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# *In Vitro* antibacterial activity of moringa leaves (Moringa oleifera) and aloe vera (Aloe barbadensis Miller) against escherichia coli and klebsiella pneumoniae

## Abstract

The medicinal properties shown by different medicinal plants are as a result of the present phytochemicals in the plants. These phytochemicals are important sources for the treatment of diseases. Different phytochemicals have an extensive range of activities, which helps to boost the immune system and give resistance against disease to protect the body from harmful pathogens. The study was aimed to determine the phytochemicals constituents and antibacterial activity of Moringa oleifera leaf and Aloe vera extracts against Two (2) bacteria associated with gastroenteritis namely; Escherichia coli and Klebsiella pneumoniae. The bacterial isolate was obtained from Microbiology Laboratory of Gombe State University, Gombe. Phytochemical screening of the leaf extract was conducted in the Plant Science Laboratory to ascertain the presence and number of bioactive components present in the both plant extract using Two (2) solvent (Ethanol and Distilled Water). The antimicrobial assay of the leaves extracts was performed using the disc diffusion method. The qualitative phytochemicals screening of the extract indicated the presence of Alkaloid, flavonoids, phenol, glycosides, saponin and tannin while steroid is found absent in both plant samples. The result shows that the extracts were active against the microorganisms. The Ethanol extract showed highest activity against the bacterial isolates than aqueous extracts. It is concluded that ethanol extract has higher effect and possesses more antibacterial activities compared to the aqueous extracts, which is attributable to the fact that ethanol extracted more of the bioactive components of the plant compared to the aqueous.

**Keywords:** Antibacterial-activity, Gastroenteritis, Phytochemical, Screening, Escherichia coli, Klebsiella pneumoniae.

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## Introduction

Phytochemicals are biochemical metabolites that occur naturally in plants with no nutritional value to human life. They are biologically active, non-nutritional plant compounds known for their protective and disease-preventive effects, act as antioxidants, enzyme stimulants, antibacterial agents, anticancer agents, and also have hormonal effects.[1] Most plants that contain large amounts of these photochemical substances are commonly called medicinal plants.[2] Medicinal plants are recognized for possessing organic compounds or secondary metabolites that exert distinct physiological effects on both the human body and the plants themselves.[3]

These metabolites include alkaloids, flavonoids, steroids, glycosides, gums, phenol, tannings, terpenes and terpenoids, which are used as chemical precursors or active pharmaceutical ingredients (APIs) for the development and manufacture of drugs.[4] More than 4000 phytochemicals have been catalogued and classified based on their functions as they protect health of plants from toxification, stress alleviation, synthesize and activates hormones, pollution treatment, insects, microbial infection and algae attack, which has shown human potential to fight diseases and illness, acting as antioxidants, hormonal and enzyme stimulation.[5-7]

In recent times, interest in natural therapeutic alternatives has significantly increased and traditional medicines owing to their perceived efficiency and fewer adverse effects compared to synthetic drugs.[1] Use of medicinal plants represents one of the important traditional medical treatments, approximately one-quarter of contemporary pharmaceuticals are derived from plant sources. after they have been used traditionally.[8] Among the many factors that influence the potential uses of plant medicine is due to it's Safe, no side effects symptoms. A number of currently available synthetic antibiotics are associated with adverse effects, such as toxicity, nausea, and allergic reactions.[9] Consequently, the use of medicinal plants as alternative therapeutic options has gained global attention, particularly in response to the increasing resistance of pathogens to standard antibiotics.[10]

Moringa oleifera and Aloe vera (Aloe barbadensis Miller) are among the medicinal plants that have attracted considerable interest because of their reputed health-promoting properties. These plants have been utilized in traditional medicine across diverse cultures for centuries due to their therapeutic value.[11] Aloe vera and Moringa oleifera are readily available medicinal plants with diverse geographical distribution, making them easily accessible resources in the outreach of people, which is used in various ways either by consumption or applications.[2,12,13]

Commonly referred to as the "miracle tree," Moringa oleifera is recognized as one of the most widely utilized and highly valued trees globally. It is a rapidly growing, evergreen or deciduous tropical species that can reach heights of 10–12meters.[2] Its leaves, often tripinnate and sometimes bipinnate, can extend up to 45cm in length and are alternately and spirally positioned along the twigs.[11] Moringa oleifera is one of 14 known species within the Moringaceae family, indigenous to regions such as Africa, Arabia, Southeast Asia,

South America, India, and the Pacific and Caribbean Islands.[14] Other members of this plant family include Moringa arborea, Moringa borziana, Moringa concanensis, Moringa drouhardii, Moringa hildebrandtii, Moringa longituba, Moringa ovalifolia, Moringa peregrina, Moringa pygmaea, Moringa rivae, Moringa ruspoliana, and Moringa stenopetala.[15] Known by various names around the world, it is called "drumstick" in India, "Nebedy" in Senegal, "Marum" in Thailand, "Benzolive tree" in Haiti, and "Malunggay" in the Philippines. In Nigeria, its local names include "Zogale" or "Bagaruwarmakka" among the Hausa people in the North, "Ewe Igbale" or "Idagbomonoye" in the Yoruba-speaking Southwest, and "Ikwaoyibo" in the Southeast among the Igbo.[16] Moringa thrives even in extremely arid and poor soil conditions where most vegetation fails to grow. Its remarkable resilience to harsh environments has earned it the nickname "never die".[17] Beyond its role as a common vegetable in many local diets, Moringa oleifera is also extensively valued for its medicinal and health-promoting properties.

Aloe vera (Aloe barbadensis Miller), often referred to as the "wonder plant," derives its name from two root languages: the Arabic term "Alloeh," meaning "shining bitter substance," and the Latin word "Vera," which translates to "true".[10] This plant has been utilized for over two millennia and holds significant relevance in phytotherapy and herbal medicine. Resembling a cactus in structure, Aloe vera consists of around 360 species and is well adapted to thrive in arid, hot climates. Due to its increasing demand, it is now widely cultivated on a commercial scale.[18] Historically, Aloe vera held great reverence: ancient Egyptians referred to it as the "plant of immortality," while the Greeks considered it a "universal remedy" over 2,000 years ago. Taxonomically, Aloe vera is a monocotyledonous member of the Asphodelaceae (and previously classified under Liliaceae) family, and it is native to regions of Eastern and Southern Africa, the Canary Islands, and parts of Spain.[19] The Aloe genus comprises approximately 300 to over 500 perennial species, although only a select few possess significant medicinal properties.[18,19] Botanically, Aloe vera is a short-stemmed, succulent shrub that typically grows between 60–100cm in height and propagates through offsets. Its leaves are thick, fleshy, and range from green to grey-green, sometimes displaying white spots on both surfaces.[20] During the summer, the plant produces flowering spikes that can reach heights of up to 90cm. The pendulous flowers have a tubular yellow corolla measuring 2–3cm in length.[9] Notably, Aloe vera leaves contain a high concentration of water between 99.0% and 99.5% which contributes to its ability to maintain skin hydration. Its gel is widely applied for wound healing, as it promotes tissue regeneration and stimulates cellular repair. The therapeutic applications of Aloe vera gel include treating digestive issues, constipation, sunburn, thermal burns, radiation injuries, skin conditions, and it is known for its anti-inflammatory, antibacterial, and antifungal effects. Moreover, studies have suggested that Aloe vera may enhance the immune system and help manage conditions such as diabetes and ulcers.[21,22] Conducting the phytochemical screening provides insights into the arrays of phytochemicals present in these plants, and ways in which they inhibit or their antibacterial efficiency against Escherichia coli and Klebsiella pneumonia.[5,23] his research was conducted to identify the phytochemical constituents present in Aloe barbadensis Miller and Moringa oleifera leaves and to ascertain if they possess any antibacterial effect on Escherichia coli and Klebsiella pneumoniae.

### Statement of problem

With the global concern over antibiotic resistance on the rise, there's a pressing need to explore alternative antimicrobial agents.[24] Due to this pressing issue a lot of focus has been put on medicinal plants. Aloe vera and Moringa oleifera, known for their rich bioactive compounds, present promising candidates for combating bacterial infections.[10,14] Escherichia coli and Klebsiella pneumonia are significant human pathogens associated with various infections, ranging from gastrointestinal disorders to more severe conditions like gastritis and peptic ulcers.[25] Assessing the antibacterial activity and efficiency of Aloe vera and Moringa oleifera leaves against this pathogen addresses a clinically relevant aspect of bacterial infections.[26]

### Objectives

i. To carry out a phytochemical screening in order to determine the bioactive compounds present in Aloe vera (Aloe barbadensis Miller) and Moringa oleifera leaves.

ii. To determine the antibacterial activities and efficacy of Aloe vera (Aloe barbadensis Miller) against Escherichia coli and Klebsiella pneumoniae.

iii. To determine the antibacterial activities and efficacy of Moringa oleifera leaves against Escherichia coli and Klebsiella pneumoniae.

iv. To determine the effectiveness of aqueous and ethanol extracts of Aloe vera (Aloe barbadensis Miller) and Moringa oleifera leaves.

### Materials and methods

Collection And Identification of Moringa oleifera Leaves and Aloe vera

The leaves of Moringa Oleifera were obtained from several houses in Kashere community, Gombe state, Nigeria, while Aloe vera was obtain in Gombe market, Gombe state, Nigeria. the leaves were identified and authenticated at the Herbarium of the Department of Plant Science, Gombe State University, Gombe state.

## Materials and methods

**Sample collection:** this should include how and where you got the samples

**Sample processing:** this should include how you got the extract of Moringa and Aloe vera through the process of air-drying, blending, water and alcohol extraction.

**Bacteriological analysis:** this should include all the aseptic techniques used ranging from media preparation, Muller Hilton media, use of well in agar or disk diffusion method,

### Extraction of moringa oleifera leaves

The leaves were air-dried for a period of four weeks and then pulverized into fine powder under laboratory conditions using a mortar and pestle. Leaf extraction followed the procedure outlined by.[27] Specifically, 50 grams of the powdered Moringa oleifera leaves were subjected to exhaustive extraction through cold maceration using distilled water and ethanol over five days. The resulting extracts were then filtered through Whatman No. 2 filter paper, after which the aqueous extract was concentrated using a water bath, while the ethanol extract was concentrated with a rotary evaporator. The extracts were collected with two different beakers labeled "Ethanol" and "Aqueous".

### Extraction of aoe vera

The plant leaves were air-dried for four weeks and then finely ground under sterile conditions using a laboratory blender. Leaf

extraction was carried out following the method described by.[24] A 50-gram portion of the powdered Aloe vera leaves was subjected to cold maceration using distilled water and ethanol for a duration of five days. The mixtures were then filtered with Whatman No. 2 filter paper. Concentration of the aqueous and ethanol extracts was achieved using a water bath and rotary evaporator, respectively. The extracts were collected with two different beakers labeled "Ethanol" and "Aqueous".

### Bacteria isolate

Two bacterial isolates commonly linked to gastroenteritis, Escherichia coli and Klebsiella pneumoniae, were obtained and identified to the species level at the Microbiology Laboratory of Gombe State University, Gombe State. Identification procedures included Gram staining, cultural characterization, and a series of biochemical assays such as Indole, Methyl Red, Voges-Proskauer, Catalase, Citrate utilization, and Coagulase tests, following the method described by.[25] The isolates were preserved on nutrient agar slants for subsequent experimental use.

### Media preparation

The weighing balance was set to zero, 7g of Nutrient Agar was measured into a conical flask and dissolved with 250g of distilled water (bit by bit) on a hot plate. After dissolving, a sterile cotton wool was used to tightly cover the conical flask, followed by a piece of foil and wrapped tightly with a masking tape to ensure there's no penetration of air. The mixture was placed in an autoclave to reach a pressure gauge of 121°C for 15minutes for proper sterilization. With the use of ethanol and cotton wool, surface sterilization was properly done to avoid contamination. On the sterilized surface, the Media was poured into 2 different Petri dishes and allowed to solidify. A wire loop was sterilized using a flaming candle on different intervals while it was used to pick and inoculate the various bacteria samples into the Media on the Petri dishes.

### McFarland turbidity standard preparation

1.17g of Barium chloride was measured into a beaker and dissolved with 100ml of distilled water. On another beaker, 1ml of sulphuric acid alongside a 100ml of distilled water (giving 1% sulphuric acid). The solutions were properly mixed. 1ml was deducted from the 1% sulphuric acid solution and 0.5ml of Barium chloride solution was added to it, giving the McFarland Standard solution. 24 hours after inoculation of the media, 10ml of distilled water was poured into Two (2) different test tubes and was sterilized using the autoclave. After sterilization, the test tubes were labelled (E. coli and K. pneumoniae) respectively. Two (2) different sterile swab sticks were used to collect the 2 different bacteria which grew on the nutrient agar medium by rubbing the stick on the surface of the medium. The collected bacteria were added to the Two (2) different test tubes containing 10ml of distilled water (one bacteria for each tube) and was mixed properly. The mixtures were compared with the McFarland Standard solution and all appeared same with a whitish coloration.

### Mueller hinton media preparation

The electronic measuring scale was set to zero and 9.5g of Mueller Hinton agar powder was measured, the powder was suspended in 200ml of distilled water. It was mixed and dissolved completely on a hot plate. The medium was sterilized by autoclaving at 121°C for 15minutes. The liquid was poured into 6 Petri dishes and allowed to solidify.

### Stock preparation of moringa oleifera

1g of aqueous and ethanol extract of Moringa oleifera leaves was put in four different sample bottles labeled "STOCK". 2ml of Dimethyl sulphoxide (DMSO) was added to both samples and mixed properly. In 8 different sample bottles containing 1ml of DMSO labelled Aq12.5, Aq25, Aq50, Aq75 and Aq100 and Eth 12.5, Eth 25, Eth 50, Eth 75 and Eth 100, 1ml of aqueous and ethanol Moringa oleifera extracts from the respective stocks were used to serially dilute the 1ml of DMSO in the respective bottles following their concentrations (12.5, 25, 50 and 100).

## Results

### Stock preparation of aloe vera

1g of aqueous and ethanol extract of Aloe vera leaves was put in Two (2) different sample bottles labeled "STOCK". 2ml of Dimethyl sulphoxide (DMSO) was added to both samples and mixed properly. In 8 different sample bottles containing 1ml of DMSO labelled Aq12.5, Aq25, Aq50, Aq100 and Met12. 5, Met 25, Met 50 and Met 100, 1ml of aqueous and ethanolic Aloe vera extracts from the respective stocks were used to serially dilute the 1ml of DMSO in the respective bottles following their concentrations (12.5, 25, 50 and 100) (Figure 1).

**Figure 1** Plain bottles for stock and concentration percentage.

### Sensitivity test

The Disk diffusion method was used, whereby, a disk was dipped into the serially diluted solutions from each of the bottles and extract following their concentration label was dropped using a sterile forceps into the zone on the 8 media plates (Figure 2).

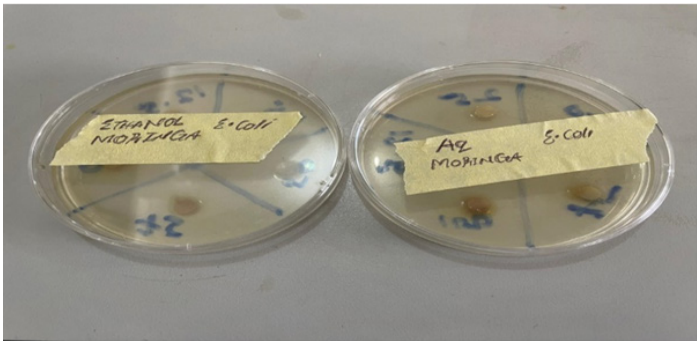


**Figure 2** Disk diffusion method.

### Antibiotics

Antibiotics (Ciprofloxacin) were used as control and placed at the middle of the media plates to mark the zone of inhibition. After 24 hours, the inhibitory zones were observed on each media plates and measured with a ruler.

### Phytochemical qualitative analysis of moringa oleifera leaves

8g of aqueous and ethanolic extracts of the Moringa oleifera leaves were dissolved in 28ml of distilled water, 2ml of these mixtures were poured into 14 different test tubes (7 for Aqueous and 7 for ethanol) and the following test was carried out:

i. **Test for alkaloids**: 2ml of choloroform was added to two test tubes containing the aqueous and ethanol extract of the sample each. Then about 3 to 4 drops of Wagner's reagent were added to the mixture, and a reddish-brown coloration confirmed the presence of alkaloids

ii. **Test for saponins**: Two of the test tubes containing aqueous and ethanol extract respectively were collected, mixed with 5ml of distilled water and well shaken. The formation of stable foam is an indication of the presence of Saponins

iii. **Test for tannins**: Ferric chloride was added to two sample tubes (one aqueous, one ethanol), a blue-green precipitate shows the presence of tannins.

iv. **Test for flavonoids**: 2% Sodium hydroxide was added to two sample tubes (one aqueous, one ethanol) The formation of an intense yellow color which turned colorless upon the addition of few drops of dilute acid indicates the presence of flavonoids.

v. **Test for steroids**: Five (5) drops of concentrated H2S04 was added to 0.1g of each extract in test tube, a containing both the aqueous and ethanol extract of the sample respectively a reddish-brown coloration indicates the presence of steroids.

vi. **Test for glycosides**: 3ml of Fehling solution was added to test tube containing both the aqueous and ethanol extract of the sample respectively. A brick red precipitate indicates the presence of glycosides.

vii. **Test for phenol**: To 2ml of the extract, a few drops of ferric chloride solution were added. The appearance of a greenish yellow color, confirms the presence of phenol.

## Phytochemical qualitative analysis of aloe vera

8g of aqueous and ethanolic extracts of the Aloe vera leaves were dissolved in 28ml of distilled water, 2ml of these mixtures were poured into 14 different test tubes (7 for Aqueous and 7 for ethanol) and the following test was carried out:

I. **Test for alkaloids**: 2ml of Wagner's reagent was added to an aqueous and ethanol extract sample, formation of a reddish-brown color indicates the presence of alkaloids.

II. **Test for saponins**: Two of the test tubes containing the aqueous and ethanol extract were collected and well shaken, long lasting persistent lather froths were formed on top.

III. **Test for tannins**: 0.5g of the dried powdered sample were boiled in 20ml of distilled water in test tube and then filtered. Few drops of 0.1% ferric chloride were added to the filtrate and formation of brownish green or blue-black coloration indicate presence of tannins.

IV. **Test for flavonoids**: 5ml of dilute ammonia solution was added to test tubes containing both the aqueous and ethanol extract of the sample respectively, followed by addition of sulphric acid ($H2SO_4$), The presence of a yellow solution which disappears on standing indicates the presence of flavonoids.

V. **Test for steroids**: 2ml of acetic anhydride and sulphuric acid was added to two of the test tubes containing aqueous and ethanol extract respectively, formation of blue-green color indicates the presence of steroids.

VI. **Test for phenol**: To 2ml of the extract, a few drops of ferric chloride solution was added. The appearance of a greenish yellow color, confirms the presence of phenol.

VII. **Test for glycosides**: 3ml of Fehling solution was added to test tubes containing both the aqueous and ethanol extract of the sample respectively. A brick red precipitate indicates the presence of glycosides (Figures 3-9).

**Figure 3** Test for saponin.

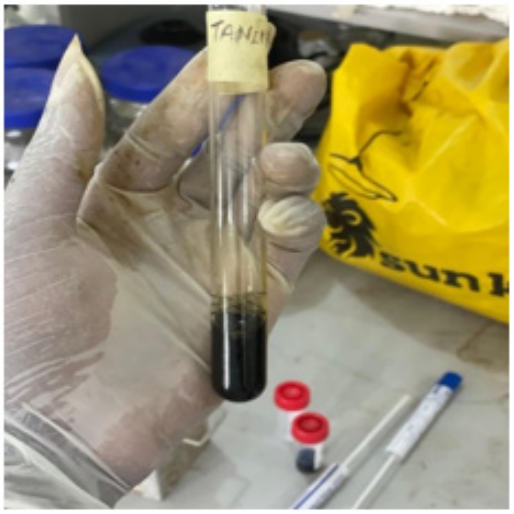


**Figure 4** Test for tanins.

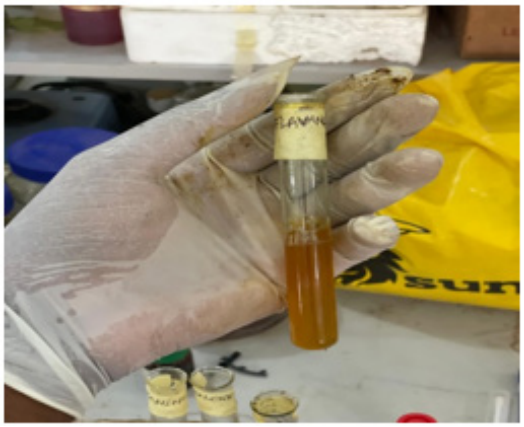

**Figure 5** Test for flavonoid.

**Citation:** Olatunji O, Adewojo AA. *In Vitro* antibacterial activity of moringa leaves (Moringa oleifera) and aloe vera (Aloe barbadensis Miller) against escherichia coli and klebsiella pneumoniae. *J Microbiol Exp.* 2025;13(2):54–61. DOI: 10.15406/jmen.2025.13.00433

**Figure 6** Test for alkaloids.

**Figure 7** Test for Phenol.

**Figure 8** Test for glycosides.

**Figure 9** Test for Steroids.

## Result

### Qualitative phytochemical screening of solvent-extracts of moringa oleifera leaves

The qualitative phytochemical screening of Moringa oleifera leaf extract using two solvents namely distilled water(aqueous) and ethanol is presented in Table 1.

**Table 1**

| Phytochemicals | Aqueous extract | Ethanol extract |
|---|---|---|
| Flavonoids | + | +++ |
| Saponins | + | ++ |
| Tannins | + | +++ |
| Alkaloids | + | ++ |
| Steroids | - | - |
| Phenol | - | - |
| Glycosides | + | + |

+ = Slight Presence of Phytochemicals, ++ = Moderate Presence of Phytochemicals

+++ = High Amount of Phytochemicals Present - = Absence of Phytochemicals

The result of qualitative phytochemical screening of both the aqueous and ethanol extract indicated the presence of five (5) bioactive compounds namely: tannins, saponins, flavonoids, alkaloids and glycosides while both steroids and phenol are absent in both extracts.

The concept of single sign (+), double sign (++) and triple sign (+++) signifies the rate of effect or coloration during the phytochemical screening where "+++ = Highly abundant; ++ = abundant; + = moderately present; - = absent."

Meaning the deeper the coloration the more abundant the bioactive compound is present in the extract. It is clear from this result that the effects were deferentially affected by aqueous and ethanol extracts (with ethanol being the highest) due to variation in the dissolution capacity of different solvents which in turn affected the degree of Phytochemicals extracted. Hence, it can be concluded that the aqueous extracts have less Phytochemicals than the ethanol extracts.

### Qualitative phytochemical screening of solvent-extracts of aloe vera

(Table 2) The result of qualitative phytochemical screening of both the aqueous and ethanol extract indicated the presence of six (6) bioactive compounds namely: tannins, saponins, flavonoids, alkaloids, phenol and glycosides while steroid is absent in ethanol extract.

**Table 2**

| Phytochemicals | Aqueous extract | Ethanol extract |
|---|---|---|
| Flavonoids | + | ++ |
| Saponins | + | + |
| Tanins | - | + |
| Steroids | - | - |
| Phenol | ++ | +++ |
| Alkaloids | + | + |
| Glycosides | + | ++ |

+++ = Highly abundant; ++ = abundant; + = moderately present; - = absent.

The aqueous extract contains five (5) bioactive compounds (flavonoids, alkaloids, phenol, saponins and glycosides) while both steroid and tannin are both absent.

**Citation:** Olatunji O, Adewojo AA. *In Vitro* antibacterial activity of moringa leaves (Moringa oleifera) and aloe vera (Aloe barbadensis Miller) against escherichia coli and klebsiella pneumoniae. *J Microbiol Exp.* 2025;13(2):54–61. DOI: 10.15406/jmen.2025.13.00433

Hence, from this result it can be concluded that the aqueous extracts have less Phytochemicals than the ethanol extracts.

**Sensitivity test result of aqueous and ethanol extract of moringa oleifera leaves**

6 is the diameter of the disk which means no visible effect observe. The antibacterial activity of aqueous Moringa oleifera leaf extract is presented in Table 3. The results showed that zones of inhibition recorded by the isolates depend on the type of bacterial isolates and concentration of the extracts. Highest zone of inhibition is demonstrated by Klebsiella pneumoniae (20mm) at 100mg/ml and the lowest zone of inhibition is demonstrated by E.coli at 12.5mg/ml. The zone of inhibition of the control (Ciprofloxacin 10µg) ranges from 28-27mm respectively (Figure 10).

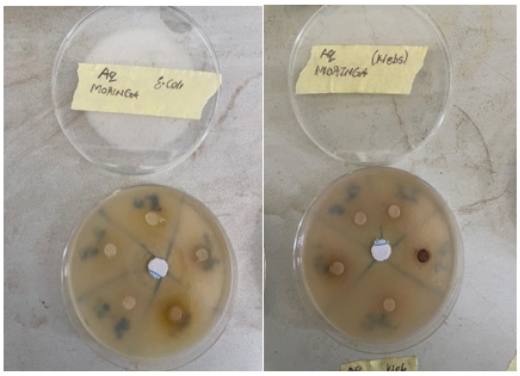


**Figure 10** Aqueous extract of Moringa oleifera on E.coli and klebsiella

**Table 3**

| Bacteria isolate | 12.5 | 25 | 50 | 75 | 100 | Control | Extract |
|---|---|---|---|---|---|---|---|
| *Escherichia coli* | 6 | 8 | 14 | 16 | 19 | 28 | Aqueous |
| *Klebsiella pneumoniae* | 7 | 10 | 15 | 17 | 20 | 27 | |

Concentration (mg/ml) / zone of inhibition (mm)

The antibacterial activity of ethanol Moringa oleifera leaf extract is presented in Table 4. The results showed that zones of inhibition recorded by the isolates depend on the type of bacterial isolates and concentration of the extracts. Highest zone of inhibition is demonstrated by Escherichia coli (23mm) at 100mg/ml and the lowest zone of inhibition is demonstrated by Klebsiella pneumoniae (6mm) at 12.5mg/ml. The zone of inhibition of the control (Ciprofloxacin 10µg) ranges from 28-30mm respectively.

**Table 4**

| Bacteria isolate | 12.5 | 25 | 50 | 75 | 100 | Control | Extract |
|---|---|---|---|---|---|---|---|
| *Escherichia coli* | 7 | 8 | 11 | 15 | 23 | 28 | Ethanol |
| *Klebsiella pneumoniae* | 6 | 6 | 9 | 14 | 22 | 30 | |

Concentration (mg/ml) / zone of inhibition (mm)

Based on the result obtained the antibacterial activity of ethanol Moringa oleifera leaf extract was also found to be highly effective on both Escherichia coli and Klebsiella pneumonia than the aqueous extract (Figure 11).

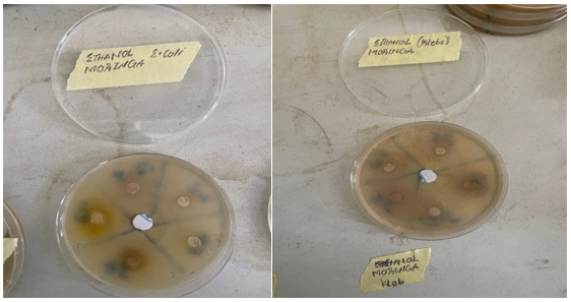


**Figure 11** Ethanol extract of Moringa oleifera on E.coli and klebsiella.

**Sensitivitytest result of aqueous and ethanol extract of aloe vera**

The antibacterial activity of aqueous Aloe vera extract is presented in Table 5. The results showed that the highest zone of inhibition is demonstrated by Escherichia coli (16mm) at 100mg/ml and the lowest zone of inhibition is demonstrated by both Escherichia coli and Klebsiella pneumoniae (6mm) at 12.5mg/ml. The zone of inhibition of the control (Ciprofloxacin 10µg) ranges from 22-19mm respectively (Figure 12).

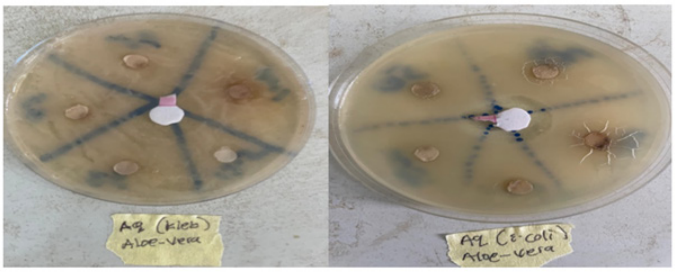


**Figure 12** Aqueous extract of Aloe vera on Klebsiella and E.coli.

**Table 5**

| Bacteria isolate | 12.5 | 25 | 50 | 75 | 100 | Control | Extract |
|---|---|---|---|---|---|---|---|
| *Escherichia coli* | 6 | 7 | 10 | 13 | 16 | 22 | Aqueous |
| *Klebsiella pneumoniae* | 6 | 6 | 6 | 8 | 10 | 19 | |

Concentration (mg/ml) / zone of inhibition (mm)

The antibacterial activity of aqueous Aloe vera extract is presented in Table 6. The results showed that the highest zone of inhibition is demonstrated by Escherichia coli (20mm) at 100mg/ml and the lowest zone of inhibition is demonstrated by Klebsiella pneumoniae (6 mm) at 12.5mg/ml. The zone of inhibition of the control (Ciprofloxacin 10µg) ranges from 24-19mm respectively (Figure 13).

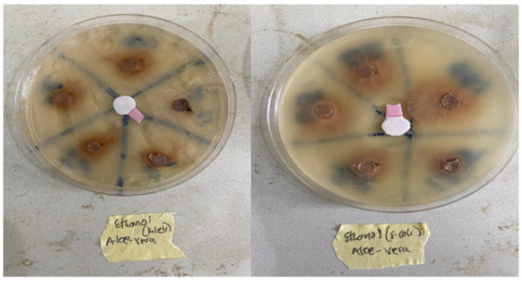


**Figure 13** Ethanol extract of Aloe vera on Klebsiella and E.coli.

**Table 6**

| Bacteria isolate | 12.5 | 25 | 50 | 75 | 100 | Control | Extract |
|---|---|---|---|---|---|---|---|
| Escherichia coli | 7 | 8 | 11 | 15 | 20 | 24 | Ethanol |
| Klebsiella pneumoniae | 6 | 7 | 9 | 12 | 14 | 19 | |

Concentration (mg/ml) / zone of inhibition (mm)

## Discussion

Phytochemical analysis of Moringa oleifera and Aloe vera leaf extracts revealed the presence of several bioactive constituents, including alkaloids, flavonoids, phenols, glycosides, saponins, and tannins. However, steroids were not detected in either of the extracts. These secondary metabolites are known to exhibit diverse pharmacological and biochemical properties and contribute significantly to human health through their antioxidant activities.[15,28] Numerous studies have previously focused on isolating and identifying bioactive components in Moringa oleifera and Aloe vera leaf extracts.[2,28] These investigations have confirmed the presence of flavonoids, alkaloids, saponins, glycosides, tannins, and phenols. The current findings are consistent with previous results reported by[29] for Moringa oleifera and[24] for Aloe vera. These phytochemicals are recognized for their medicinal relevance and are widely utilized in the pharmaceutical industry for the development of therapeutic drugs. Their presence in the leaves of Moringa and Aloe vera likely contributes to the plants' traditional applications in treating various ailments, including arthritis, atherosclerosis, diabetes, skin infections, nausea, asthma, diarrhea, dysentery, colitis, and cancer. Alkaloids, a major group of nitrogen-containing compounds, are commonly employed in cancer chemotherapy, anesthesia, and as stimulants of the central nervous system.[30]

These compounds are also involved in metabolic regulation and developmental processes in living organisms, which may explain their antimicrobial roles in Moringa and Aloe vera.[31] In plants, alkaloids serve defensive roles by repelling pests and parasites.[32] Flavonoids are potent antioxidants, known to function in both normal physiological processes and in response to disease. For example, flavonoids found in tea have been shown to inhibit low-density lipoprotein (LDL) oxidation and reduce blood cholesterol and triglyceride levels.[10] These compounds are also upregulated in response to microbial infections in plants, suggesting their antimicrobial potential. Moreover, flavonoids have been linked to cancer prevention by triggering cell death in tumor cells and inhibiting tumor spread.[33] Their strong antioxidant activity lies in their capacity to neutralize hydroxyl radicals, superoxide anions, and lipid peroxides, which is considered one of their most critical biological functions.[11]

Saponins are recognized for both health-promoting and adverse effects. While they may reduce cholesterol levels and support immune function, they also exhibit cytotoxicity and may increase intestinal permeability.[5] Several studies have highlighted the positive effects of saponins on cholesterol regulation, bone health, cancer inhibition, and immune system activation.[34] In medicinal plants, saponins contribute to cell growth regulation and inflammation control. Their presence in Moringa and Aloe vera supports their use in treating inflammatory conditions.[26,35] Due to their foaming ability, saponin-containing plant extracts are also used locally to make soap for bathing purposes.[36]

Tannins, a class of polyphenolic compounds found in various parts of many plant species, also demonstrate therapeutic effects. They help control bleeding and reduce inflammation and swelling.[37] Tannins are beneficial when applied to mucosal tissues and are used in traditional remedies such as mouthwashes, eye rinses, snuffs, vaginal douches, and for treating rectal disorders.[9] The findings of the present study, consistent with those reported by,[35,38] affirm the antimicrobial potential of Moringa oleifera and Aloe vera leaf extracts against bacterial strains implicated in gastroenteritis.

## Conclusion

The presence of secondary metabolites like flavonoid, alkaloids, phenols, glycosides, saponin and tannin in the studied plants Moringa oleifera and Aloe vera (Aloe barbadensis Miller) is responsible for the studied plant healing potentials. The present of these phytochemicals prove the medicinal values of these two (2) plants and their antibacterial efficacy against two (2) bacteria associated with gastroenteritis namely: Escherichia coli and Klebsiella pneumoniae.

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## Conflict of interests

Authors declare no conflict of interest.

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