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Evaluation of Bioactive Compounds and Antibacterial Potentials of *Moringa oleifera* and *Aloe vera* Leaves against *Escherichia coli* and *Klebsiella pneumoniae*

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Abstract

The medicinal properties shown by different medicinal plants are 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 help to boost the immune system and give resistance against disease to protect the body from harmful pathogens. The study aimed to determine the phytochemical 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 isolates were obtained from the Microbiology Laboratory of Gombe State University, Gombe. Phytochemical screening of the leaf extract was conducted to ascertain the presence and amount of bioactive components present in both plant extracts using two solvents (Ethanol and Distilled Water). The antimicrobial assay of the leaf extracts was performed using the disc diffusion method. The qualitative phytochemicals screening of the extract indicated the presence of Alkaloids, flavonoids, phenols, glycosides, saponins, and tannins, while steroids were absent in both plant samples. The result shows that the extracts were active against the microorganisms. The ethanol extract showed the highest activity against the bacterial isolates compared to the aqueous extracts. It is concluded that ethanol extract has a higher effect and possesses more antibacterial activities compared to the aqueous extracts, which is attributable to the fact that ethanol extracts more of the bioactive components of the plant compared to the aqueous.

Keywords: Antibacterial activity, Bacteria, Gastroenteritis, Phytochemical, Escherichia coli, Klebsiella pneumoniae.

INTRODUCTION

Phytochemicals are biochemical metabolites that occur naturally in plants with no nutritional value to human life. They are bioactive non-nutritive phytochemicals that have protective or preventive properties, act as antioxidants, enzyme stimulants, antibacterial agents, anticancer agents, and also have hormonal effects (Berkovich *et al.*, 2013).

Most plants that contain large amounts of these photochemical substances are commonly called medicinal plants (Vinoth *et al.*, 2012). Medicinal plants are known to contain some organic compounds or metabolites that have specific physiological effects on the human body and the plant itself (Patel Rameshwar *et al.*, 2010).

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 (Mirazeian, 2021). More than 4000 phytochemicals has 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 (Ali *et al.*, 2021; Park *et al.*, 2019)

The presence of photochemicals in the leaves, stems, bark, or roots of vegetables and other plants does not exclude the antioxidant potential and medicinal properties of the plants and their extracts (Abdallah *et al.*, 2011). Medicinal plants have played important roles in

the history of humanity through the formulation of different methods and ways to solve health-related needs (Li et *al.*, 2020).

Plants hold a vast number of organic compounds, which are used for nutritional, therapeutic, and curative purposes and serve as a source for pharmaceutical development of new drug agents (Xi et *al.*, 2020). The use of plants as medicines cannot be debated, since human civilization has existed since 4500 B.C. and is documented in the oldest human archives (Li et *al.*, 2020). As early as humans existed, they have isolated different plants by boiling with water or roasting over fire to solve their daily issues and provided leads in the development of several life-saving traditional medicinal drugs, which are used today (Miroddi *et al.*, 2015).

Due to the large variety of plants, medicinal plants with great potential for Pharmacological significance are being discovered mainly due to their diverse nutritional and phytochemical composition, which is widely consumed and used in therapeutics (Ahmad and Nazir, 2016).

Use of medicinal plants represents one of the important traditional medical treatments, and it is estimated that about 25% of modern medicines are made from plants after they have been used traditionally (Gupta and Rawat, 2017). Many of the existing synthetic (antibiotics) drugs are known to cause various side effects, such as intoxication, nausea, and other allergies (Kargaran *et al.*, 2016). Due to this implication, the use of medicinal plants is now forming an alternative therapy that has gained attraction throughout the world due to the growing resistance of pathogens to conventional antibiotics (Danish *et al.*, 2020).

Aloe vera (*Aloe barbadensis Miller*) and Moringa (*Moringa oleifera*) are two such plants that have garnered attention due to their purported medicinal properties. Both of these plants have a long history of traditional use in various cultures for their therapeutic benefits (Daba, 2016).

Moringa oleifera, commonly called Moringa or “miracle tree,” is regarded as one of the most popular and valuable trees in the world. *Moringa oleifera* is a fast-growing, evergreen, deciduous multipurpose tropical tree that can grow to a height of 10- 12 m (Vinoth *et al.*, 2012). The leaves are bipinnate or more commonly tripinnate, up to 45 cm long, and are alternate and spirally arranged on the twigs (Daba, 2016). *Moringa oleifera* flowers are fragrant and bisexual, surrounded by five unequal, thinly veined yellowish-white petals (Nepolean *et al.*, 2009). The vegetation is fragrant and bisexual, surrounded by 5 unequal, thinly veined, yellowish-white petals. *Moringa oleifera*, however, is one of the 14 species of the Moringaceae family, local to Africa, Arabia, Southeast Asia, southern America, India, the Pacific, and Caribbean Islands (Bukar *et al.*, 2010). The other species includes *Moringa arborea, Moringa borziana, Moringa concanensis, Moringa drouhardii, Moringa hildebrandtii, Moringa longituba, Moringa ovalifolia, Moringa peregrine, Moringa pygmaea, Moringa rivae, Moringa ruspoliana, and Moringa stenopetala* (Aondo *et al.*, 2018).

It is known in India as drumstick, in Senegal as Nebedy, in Thailand as Marum, in Haiti as Benzolive tree, and in the Philippines as Malunggay. It is also well known in all parts of Nigeria, in the North, the Hausas refer to it as Zogale or Bagaruwarmakka, in the south-west, the Yorubas call it Ewe Igbale or Idagbomonoye, and in the southeast, the Igbo call it Ikwaoyibo (Thilza et *al.*, 2010).

Moringa oleifera can be grown in even the harshest and driest of soils, where scarcely anything else will grow. *Moringa oleifera* is nicknamed "never die" because of its staggering capacity to endure harsh climate and even dry season (Rockwood *et al.*, 2013). Traditionally, besides being a daily used vegetable among people of these regions, *Moringa oleifera* is also widely known and used for its health benefits.

Moringa oleifera is rich in nutrition attributable to the presence of a range of essential phytochemicals gift in its leaves, pods, and seeds. In fact, *Moringa oleifera* provides 7 times more vitamin C than oranges, 10 times more vitamin A than carrots, 17 times more calcium than milk, 9 times more protein than yoghurt, 15 times more potassium than bananas, and 25 times more iron than spinach (Rockwood *et al.*, 2013). The leaves of *Moringa oleifera* are rich in minerals like calcium, potassium, zinc, magnesium, iron, and copper (Kasolo *et al.*, 2010). Vitamins like beta-carotene of vitamin A, vitamins B such as folic acid, pyridoxine, and nicotinic acid, vitamin C, D, and E are also present in *Moringa oleifera* leaves (Vinoth *et al.*, 2012; Mbikay, 2012). Phytochemicals such as Tannins, Sterols, Terpenoids, flavonoids, Saponins, Anthraquinones, Alkaloids, and reducing sugar are present along with anti-cancerous agents like Glucosinolates,

Isothiocyanates, Glycoside compounds, and Glycerol-1-9-Octadecanoate in the leaves (Berkovich *et al.*, 2013).

Aloe vera (*Aloe barbadensis Miller)* is commonly known as the "wonder plant". The word *Aloe vera* is derived from an Arabic word, "Alloeh" means that "shining bitter substance" and the 'Vera' is a Latin word means "true" (Danish *et al.*, 2020). *Aloe vera* is an herb that has been used for over 2000 years, and has a great ability to be used in phytotherapy or phytomedicines. It is a cactus-like plant that has around 360 species and grows in a hot, dry climate. Nowadays, it has high demand, which is why it is cultivated on a large scale (Khaing, 2011). Egyptian scientists regarded *Aloe vera* as "the plant of immortality," and around 2000 years ago, Greeks called it "universal panacea.

Aloe vera (Aloe barbadensis Miller) is a monocotyledonous plant, belonging to the family Asphodelaceae and Liliaceae, and is indigenous to Eastern and Southern Africa, the Canary Islands, and Spain (Bukhari et *al.*, 2017). The genus comprises about 300 perennial species (Khaing, 2011). The genus Aloe has more than 500 species, but only a few are medicinally important (Bukhari *et al.*, 2017). The plant is a short-stemmed succulent shrub growing to 60-100cm (24-39 inches) tall and spreading by offsets. The leaves are thick and fleshy, green to grey-green with some varieties showing white flecks on the upper and lower stem surface (Kumar *et al.*, 2015). The flowers are produced in summer on a spike up to 90cm (35 inches) tall, each flower being pendulous with a yellow tubular corolla 2-3cm (0.8- 1.2 inches) long (Kargaran *et al.*, 2016).

Aloe vera being a plant that has high water contents which is ranges from 99.0-99.5%, due to this high capacity for holding of water, it is use to keep the skin moisture and any damaged on skin can be treated by its gel as its gel enhance the restoration of wound and stimulate the cell growth, Stomach ailments, constipation, thermal burn, sunburn, injuries caused by radiations, skin disease,anti-inflammatory effect, antibacterial effect, antifungal effects, diabetes, ulcer etc. can be treat by the use of *Aloe vera* gel, several researches also proposes that body's immune system can be stimulate by the gel of *Aloe vera* (Radha and Laxmipriya, 2015; Ishrat *et al.*, 2015).

The active compounds reported in this plant are saponins, sugar, enzymes, vitamins, aloesin, aloeemodin, aloin, acemannan aloemannan, aloeride, methylchromones, flavonoids, naftoquinones, sterols, minerals, anthraquinones, amino acids, lignin and salicylic acid and other different compounds including fat-soluble and water-soluble vitamins, enzymes, minerals, simple/complex sugars, organic acid and phenolic compounds (Radha and Laxmipriya, 2015).

This study aimed to determine the phytochemical compounds present in *Aloe barbadensis Miller* and *Moringa oleifera* leaves and to ascertain if they possess any antibacterial effect on *Escherichia coli* and *Klebsiella pneumoniae*.

MATERIALS AND METHODS

Collection and Identification of *Moringa oleifera* and *Aloe vera* Leaves

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

Extraction of *Moringa oleifera* Leaves

The leaves were air-dried for 2 weeks, then ground into fine powder under laboratory conditions using a mortar and pestle. The leaf extract was prepared according to the method adopted by Abubakar and Usman (2016). 50g of the ground powdered *Moringa oleifera* leaves were extracted exhaustively (cold maceration) using distilled water and ethanol for 5 days. The extracts were filtered using Whatman No. 2 filter paper and concentrated in a water bath and a rotary evaporator for the aqueous and ethanol extracts, respectively. The extracts were collected with two different beakers labeled "Ethanol" and "Aqueous".

Extraction of *Aloe vera*

The leaves of the plant were air-dried for 2 weeks, then ground into fine powder under laboratory conditions using a sterile Laboratory blender. The leaf extract was prepared according to the method adopted by Bibi *et al.* (2021). 50 g of the ground powdered *Aloe vera* leaves was extracted exhaustively (cold maceration) using distilled water and ethanol for 5 days. The extracts were filtered using Whatman No. 2 filter paper and concentrated in

a water bath and a rotary evaporator for the aqueous and ethanol extracts, respectively. The extracts were collected with two different beakers labeled "Ethanol" and "Aqueous".

Bacterial Isolates

Two (2) different bacterial isolates associated with gastroenteritis, namely Escherichia coli and *Klebsiella pneumoniae*, were obtained and characterized to the species level at the Microbiology Laboratory of the Gombe State University, Gombe State. The isolates were characterized using different procedures, including Gram's stain, cultural characterization, and Biochemical tests (Indole, Methyl red, Voges Proskauer, Catalase, Citrate utilization, and coagulase tests) as described by Cheesbrough (2019). The isolates were maintained on Nutrient agar slants for further use.

McFarland Turbidity Standard Preparation

Barium chloride (1.17g)was measured into a beaker and dissolved in 100ml of distilled water. On another beaker, 1ml of sulphuric acid alongside 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. Twenty-four 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 that 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 bacterium for each tube) and were mixed properly. The mixtures were compared with the McFarland Standard solution, and all appeared the same with a whitish coloration.

Stock Preparation of *Moringa oleifera*

One (1)g 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).

Stock Preparation of *Aloe vera*

One (1)g 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).

Sensitivity Test

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

Antibiotics

Antibiotics (Ciprofloxacin) were used as a control and placed in 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

Four (4)g of aqueous and ethanolic extracts of the *Moringa oleifera leaves* were dissolved in 16ml of distilled water, 2ml of these mixtures was poured into 16 different test tubes(8 for Aqueous and 8 for ethanol), and the following test was carried out:

1. **Test for Alkaloids:** 2ml of chloroform 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.

2. **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

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formation of stable foam is an indication of the presence of Saponins.

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

4. **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 a few drops of dilute acid, indicates the presence of flavonoids.

5. **Test for Steroids:** Five (5) drops of concentrated H_2SO_4 were added to 0.1g of each extract in a test tube, containing both the aqueous and ethanol extract of the sample, respectively. A reddish brown coloration indicates the presence of steroids.

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

7. **Test for Phenol:** To 2 ml 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*

Three (3)g of aqueous and ethanolic extracts of the *Aloe vera* leaves were dissolved in 14ml of distilled water, 2ml of these mixtures was poured into 14 different test tubes(7 for Aqueous and 7 for ethanol), and the following test was carried out:

1. **Test for Alkaloids:** 2ml of Wagner's reagent was added to an aqueous and ethanol extract sample; the formation of a reddish brown color indicates the presence of alkaloids.
2. **Test for Saponins:** Two of the test tubes containing the aqueous and ethanol extract were collected and well shaken, and long-lasting, persistent lather froths were formed on top.
3. **Test for Tannins:** 0.5g of the dried powdered sample was boiled in 20 ml of distilled water in a test tube and then filtered. A few drops of 0.1% ferric chloride were added to the filtrate, and the formation of brownish-green or blue-black coloration indicates the presence of tannins.
4. **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 the addition of sulphuric acid (H_2SO_4). The presence of a yellow solution, which disappears on standing, indicates the presence of flavonoids.
5. **Test for Steroids:** 2ml of acetic anhydride and sulphuric acid was added to two of the test tubes containing aqueous and ethanol extract, respectively. The formation of blue-green color indicates the presence of steroids.
6. **Test for Phenol:** To 2 ml of the extract, a few drops of ferric chloride solution were added. The appearance of a greenish-yellow color confirms the presence of phenol.
7. **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.

RESULTS

The result of qualitative phytochemical screening of *Moringa oleifera* leaf extract using two solventsnamely distilled water(aqueous) and ethanol, is presented in Table 1. The result indicated the presence of five (5) bioactive compounds, namely: tannins, saponins, flavonoids, alkaloids, and glycosides, while both steroids and phenolare were 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 fewer Phytochemicals than the ethanol extracts.

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Table 1: Qualitative Phytochemical Screening of Solvent-Extracts of *Moringa oleifera* Leaves

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

Key:+ = 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 of *Aloe vera* indicated the presence of six (6) bioactive compounds, namely: tannins, saponins, flavonoids, alkaloids, phenol, and glycosides, while steroids are absent in the ethanol extract (Table 2). The aqueous extract contains five (5) bioactive compounds (flavonoids, alkaloids, phenol, saponins, and glycosides) while both steroid and tannin are absent. Hence, from this result, it can be concluded that the aqueous extracts have fewer Phytochemicals than the ethanol extracts.

Table 2:Qualitative Phytochemical Screening of Solvent-Extracts of *Aloe vera*

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

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

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 the concentration of the extracts. The 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 10 µg) ranges from 28-27 mm, respectively. Significant difference was observed in the sensitivity of *Escherichia coli* and *Klebsiella pneumoniae* to the aqueous extract of Moringa leaves at Ciprofloxacin 10 µg (control), 12.5, 25, and 100 concentrations.

Table 3: Antibacterial Sensitivity Testing of Aqueous Extract of *Moringa Oleifera Leaves*

Bacteria isolate	12.5	25	50	75	100	Control	Extract
Escherichia coli	6^{e}	8^{d}	14^{c}	16^{c}	19^{b}	28^{a}	Aqueous
Klebsiella pneumoniae	7^{e}	10^{d}	15^{c}	17^{c}	20^{b}	27^{a}	

Key: Different alphabets indicate significant/statistical difference

Table 4: Antibacterial Sensitivity Testing of Ethanol Extract of *Moringa Oleifera Leaves*

Bacteria isolate	12.5	25	50	75	100	Control	Extract
Escherichia coli	7^{e}	8^{e}	11^{d}	15^{c}	23^{b}	28^{a}	Ethanol
Klebsiella pneumoniae	6^{e}	6^{e}	9^{d}	14^{c}	22^{b}	30^{a}	

Key: Different alphabets indicate significant/statistical difference

Table 5: Antibacterial Sensitivity testing of Aqueous Extract of*Aloe vera*

Bacteria isolate	12.5	25	50	75	100	Control	Extract
Escherichia coli	6^{c}	7^{bc}	10^{bc}	13^{bc}	16^{b}	22^{a}	Aqueous
Klebsiella pneumoniae	6^{c}	6^{bc}	6^{bc}	8^{bc}	10^{b}	19^{a}	

Key: Different alphabets indicate significant/statistical difference

Table 6: Antibacterial Sensitivity testing of Ethanol Extract of*Aloe vera*

Bacteria isolate	12.5	25	50	75	100	Control	Extract
Escherichia coli	7^{d}	8^{cd}	11^{cd}	15^{bc}	20^{ab}	24^{a}	Ethanol
Klebsiella pneumoniae	6^{d}	7^{cd}	9^{cd}	12^{bc}	14^{ab}	19^{a}	

Key: Different alphabets indicate significant/statistical difference

The antibacterial activity of the ethanol extract of *Moringa oleifera* leaf is presented in Table 4. The results showed that zones of inhibition recorded by the isolates depend on the type of bacterial isolates and the concentration of the extracts. The highest zone of inhibition is demonstrated by *Escherichia coli* (23 mm) 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 10 µg) ranges from 28-30 mm, respectively. Based on the result obtained, the antibacterial activity of ethanol *Moringa oleifera* leaf extract was also found to be more effective on both *Escherichia coli* and *Klebsiella pneumoniae* than the aqueous extract. Also, a significant difference was observed in the sensitivity of *Escherichia coli* and *Klebsiella pneumoniae* to the ethanol extract of Moringa leaves at all the concentrations.

The antibacterial activity of the aqueous extract of *Aloe vera* is presented in Table 5. The results showed that the highest zone of inhibition is demonstrated by *Escherichia coli* (16 mm) at 100mg/ml, and the lowest zone of inhibition is demonstrated by both *Escherichia coli* and *Klebsiella pneumoniae* (6 mm) at 12.5mg/ml. The zone of inhibition of the control (Ciprofloxacin 10 µg) ranges from 22-19 mm, respectively. Significant difference was observed in the sensitivity of *Escherichia coli* and *Klebsiella pneumoniae* to the aqueous extract of *Aloe vera* leaves at Ciprofloxacin 10 µg (control), 12.5, 25, and 100 concentrations.

The antibacterial activity of ethanol*Aloe vera* extract is presented in Table 6. The results showed that the highest zone of inhibition is demonstrated by *Escherichia coli* (20 mm) 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 10 µg) ranges from 24-19 mm, respectively. Also, a significant difference was observed in the sensitivity of *Escherichia coli* and *Klebsiella pneumoniae* to the ethanol extract of *Aloe vera* leaves at all concentrations.

DISCUSSION

The phytochemical screening of the leaf extracts of *Moringa oleifera leaves* and *Aloe vera* revealed the presence of alkaloids, flavonoids, phenol, glycosides, saponin, and tannin, while steroids are absent in both plant extracts. These phytochemicals exhibit various pharmacological and biochemical actions and are found to be beneficial to human health, as well as possessing antioxidant activity (Aondo *et al.*, 2018; Radha and Laxmipriya, 2015). Several studies have been conducted in isolating and characterizing some bioactive compounds from *Moringa oleifera* leaf extracts and *Aloe vera* (Vinoth *et al.*, 2012; Selamoglu, 2018). The phytochemical studies had resulted in the isolation of flavonoids, saponins, alkaloids, tannins, phenols, glycosides, and alkaloids. The finding of the study is in conformity with the finding of Ayoade *et al.* (2019) for *Moringa oleifera* and Bibi *et al.* (2021) for *Aloe vera*.

The phytochemicals possessed several medicinal properties and hence, are used in pharmaceutical industries for the manufacture of drugs. Therefore, the presence of these bioactive components in *Moringa* leaf extracts and *Aloe vera* could account for the medicinal properties of the plants for the treatment of various diseases such as atherosclerosis, arthritis, diabetes, nausea, asthma, skin antiseptic, diarrhea, dysentery, colitis, and cancer. Alkaloids comprise a large group of nitrogenous compounds that are widely used as cancer chemotherapeutic agents, anaesthetics, and Central Nervous Stimulants (Adebayo *et al.*, 2017). Alkaloids are known to play some metabolic roles and control development in living systems; hence, the presence of alkaloids in *Moringa oleifera* leaves and *Aloe vera* could account for their use as antimicrobial agents (Cardarelli *et al.*, 2017). Alkaloids are beneficial chemicals to plants, serving as repellents to predators and parasites (Kasolo *et al.*, 2010).

Flavonoids have also been implicated as antioxidants both in physiological and diseased states. For instance, tea flavonoids have been reported to reduce the oxidation of low-density lipoprotein, lower the blood level of cholesterol and triglycerides (Danish *et al.*, 2020). Flavonoids are also expressed in plants in response to microbial infection, suggesting their antimicrobial activity.

The flavonoids induce mechanisms that may kill cancer cells and inhibit tumor invasion (Ahmad and Nazir, 2016). The potent antioxidant activity of flavonoids reveals their ability to scavenge hydroxyl radicals, superoxide anions, and lipid peroxy radicals; this may be the most important function of flavonoids (Daba, 2016).

Saponins have been shown to possess both beneficial (cholesterol-lowering) and deleterious (cytotoxic; permeabilization of the intestine) properties (Ali *et al.*, 2021). Studies have illustrated the beneficial effects of saponin on blood cholesterol levels, cancer, bone health, and stimulation of the immune system (Priyanka *et al.*, 2013). Saponins in medicinal plants are responsible for most biological effects related to cell growth and division in humans and have incivility effect on inflammation. Present of saponin in *Moringa oleifera* leaves and *Aloe vera* supports the usefulness of the plant in managing

inflammation (Rani *et al.*, 2018; Salehi *et al.*, 2018). Due to its ability to form froth, soap is being produced locally from it for bathing (Abdallahi, 2011).

Tannins are polyphenols that are obtained from various parts of different plants belonging to multiple species. Tannins can also be effective in curbing hemorrhages as well as restricting bare swellings (Omodanisi *et al.*, 2017). While tannins are proven haemostatic, they are also beneficial when applied to the mucosal coating in the mouth. Hence, herbs possessing tannins are widely used as mouthwashes, eyewashes, snuff, and even as vaginal douches and also treat rectal disorders (Kargaran *et al.*, 2016). The studies by Rani *et al.* (2018) and Kaur *et al.* (2015) showed that the leaves of *Moringa oleifera* and *Aloe vera* possess antimicrobial potential against some bacterial isolates associated with gastroenteritis.

CONCLUSION

Ethanol extract has a higher effect and possesses more antibacterial activities compared to the aqueous extracts, which is attributable to the fact that ethanol extracts more of the bioactive components of the plant compared to the aqueous extract. The presence of secondary metabolites like flavonoids, alkaloids, phenols, glycosides, saponins, and tannins in the studied plants, *Moringa oleifera* and *Aloe vera* (*Aloe barbadensis Miller),* is responsible for the studied plants healing potentials. The present of these phytochemicals proves 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*. The use of *Moringa oleifera* and *Aloe vera* for the treatment of some ailments, and further research to isolate the active compounds/chemicals responsible for antibacterial activities for further purification, pharmacological, and clinical testing is recommended.

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