of the death rate (Elisha et al., 2017). According to estimates, antibiotic resistance can cost the economy up to \$20 billion in direct medical expenses and \$35 billion in lost productivity annually (Morehead et al., 2018; Okeke et al., 2023). By 2050, the number of deaths will reach 10 million, and the global cost might reach \$100 trillion if nothing is done to find new medications that can challenge and destroy these microbial diseases. In most cases, *Staphylococcus aureus* and *Escherichia coli* are chosen for antibacterial careening because of their

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importance in hygiene and sanitation (Kebede et al., 2021; Maryam et al., 2024; Sunday and Remi, 2020).

In food systems, antioxidants are essential because they stop the oxidation of proteins and lipids, maintaining texture, color, and flavor throughout. By shielding biomolecules from oxidative damage, dietary antioxidants—mostly phenolics and flavonoids found abundance in fruits and vegetables—help lower the chance of developing chronic oxidative stress. Recent studies have highlighted substances like bromophenols for their disease-preventive antioxidant and enzyme-inhibiting qualities. Medicinal plants contain antioxidants which are crucial components since they can fight infections and improve human health (Danladi et al., 2024). By reducing oxidative stress and cellular damage, antioxidants are essential for preserving food quality and human health (Chakmakci et al., 2015; Cherian et al., 2019; Demirta et al., 2025; Gulcin et al., 2025).

Moringa oleifera, comes from the family of Moringaceae. This plant originated from Africa, India, Europe, Southern America, Europe, the Middle East, and Asia (Alegbeleye, 2018; Raman et al., 2018). The applications of *Moringa* include hypoglycemic, antioxidant, antibacterial, anti-inflammatory, antifungal, cholesterol-lowering, antihypertensive properties. Some antibacterial compounds in moringa includes quercetin, kaempferol, and many other phytochemicals (Oladeji et al., 2020; Gandji et al., 2018; Danjuma et al., 2025).

Vernonia amygdalina comes from Asteraceae family. The plant is mostly found in Africa and is used to cure diabetes, diarrhea, evil eye and eye disease, hepatitis, healing of wound, tonsillitis, malaria, headache, urine infection, intestinal parasite, bloating, hepatitis, toothache, anthrax, gastritis, snake bites, and stomach disorders. Reports showed that vernolide and isorhamnetin identified in the flowers of *Vernonia amygdalina* possess antibacterial activity (Degu et al., 2024).

Linum usitatissimum comes from the famil Linaceae. It grows in temperature climate zone, and it used to decrease the risk of cardiovascular disease, anti-inflammatory, cancer, prostate gland and colon cancers, decreasing rate of tumor growth, reducing serum cholesterol level, laxative effect, and alleviation of menopausal symptoms and osteoporosis. Some lignans and phenols found in *Linum usitatissimum* were found to possess antibacterial activity (Saroj et al., 2023).

Anacardium occidentale, called cashew, is a medicinal plant that provides food and medicine to humans. antibacterial compounds in *Anacardium occidentalis* are amentoflavone, quercetin, and some glycosides (Edet et al., 2023).

Anacardium occidentale is found to be antioxidant and it helps in reducing inflammation. The dominant

Searching for novel antibiotics from these plants' extracts is crucial, as evidenced by the traditional usage of natural goods in the treatment of illnesses. Plants' medicinal value is determined by the kinds of phytochemical chemicals they contain, which have a range of physiological effects on human health (Azizaram et al, 2021; Ezeonu and Ejikeme, 2016). Therefore, this research was done to carry out phytochemical screening, antioxidant and antibacterial activities of the leaf extracts of the selected medicinal plants cultivated in northern Nigeria.

2. MATERIALS AND METHOD

2.1 Collection of plants materials

The leaves samples of *moringaoleifera*, *vernonia amygdalina*, *linus usitatissimum*, and *anacardium occidentale* were collected from the premises of the Federal Polytechnic Idah, Kogi State, Nigeria. The samples were identified and authenticated by Botany unit of the department of Science Laboratory Technology, Federal Polytechnic Idah. The samples were washed with tap water and dried. The dried samples were crushed into powder using laboratory mortar and pestle and the powdered samples were kept in polythene bags until use.

2.2 Preparation of the Plants Extracts.

Maceration extraction method was used. The extract of each plant leaves was prepared by soaking 250 g of the powdered sample in 750 mL 95 % ethanol for seven days with frequent agitation. Each of the resulting mixture was filtered by gravity filtration and the filtrate was air-dried and weighed. The yield was calculated using the formula below:

$$\% \text{ Yield} = \frac{\text{Weight of solid powder}}{\text{Weight of crude extract}} \times 100 \quad 1$$

2.3 Phytochemical Screening

The screening of Phytoconstituents of each plant extract was done using standard methods described by standard Ushie et al (2018), Bako et al. (2023), Sagayaraj et al. (2015), and Muhammad et al. (2024) to evaluate the presence of alkaloids, anthraquinones, flavonoids, tannins, saponins, glycosides, terpenoids, Proteins, steroids, phenolics, etc. The results were denoted as (+) for the presence and (-) for the absence of phytochemicals.

2.3.1 Detection of Saponins (Frothing Test)

A small quantity of the extract was mixed with about twenty milliliters of distilled water and shaken in a

graduated cylinder for 15 minutes. Formation of foaming afterwards indicates the presence of saponins (Ushie et al., 2018; Bako et al., 2023; Sagayaraj et al., 2015; Muhammad et al., 2024)

2.3.2 Detection of Flavonoids (Alkaline Test)

Each extract was mixed with few drops of sodium hydroxide solution (NaOH). Formation of intense yellow color that changes to colorless when 1% hydrochloric acid solution was added shows the presence of flavonoids (Ushie et al., 2018; Bako et al., 2023; Sagayaraj et al., 2015; Muhammad et al., 2024).

2.3.3 Detection of Tannins

A small amount of each extract was mixed with distilled water followed by heating on a water bath. The mixture was filtered and then ferric chloride was added. A blue black shows the presence of tannins (Ushie et al., 2018; Bako et al., 2023; Sagayaraj et al., 2015; Muhammad et al., 2024)

2.3.4 Detection of Anthraquinone

A small portion of each extract was boiled with two milliliters of hydrochloric acid for about 5 minutes in a water bath followed by filtration and cooling at room temperature. A small volume of chloroform was added to the filtrate followed by few drops of 10 % ammonia solution and then heated. An occurrence of rose-pink color indicates the presence of anthraquinone (Ushie et al., 2018; Bako et al., 2023; Sagayaraj et al., 2015; Muhammad et al., 2024)

2.3.5 Detection of Terpenoids

A small portion of each extract was combined with two milliliters of chloroform and three milliliters of concentrated sulfuric acid. An appearance of reddish-brown coloration indicates the presence of terpenoids (Ushie et al., 2018; Bako et al., 2023; Sagayaraj et al., 2015; Muhammad et al., 2024)

2.3.6 Detection of Phenolics

About one milliliter of the extract was mixed with two milliliters of distilled water followed by addition of 2 drops of 10 % ferric chloride solution. An appearance of blue color indicates the presence of phenolics (Ushie et al., 2018; Bako et al., 2023; Sagayaraj et al., 2015; Muhammad et al., 2024)

2.3.7 Test for Steroids

In a test tube, five drops of concentrated sulfuric acid was added to one milliliter of the extract. An appearance of a red coloration indicates the presence of steroids (Ushie et al., 2018; Bako et al., 2023; Sagayaraj et al., 2015; Muhammad et al., 2024)

2.3.8 Alkaloids Test (Wagner's Test)

An extract was dissolved one percent hydrochloric acid solution and filtered. The filtrate was treated with

Wagner's reagent. A formation of a brown/reddish precipitate indicates the presence of alkaloids.

2.3.9 Test for essential oils

Ten milliliters of the extract were dissolved in a ninety percent alcohol followed by addition of three drops of ferric chloride. A green coloration indicates the presences of essential oils (Ushie et al., 2018; Bako et al., 2023; Sagayaraj et al., 2015; Muhammad et al., 2024)

2.3.10 Detection of Glycosides (Borntrager's Test)

A ferric chloride solution was added to a small amount of the extract followed by immersing the mixture in boiling water for five minutes. The mixture was cooled and extracted with benzene. The benzene layer was subsequently separated from the mixture and ammonia solution was added to it. A formation of rose-pink color in the ammonia layer shows the presence of glycosides (Ushie et al., 2018; Bako et al., 2023; Sagayaraj et al., 2015; Muhammad et al., 2024)

2.3.11 Test for resin

Two mL of the extract was mixed with a small volume of acetic anhydride solution followed by addition of a few drops of concentrated sulfuric acid. An observed violet coloration shows the presence of resins (Ushie et al., 2018; Bako et al., 2023; Sagayaraj et al., 2015; Muhammad et al., 2024).

2.3.12 Reducing sugars test

A small amount of the extract was mixed with distilled water and filtered. The filtrate was treated with few drops of Fehling's solution A and B followed by boiling. The appearance of a precipitate in orange-red color showed the presence of reducing sugars (Ushie et al., 2018; Bako et al., 2023; Sagayaraj et al., 2015; Muhammad et al., 2024).

2.4 Antioxidant Assay by DPPH

A solution of about 0.1 mM of 2,2-diphenyl-1-picryl hydrazyl (DPPH) in ethanol solvent was prepared. A quantity of one milliliter of the prepared DPPH solution was mixed with three milliliters of each extract solution which was dissolved in ethanol at prepared concentrations of 500 µg/ml, 250 µg/ml, 125 µg/ml, 62.5 µg/ml, 31.2 µg/ml, 15.6 µg/ml, and 7.8 µg/ml). The mixture was allowed to stand for thirty minutes before taking the absorbance at 517nm. Ascorbic acid prepared using the same procedure was used as standard, and DPPH without the sample was taken as negative control. The analysis was done in triplicates and average was measured and the percent inhibition of free radical scavenging of the mixture was calculated using the equation below (Zhang et al., 2021):

$$Inhibition (\%) = \frac{A - B}{A} \times 100 \quad (2)$$

Where: A = Absorbance of control
 B = Absorbance of sample

The samples concentrations resulting in fifty percent (50 %) inhibition on DPPH (IC₅₀ value) was determined using the linear regression equations.

2.5 Antibacterial activity

2.5.1 Disc diffusion assay

The bacterial isolates used were *Staphylococcus aureus* and *Escherichia coli* collected from Biology/Microbiology department, Federal Polytechnic Idah. The microorganisms were inoculated in conical

flask which contains 100 ml of nutrient broth followed by incubation at 37 °C for twenty-four hours. The media used were Muller Hinton Agar prepared according to the manufacturers’ instructions which was then poured on sterilized petridishes followed by incubation with the test organisms from the seeded broth using cotton swabs. Hole of 6 mm in diameter were made on the sterile discs and 20 µl of samples were into the upper part of the seeded agar plates. The plates were then incubated at 37 °C overnight. Using a ruler, the inhibition zones were recorded by measuring the width of the disc where the resistance occurred. The standards used were amoxicillin and ketoconazol (100 µg/disc concentration) and the negative control was dimethylsulfoxide (DMSO) (Danjuma et al., 2024).



Vernonia amygdalina



Linus usitatissimum



Moringa oleifera



Anacardium occidentale

Figure 1. Sample leaves of the medicinal plants studied

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Percentage Yield

The percentage yield of each of the plant leaf extract was presented in Table 1 and figure 2, and the result showed

that the medicinal plants tested showed variations in the percentage yields, with *Moringa oleifera* showing the highest extraction yield value of 20.9 %. This was followed by an extract from *Vernonia amygdalina* which produced a percent yield of 18.4 %. The third and the least were extracts from *Anacardium occidentale* and

Linus usitatissimum with extraction yields of 17.5 % and 16.8 %, respectively.

Table 1. Percent extraction yield of the plant samples

S/N	Plant sample	Weight of powdered sample (g)	Weight of extract (g)	Yield (%)
1	<i>M. oleifera</i>	250	20.9	8.36
2	<i>V. amygdalina</i>	250	18.4	7.36
3	<i>L. usitassimum</i>	250	16.8	6.72
4	<i>A. occidentale</i>	250	17.5	7.0

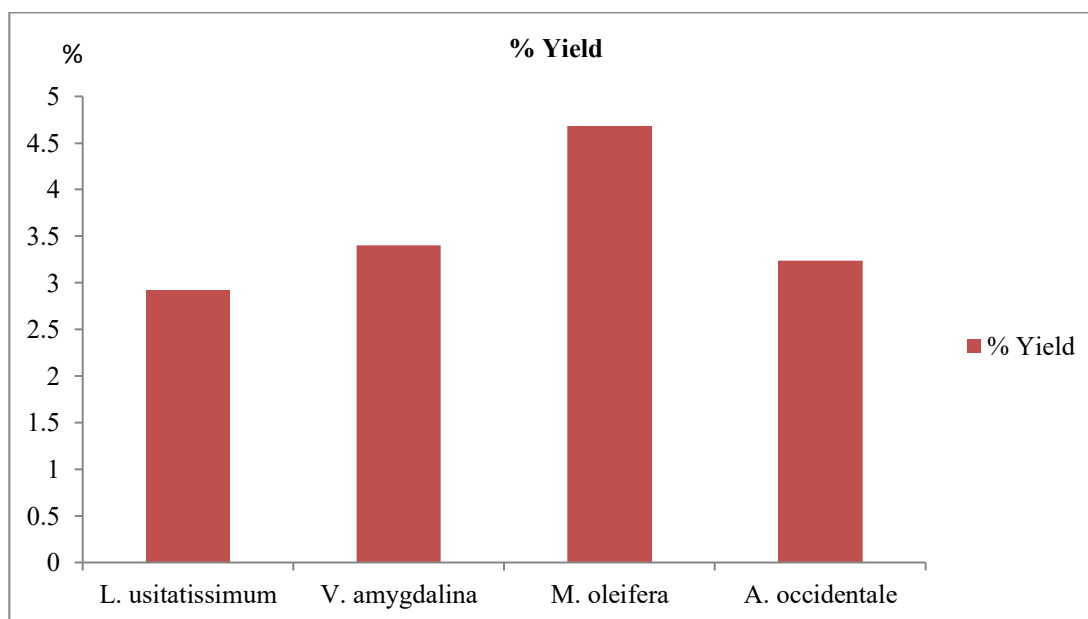


Figure 2. Percentage yield of the extracts

3.2 Phytochemicals Screening

The result of phytochemical screening of the medicinal plants was presented in table 2. The extracts from the medicinal plants tested showed remarkable phytochemicals constituents present. The extract from *Moringaoleiferashowed* the presence of all the phytochemicals except only glycosides and resins. Also,

glycosides and essential oils were the only phytochemicals not detected in *Linus usitatissimum* extract. *Vernonia amygdalina* possesses all the phytochemicals except glycosides, essential oils, and resins. *Anacardium occidentale* didn't reveal glycosides and terpenoids. It is observed that glycosides were not detected in all the four plants leaves studied.

Table 2. Phytochemical screening of the plant samples

S/N	Phytochemicals	Samples Plants			
		<i>M. Oleifera</i>	<i>L. usitassimum</i>	<i>V. amygdalina</i>	<i>A. occidentale</i>
1	Flavonoids	+	+	+	+
2	Steroids	+	+	-	-
3	Tannins	+	+	+	+
4	Alkaloids	+	+	+	+
5	Phenolics	+	+	+	+
6	Carbohydrates	+	+	+	+
7	Glycosides	-	-	-	-
8	Saponins	+	+	+	+
9	Anthraquinones	+	+	+	+
10	Essential Oils	+	-	-	+
11	Resins	-	+	-	+
12	Terpenoids	+	+	+	-

Key: + means presence, and – means absence

3.3 Antioxidant Activity

Table 3 shows the absorbance of the ascorbic acid and the four medicinal plants studied. The absorbance of control was 0.545. From the results, it was observed that *moringa oleifera* shows lowest absorbance, an indication of very good antioxidant activity. This was followed by

the extracts from *Linus usitatissimum*, *Vernonia amygdalina*, and *Anacardium occidentale*. Ascorbic acid, being the standard antibiotic, shows the lowest absorbance. A reaction mixture with lower absorbance implies higher free radical scavenging activity and vice versa.

Table 3. Absorbance of the extracts and the standard. The absorbance of control = 0.545

Conc. (µg/ml)	A. Acid	Samples Plants			
		<i>M. Oleifera</i>	<i>L. usitassimum</i>	<i>V. amygdalina</i>	<i>A. occidentale</i>
500	0.0133	0.2904	0.2492	0.2662	0.3004
250	0.0155	0.2994	0.2784	0.2814	0.3213
125	0.0192	0.3094	0.3143	0.2983	0.3400
62.5	0.0294	0.3489	0.3301	0.3295	0.3840
31.2	0.0436	0.3946	0.3773	0.3504	0.4350
15.6	0.0673	0.4303	0.4164	0.3893	0.4433
7.8	0.1465	0.4590	0.4554	0.4087	0.4715

Antioxidants molecules are very important and essential for preventing the oxidative damage brought on by reactive oxygen species. In the food and pharmaceutical industries, DPPH radical elimination is one of the most popular and commonly utilizes techniques. The most convenient and widely used radical removal technique for assessing the antioxidant capacity of compounds and herbal

extracts are DPPH radical scavenging, a widely used spectrophotometric method that is simple, sensitive, quick, and reproducible. It is used to determine the antioxidant capacity of beverages, pure substances, foods, and herbal extracts (Danjuma et al., 2024).

Table 4. Percent inhibition of the plants leaves

Conc. (µg/ml)	A. Acid	Percent Inhibitions of the samples (%)			
		<i>M. Oleifera</i>	<i>L. usitassimum</i>	<i>V. amygdalina</i>	<i>A. occidentale</i>
500	97.55	46.71	51.27	51.14	44.87
250	97.14	45.06	48.90	48.36	41.03
125	96.46	44.25	42.33	45.26	37.60
62.5	94.59	35.97	39.42	39.54	29.54
31.2	92.00	27.59	30.77	35.70	20.17
15.6	87.65	21.04	23.59	28.56	18.66
7.8	73.11	15.77	16.44	25.00	13.48

Lipid peroxidation is frequently caused by radical chain reactions. By halting peroxidation chain events, radical scavengers improve the stability and quality of food products. Radical scavenger molecules do this by directly interacting with peroxide radicals and swiftly scavenging them. There is a known method for free

radical scavenging, in which antioxidants directly prevent lipid peroxidation. In studies of antioxidant activity, this approach is the most common, standard, quick, and useful. The harmful effects of free radicals in foods and pharmaceuticals make radical elimination activity crucial (Chiorcea-Paquim et al., 2020).

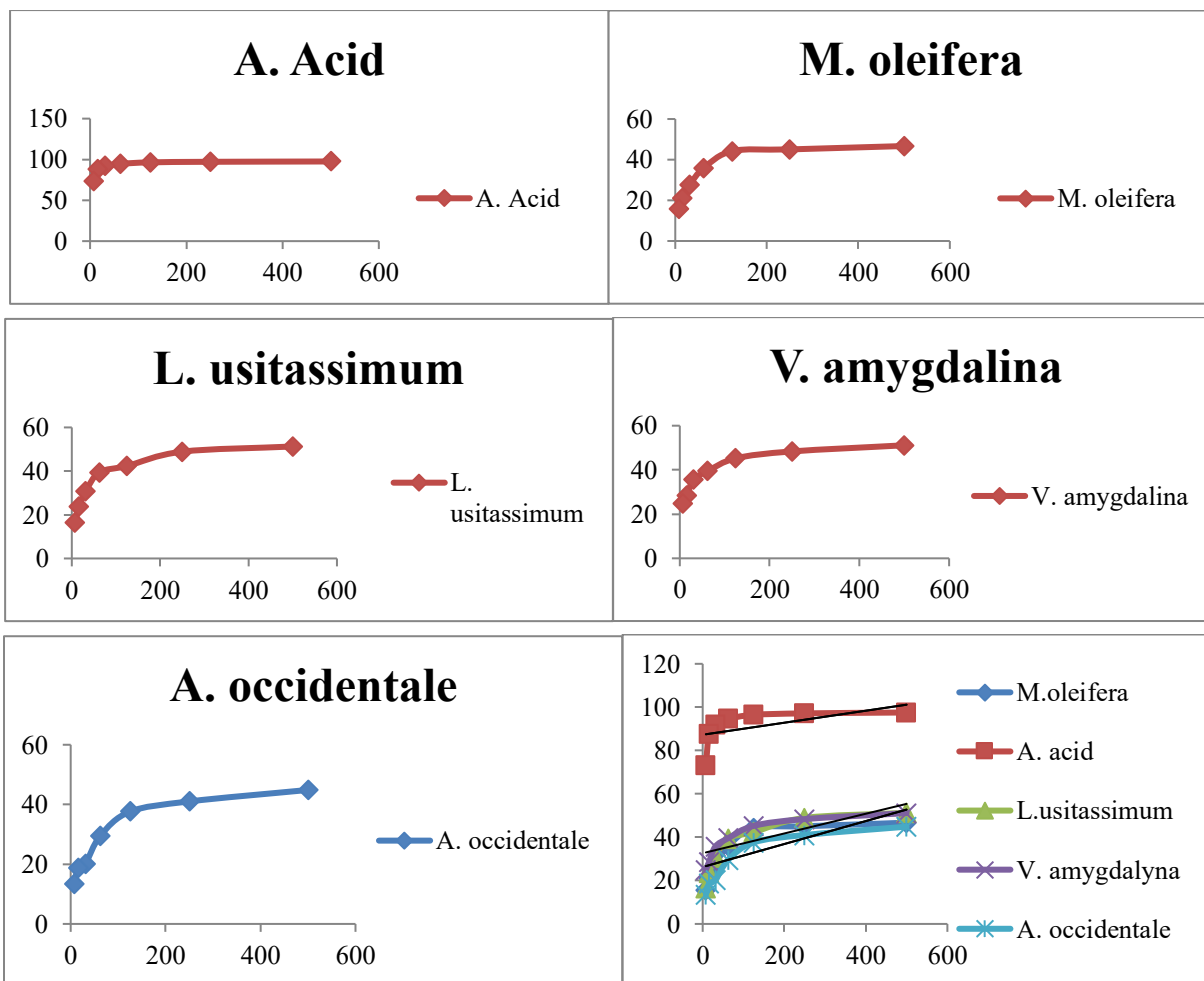


Figure 3. Absorbance and Inhibition zones of the medicinal plants and the standard

Table 5. IC50 values of the samples

Test Samples	IC ₅₀ (µg/ml)
A. Acid	14.14
<i>L. usitatissimum</i>	43.09
<i>V. amygdalina</i>	54.64
<i>M. Oleifera</i>	41.95
<i>A. occidentale</i>	66.85

The IC₅₀ value is has been a parameter used for determining the rate of antioxidant activity. A higher IC₅₀ value indicates a lower antioxidant capacity,

and a lower IC₅₀ value denotes a stronger antioxidant activity. Table 5 contains the IC₅₀ values of the studied medicinal plants and the standard. The lowest value was observed with *moringa oleifera* (IC₅₀ = 41.96 µg/ml) and this explains that *moringa oleifera* was the most active antioxidant medicinal

plant among the four medicinal plants tested. The second plant with lower IC₅₀ and higher antioxidant activity was *Linus usitatissimum* (IC₅₀ = 43.09 µg/ml). The *Vernonia amygdalina* and *Anacardium occidentale* came third and fourth with IC₅₀s of 54.64 µg/ml and 66.85 µg/ml, respectively. Ascorbic acid which has lowest IC₅₀ of 14.14 µg/ml showed highest antioxidant activity. The antioxidant activity follows this order: ascorbic acid > *moringa oleifera* > *Linus usitatissimum* > *Vernonia amygdalina* > *anacardium occidentale* (figure 4).

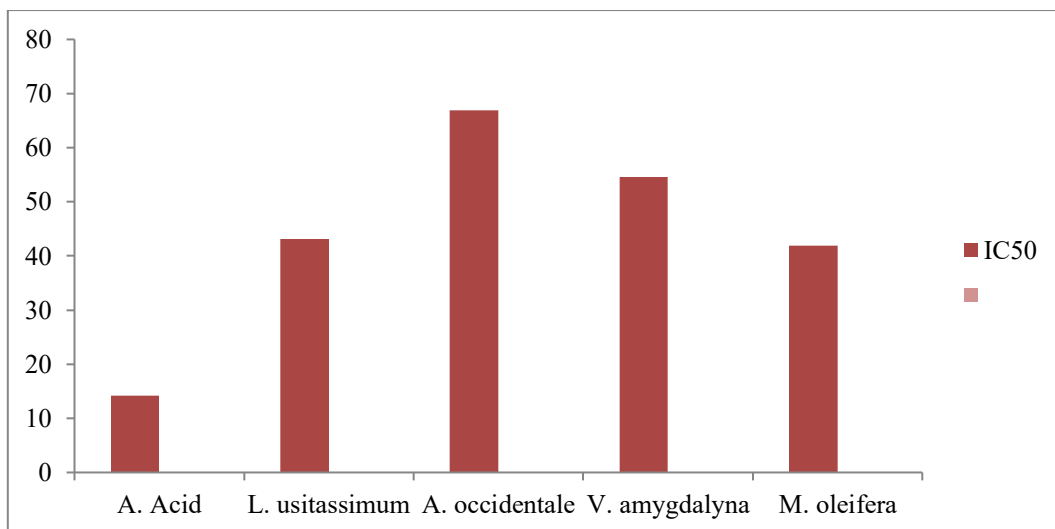


Figure 4. IC50 range of the medicinal plants

An antioxidant activity of a substance is said to be very strong if the IC50 is below 50 µg/ml, and strong if the IC50 is in the range of 51 µg/ml to 100 µg/ml, moderate if the IC50 is between 101 µg/ml to 250 µg/ml, and not active if the IC50 is above 500 µg/ml (Athira et al., 2021). According to the IC50s obtained from the medicinal plants in this study, it can be said that *Linus usitatissimum* and *moringa oleifera* showed very high antioxidant activity with IC50 values less than 50 µg/ml, while *Anacardium occidentale* and *Vernonia amygdalina* showed strong antioxidant activity with IC50 values between 50 µg/ml to 100 µg/ml.

3.4 Antimicrobial Activity

Table 6 and 7 and figure 5 showed the antibacterial activity of the medicinal plants studied. The results showed that *moringa oleifera* showed the largest zones of inhibition which is an indication that it has highest antibacterial activity among the medicinal plants tested. This was followed by *Vernonia amygdalina*, *Linus usitatissimum*, and the last was *Anacardium occidentale* which has lowest zone of inhibitions. It has been observed that *S. aureus* shows lower resistance to all the four tested medicinal plants than the *E. coli*.

Table 6. Antibacterial zone of inhibitions of the plants against *Staphylococcus aureus*

Conc. (mg/ml)	Inhibition				Standard
	<i>M. oleifera</i>	<i>L. usitatissimum</i>	<i>V. amygdalina</i>	<i>A. occidentale</i>	Amoxicillin
60	17	13	14	12	20
30	10	8	12	10	
15	7	4	6	8	

Table 7: Antibacterial zone of inhibition of the plants against *Escherichia coli*.

Conc. (mg/ml)	Inhibition				Standard
	<i>M. oleifera</i>	<i>L. usitatissimum</i>	<i>V. amygdalina</i>	<i>A. occidentale</i>	Amoxicillin
60	11	7	9	8	16
30	8	4	6	5	
15	5	2	3	3	

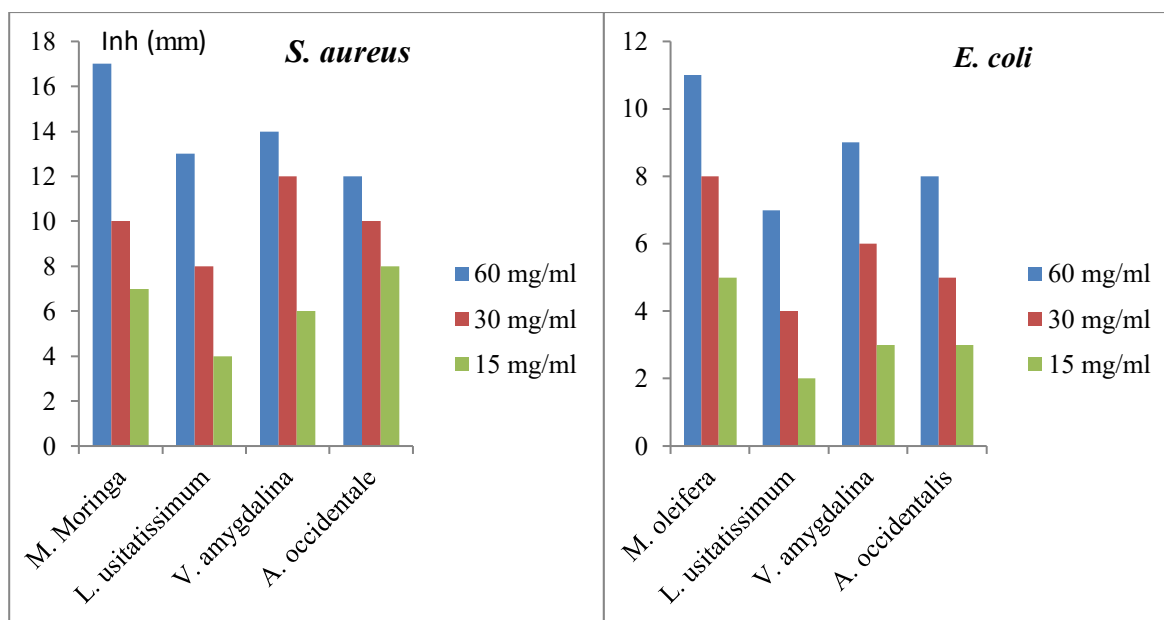


Figure 5. Antibacterial activity of the medicinal plants against *S. aureus* and *E. coli*

3.2 Discussion

Phytochemicals screening is useful in assessing the chemical constituents that could be used in making therapeutic medications. In this study, the result of the qualitative phytochemical screening of the plants' extracts showed that phenolics, flavonoids, saponins, tannins, alkaloids, carbohydrates, and anthraquinones were present in all the four plants' extracts. Flavonoids detected in the plants were found to possess antioxidant potentials. Tannins were found to have antibacterial, antitumor, and antiviral effects (Bhattacharya et al., 2016). Alkaloids are reported to possess powerful anti-HIV and antiparasitic properties (Nugraha et al., 2019).

The antimicrobial activity associated with the plants' extracts against *S. aureus* and *E. coli* in this study could be due to the noticeable number of phytochemicals detected in the plants such as alkaloids, phenolics, saponins, flavonoids, tannins, carbohydrates, terpenoids, and anthraquinones (Tables 6 and 7). Reports showed that Phenolics alter the working principles of cytoplasmic membrane, affecting energy metabolism and thereby altering the nucleic acids synthesis in the process (Salehi-Sardoei and Khalil, 2022). Another study showed that alkaloids and terpenoids associate with proteins and enzymes membrane microbial cells making it to disperse a protein flux towards the external cell that cause the cells to die. Flavonoids were said to have the ability of inhibiting DNA bacterial polymerase, Reverse polymerase, RNA polymerase, telomerase and Reverse Transcriptase (Kouadri, 2018). The saponins reduce surface tension influencing an accruing of cells leakage or permeability leakage, causing a intracellular compounds discharge (Bhattacharya et al., 2016)

Plants high in physiologically active substances, including flavonoids, alkaloids, tannins, and essential oils, which have been demonstrated to have antibacterial, anti-inflammatory, and antioxidant qualities, are good source of herbal extracts. Compared to synthetic antibiotics, which frequently lead to the evolution of resistant bacterial strains, these natural compounds provide a sustainable and eco-friendly substitute. Additionally, phytochemicals found in herbal extracts can target a variety of bacterial pathways, potentially lowering the chances of development of antimicrobial resistance (Kishlay et al., 2025). Significant variations ($p < 0.05$) in the extracts' antibacterial activity were found through statistical analysis. The potential of these plants as natural antibacterial agents was highlighted by the findings that *moringa oleifera* and *Vernonia amygdalina* were significantly more effective than *Linus usitatissimum* and *Anacardium occidentale* extracts. Natural antibiotics extracts pose significant benefit over synthetic antibiotics, which frequently target a single bacterial structure. These extracts may play a major role in addressing the worldwide problem of antibiotic resistance due to their broad-spectrum efficacy and decreased risk of resistance development.

The lower Inhibition concentration (IC50) of all the extracts obtained from the medicinal plants studied here emphasizes the plants' potential antioxidant agents. The leaves of *moringa oleifera*, having the lowest IC50 values of 41.95 $\mu\text{g/ml}$, placed *moringa* as the most powerful antioxidant agent among the four medicinal plants tested in comparison with the standard ascorbic acid. The IC50 value of *linus usitatissimum* leaves, being very close to that of *moringa* at 43.09 $\mu\text{g/ml}$ shows their position as the second most powerful antioxidant agents. The extracts from *Vernonia amygdalina* and *Anacardium occidentale* came third and fourth as the

most antioxidant medicinal plants with IC50 of 54.64 µg/ml and 66.85 µg/ml, respectively.

3.2.1 Implication

The results showed that the four medicinal plants studied are natural suppliers of bioactive compounds that can suppress the reaction of the reactive oxygen species in the human body. Regular uptake of medicinal plants tested in this study could provide necessary antioxidants that could provide succor against dire conditions such as depression, cancers, diabetes, asthma, oxidative stress and other diseases induced by free radical's unbalance (Danjuma et al., 2025).

3.2.2 Research Contribution

This research is the first of its kind. The sample of each plant tested in this study was collected from the premises of the Federal Polytechnic Idah, Kogi State, Nigeria, and no previous research like this has been done before on the plants especially in the same area. So the findings reveal that the leaves of the plants tested could serve as potential sources of bioactive chemicals that could serve as antioxidant and antimicrobials agents in the treatment of numerous diseases. Variation in location of plants can have a substantial impact on their quality and quantity of phytochemicals present which in turn may have an impact on the potential medicinal applications of the plants such as antioxidant and antimicrobial properties (Eka et al., 2024).

3.2.3 Limitation

This research was done on the leaf extracts of the medicinal plants studied. The research has not touched the other parts such as stems, roots, and fruits of the plants. And also, the research has been limited to the sample plants grown and cultivated in Idah Local Government Area, Kogi State, North Central Nigeria.

3.2.4 Suggestions

Based on the findings of this study, the following suggestions were made:

- i. To have a wider coverage, phytochemical screening and bioactivity testing should be carried out on the extracts from the stems, roots, and fruits of the medicinal plants cultivated from the same area as in this research to assess their medicinal applications.
- ii. For safety purpose, cytotoxicity testing should be performed on plants' extracts to ascertain whether they are potentially toxic or not.
- iii. To get new antibiotics, isolation and identification of bioactive compounds from the extracts of the same medicinal plants should be carried out. These bioactive compounds, when isolated, identified and clinically tested, could serve as potential replacements and solutions for the global threats of antimicrobial resistance.

4. CONCLUSION

The results of this study showed that herbal extracts from the leaves of *moringa oleifera*, *Vernonia amygdalina*, *linus usitatissimum*, and *anacardium occidentale* possess bioactive natural phytoconstituents that are potential agents against reactive oxygen species. The extracts from the medicinal plants studied also are good antibacterial agents against the multidrug-resistant bacteria such as *Escherichia coli* and *Staphylococcus aureus*. The strong bioactive substances like tannins, flavonoids, and phenolics are responsible for the reported antioxidant and inhibitory effects. By breaking down bacterial cell membranes, preventing biofilm formation, and impairing quorum sensing, these substances stop bacteria from growing. The study emphasizes these natural compounds' potential as sustainable and eco-friendly substitutes for manufactured antibiotics. The future research should be done to isolate and characterize these bioactive chemicals in order to create therapeutic medicines that effectively cure bacterial illnesses that are resistant to antibiotics.

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AUTHORS CONTRIBUTIONS

All the authors contributed equally. Together they conceptualized the idea, designed and conducted the experiment, analyzed the data, and wrote the paper.

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