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Research Article

Antibacterial Screening of Five Selected Plants Commonly Used Against Ear Nose and Throat (ENT) Pathogens

Fatima, A.[1] and *Muhammad, S.[2]

[1]Department of Biological Sciences, Sokoto State University, Sokoto-Nigeria
[2]Department of Plant Sciences, Usmanu Danfodiyo University, Sokoto-Nigeria
***Corresponding Author's email*: smsamdiri@gmail.com**

ABSTRACT
This study investigates the antibacterial properties of five medicinal plants *Mangifera indica* (mango leaves), *Cola nitida* (kolanut), *Zingiber officinale* (ginger), *Xylopia aethiopica* (Negro pepper), and *Allium sativum* (garlic) traditionally used for the treatment of ear, nose, and throat (ENT) infections in Sokoto, Nigeria. Ethanolic, aqueous, diethyl ether, and n-hexane extracts were tested against various ENT pathogens including *Staphylococcus aureus, Streptococcus pneumoniae, Klebsiella pneumoniae, Salmonella typhi, Pseudomonas aeruginosa,* and *Escherichia coli*. The study employed agar well diffusion methods to determine zones of inhibition, as well as Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) assays. Results showed significant antibacterial activity, especially in the ethanolic extract of *X. aethiopica*, which demonstrated the highest activity against most pathogens. The findings support the ethnomedicinal use of these plants and suggest potential development into alternative antimicrobial agents.

Keywords: Medicinal plants; Antibacterial activity; ENT infections; Ethanolic extracts; Xylopia aethiopica; Antibiotic resistance; Minimum inhibitory concentration (MIC); Nigeria

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INTRODUCTION

Ear, Nose and Throat (ENT) infections are among the most prevalent diseases affecting populations globally (Ali *et al.,* 2008), particularly in developing regions where access to modern healthcare is limited (Iwu *et al.,* 1999; Ahmad *et al.,* (2016). The emergence of antibiotic-resistant pathogens has heightened the urgency to explore alternative antimicrobial sources (Akinyemi *et al.,* 2005; Cushnie and Lamb 2011). Medicinal plants, used for centuries in traditional medicine, are promising candidates due to their bioactive compounds such as alkaloids, flavonoids, and tannins (Nair 2013; Ali *et al.,* 2008; Okigbo and Igwe 2007). Evaluating their antibacterial efficacy against known ENT pathogens will provide scientific validation for their use and identify potential natural alternatives to synthetic antibiotics (Ahmad *et al.,* 2016; Ankri and Mirelman, 1999).

The increasing resistance of ENT pathogens to conventional antibiotics poses a significant public health threat (Akinyemi *et al.,* 2005; Cushnie and Lamb 2011). Many people in rural and semi-urban areas of Nigeria rely on traditional medicine to treat infections (Iwu *et al.,* 1999; Okigbo and Igwe, 2007), yet the scientific basis for the efficacy of these treatments remains underexplored (Ahmad *et al.,* 2016; El Astal *et al.,* 2005). The lack of documented evidence on the antibacterial potential of plants

such as *Mangifera indica, Cola nitida, Zingiber officinale, Xylopia aethiopica*, and *Allium sativum* against ENT pathogens necessitates empirical investigation to validate their traditional use (Sharma *et al.,* 2017; Ross *et al.,* 2001; Ali *et al.,* 2008; Adegoke and Skura 2000).

The overuse and misuse of antibiotics have accelerated the emergence of resistant bacterial strains, necessitating the search for new antimicrobial agents (Akinyemi *et al.,* 2005; Kalia, 2013). Medicinal plants offer a valuable reservoir of bioactive compounds with potential therapeutic applications (Nair 2013; Parmar *et al.,* 1997). This research is justified by the urgent need for alternative treatments for ENT infections (Iwu *et al.,* 1999; Ahmad *et al.,* 2016), particularly in resource-limited settings. Validating the antibacterial properties of commonly used medicinal plants may lead to the development of affordable, plant-based therapies that are culturally acceptable and readily available (Ankri and Mirelman, 1999; Okigbo and Igwe, 2007). This study determined the antibacterial properties of plant used locally against ENT infection in Sokoto metropolis.

MATERIALS AND METHODS

Antibacterial Screening.

Collections of microorganisms

Preserved stock culture of ENT pathogens that include; *Streptococcus pnuemoniae*, *Pseudomonas aeroginosa, Staphylococcus aureus, Proteus vulgaris, Proteus mirabilis, Klebsiella pnuemoniae, Haemophilus strep., Escherichia coli, Aspergilus niger, Candida spp* were collected at Usmanu Danfodiyo University Teaching Hospital Sokoto, Specialist Hospital Sokoto and Noma Hospital Sokoto. The samples were immediately cultured for isolation of the organism. These were later subcultured for antibacterial assay.

Preparation of Culture Media

Blood Agar: Blood agar base was prepared by weighing 30 g of the nutrient agar and dissolved in 1 liter of distilled H_2O. The suspension was dissolved by heated using hot plate. The flask containing the agar was plugged with cotton wool and wrapped with aluminum foil. It was then sterilized by autoclaving at 121^0C for 15 minutes. The medium was allowed to cool to 45^0C and 5% blood was added by aseptic procedure and slightly shaken and rotated for homogeneity. The medium was then poured into sterile plates.

Nutrient agar

About 38g of nutrient agar was weighted and poured onto 1-liter conical flask, 1 liter of distilled H_2O was added to dissolve the agar. The medium was heated on a hot plate. The flask containing the medium was plugged with cotton wool and wrapped with Aluminum foil. It was sterilized at 121^0C for 15 minutes. The medium was then allowed to cool to 45^0C before it was transferred into sterile plate.

Preparation of Physiological Saline

One (1g) of sodium chloride (NaCl) was weighed and dissolved in 100mls of distilled water in a flask. This was corked and allowed to dissolve evenly to get a homogeneous suspension. It was then autoclaved at 121^0C for 15 minutes.

Preparation of Turbidity Standard

One (1%) v/v solution of sulphuric acid was prepared by adding 1ml of concentration sulphuric acid to 99ml of sterile distilled water. 1% w/v solution of barium chloride was prepared by dissolving 0.5g of dehydrated barium chloride in 50 ml of distilled water.

A portion (0.6 ml) of the barium chloride solution was then added to 99.4mls of the sulphuric acid solution and mixed. The mixture then turned turbid, small amount of the turbid solution was transferred into a test tube of the same type that was used to prepare the test inoculate. It was plugged with cotton wool and kept in the dark until it was needed.

Subculture of the Test Inoculum

Four (4ml) of sterile physiological saline was dispense in a test tube using sterile syringe using a flamed wire loop, 3-5 well isolated colonies of the organism to be prepared was touched and emulsify in the 4ml sterile physiological saline.

Antibacterial Assay

Nutrient agar was used for testing of these extracts. Three wells were made on each plate agar using sterilized 14mm cork borer. Each plate agar was inoculated with different isolates separately. This was done with the use of sterilized wire loop after standardization of each inoculum.

After inoculation, different concentration of the plant extract was mixed with little plain agar and pour into designated well which carry the specific concentration of the extract 500, 1000 and 1500mg/mol. The inoculated plates were allowed to

stand for 15 minutes before incubating them for 24 hours at 37^0C for bacteria. The zone of inhibition was measured using meter rule. Minimum Inhibitory Concentration (MIC) was then conducted on positive inhibited test organisms.

Determination of Minimum Inhibitory Concentration

The minimum inhibitory concentration (MIC) was determined as the least concentration that showed an inhibitory effect on test organism using the tube method. Two-fold serial dilution was made using nutrient broth. 5 ml of a solution of each plants extract (80 mg/ml) was added aseptically to 5 ml of double strength medium and mixed by shaking. Using a fresh pipette, 5 ml of the mixture was transferred to test tube 2 which contained 5 ml of the single strength medium. This too was mixed by shaking and from it 5 ml was taken into test tube 3 aseptically and mixed by shaking. This procedure was repeated up to test tube 8 and 5 ml from the same test tube 8 was discarded after shaking. The 9th tube containing no test compound served as control. Finally, to each tube was added 0.2 ml inoculum of the test organism (*Streptococcus sp.* and *P. aureus*) aseptically. The test was covered with cotton wool and incubated at 37^0C for 24 hours and then observed for turbidity. The lowest concentration that inhibited growth of test organism was noted as the MIC.

In a good light and colour background the turbidity of the suspension was matched with that of the turbidity standard. The turbidity of the test inoculum was adjusted by either adding more *Candida albican* or more physiological saline until a good match is obtained

Minimum Bactericidal Concentration (MBC)

The minimum bactericidal concentration (MBC) is the lowest concentration of an antibacterial agent required to kill a particular bacterium. It is determined by subculturing from the minimum inhibitory concentration (MIC) test and identifying the lowest concentration that reduces the viability of the initial bacterial inoculum by ≥99.9%. The MBC is complementary to the MIC, as the MIC test demonstrates the lowest level of antimicrobial agent that inhibits growth, while the MBC demonstrates the lowest level that results in microbial death (Clow, 2020).

RESULTS

Table 1 shows zone of inhibition of various extracts of *Mangifera indica* and *Cola nitida*. The antibacterial activity of mango leaf ethanolic extract showed significant activity against *Escherichia coli* (17.7±2.4 mm), *Staphylococcus aureus* (13.0±1.0 mm), *Streptococcus* spp. (16.0±2.0 mm), and *Klebsiella pneumoniae* (8.7±2.4 mm). The n-hexane, aqueous and diethyl ether extracts exhibited minimal to no activity on *P.* aeroginosa. The results for *Cola nitida* indicate that antibacterial activity was only observed against *Klebsiella pneumoniae*, with ethanol (12.7±2.9 mm) and aqueous extracts (13.3±4.0 mm), while no activity was observed against the other organisms with any solvent.

Table 2 shows zone of inhibition of various extracts of *Z. officinale* and *X. aethiopica*. The ethanol extract of *X. aethiopica* exhibited the highest antibacterial activity, particularly against *Streptococcus* spp. (22.0±4.0 mm), *S. aureus* (20.7±6.0 mm), and *P. aeruginosa* (15.3±0.7 mm). Moderate activity was also observed against *E. coli* and *S. typhi*. The n-hexane extract showed moderate activity against *E. coli* (6.0±2.9 mm) and weak activity against *S. aureus* (8.7±1.3 mm) and *Streptococcus* spp. (4.7±2.9 mm). The diethyl ether extract showed significant activity against *S. aureus* (10.7±2.6 mm), *Streptococcus* spp. (14.7±1.7 mm), and *S. typhi* (7.7±2.0 mm). The aqueous extract ginger exhibited no activity against all tested organisms. Similarly, the ethanol extract exhibited moderate activity against *Streptococcus* species (5.7 ± 2.0 mm), the n-hexane extract showed activity against *Klebsiella pneumoniae* (8.0 ± 2.0 mm) and *Pseudomonas aeruginosa* (4.3 ± 1.7 mm), there was no activity in diethyl ether and aqueous extracts (Table 2).

The ethanol extract of *Allium sativum*, exhibited moderate activity against *K. pneumoniae* with a mean inhibition zone of 20.3±4.7 mm. However, it showed no activity against the other tested organisms. The n-hexane extract demonstrated moderate activity against *E. coli* (23.0±6.0 mm), weak activity against *S. typhi* (7.3±2.7 mm), and minimal activity against *K. pneumoniae* (10.6±0.9 mm). The diethyl ether extract showed moderate activity against *Streptococcus* spp. (19.0±4.3 mm) but was inactive against the other organisms. The aqueous extract displayed activity only against *E. coli*

(11.7±7.6 mm) and showed no effects on other bacteria (Table 3).

Table 1. Antibacterial Activity (Zone of Inhibition in mm) of *Mangifera indica* (Mango Leaves) and *Cola nitida* (Kola Nut) Extracts Against Selected Bacteria

Organism	*Moringa indica*				*Cola nitidat*			
	E	**N-H**	**DE**	**A**	**E**	**N-H**	**DE**	**A**
E. coli	17.7±2.4^{a}	0.0±0.0^{b}	0.0±0.0^{b}	0.0±0.0^{b}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}
S. aureus	13.0±1.0^{a}	0.0±0.0^{b}	0.0±0.0^{b}	0.0±0.0^{b}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}
Strep. sp.	16.0±2.0^{a}	0±1.5^{b}	0.0±0.0^{c}	0.0±0.0^{c}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}
S. typhi	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}
K. pneumonia	8.7±2.4^{a}	0.0±0.0^{b}	0.0±0.0^{b}	0.0±0.0^{b}	12.7±2.9^{a}	0.0±0.0^{b}	0.0±0.0^{b}	13.3±4.0^{a}
P. aeruginosa	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}

Note: Values are expressed as mean ± standard error (SE). Values with the same superscript letters are not significantly different ($p > 0.05$), while those with different superscripts differ significantly ($p < 0.05$) **Key**: E; Ethanol, N-H; N-Hexane, DE; Diethylether and A; Aqueous extract, *Strept*; *Streptococococcus* sp.

Table 2. Antibacterial Activity (Zone of Inhibition in mm) of *Zingiber officinale* (Ginger) and *Xylopia aethiopica* (Negro Pepper) Extracts Against Selected Bacteria

Organism	*Zingiber officinale*				*Xylopia aethiopica*			
	E	**N-H**	**DE**	**A**	**E**	**N-H**	**DE**	**A**
E. coli	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	9.0±2.6^{a}	6.0±2.9^{a}	0.0±0.0^{b}	0.0±0.0^{b}
S. aureus	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	20.7±6.0^{a}	8.7±1.3^{b}	10.7±2.6^{b}	0.0±0.0^{c}
Strep. sp.	5.7±2.0^{a}	0.0±0.0^{b}	0.0±0.0^{b}	0.0±0.0^{b}	22.0±4.0^{a}	4.7±2.9^{b}	14.7±1.7^{a}	0.0±0.0^{b}
S. typhi	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	13.3±2.3^{a}	0.0±0.0^{b}	7.7±2.0^{a}	0.0±0.0^{b}
K. pneumonia	0.0±0.0^{b}	8.0±2.0^{a}	0.0±0.0^{b}	0.0±0.0^{b}	9.0±2.0^{a}	0.0±0.0^{b}	0.0±0.0^{b}	0.0±0.0^{b}
P. aeruginosa	0.0±0.0^{b}	4.3±1.7^{a}	0.0±0.0^{b}	0.0±0.0^{b}	15.3±0.7^{a}	0.0±0.0^{b}	0.0±0.0^{b}	0.0±0.0^{b}

Note: Values are expressed as mean ± standard error (SE). Values with the same superscript letters are not significantly different ($p > 0.05$), while those with different superscripts differ significantly ($p < 0.05$) **Key:** E; Ethanol, N-H; N-Hexane, DE; Diethylether and A; Aqueous extract, *Strept*; *Streptococococcus* sp.

Table 3. Antibacterial Activity (Zone of Inhibition in mm) of *Allium sativum* (Garlic) Extracts Against Selected Bacteria

Organism	**E**	**N-H**	**DE**	**A**
E. coli	0.0±0.0^{b}	0.0±0.0^{b}	0.0±0.0^{b}	11.7±7.6^{a}
S. aureus	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}
Strep. sp.	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{b}	0.0±0.0^{a}
S. typhi	0.0±0.0^{b}	7.3±2.7^{a}	0.0±0.0^{b}	0.0±0.0^{b}
K. pneumonia	20.3±4.7^{a}	10.6±0.9^{b}	0.0±0.0^{b}	0.0±0.0^{b}
P. aeruginosa	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}	0.0±0.0^{a}

Note: Values are expressed as mean ± standard error (SE). Values with the same superscript letters are not significantly different ($p > 0.05$), while those with different superscripts differ significantly ($p < 0.05$). **Key**: E; Ethanol, N-H; N-Hexane, DE; Diethylether and A; Aqueous extract, *Strept*; *Streptococococcus* sp.

Table 4 shows minimum inhibitory concentration for the active extracts which are ethanolic, diethyl ether, N-Hexane and aqueous extract for Negro pepper, diethyl ether, N-Hexane extract and aqueous for Garlic and ethanol and aqueous for kola nut. *Xylopia aethiopica* negro pepper ethanol and n-hexane extracts were most effective, with MIC as low as 125 mg/mL against *E. coli, S. aureus, Streptococcus sp., K. pneumoniae,* and *P. aeruginosa*. *Cola nitida* kolanut, extracts (ethanol & water) showed moderate activity, with MIC values ranging 125–500 mg/mL, especially active against *S. aureus* (125 mg/mL). *Allium sativum* Garlic extracts (aqueous and diethyl ether) generally had weaker activity, with most MIC values 500 mg/mL, though some inhibition occurred. *Zingiber officinale* Ginger n-hexane extract consistently showed MIC values of 125–500 mg/mL, particularly inhibiting *P. aeruginosa* (250 mg/mL).

In Table 5, *Xylopia aethiopica* Negro pepper diethyl ether extract killed *K. pneumoniae, S. aureus, Streptococcus* sp*., S. typhi,* at 250 mg/mL, but required 500 mg/mL for *P*. *aeruginosa*. *Cola nitida* kolanut ethanol extract showed very strong bactericidal activity against *S. aureus* and *Streptococcus* sp. at 125 mg/mL, but higher (500 mg/mL) for *K. pneumoniae*. Similarly, *Cola nitida* aqueous extract killed *S. typhi* (500 mg/mL), *S. aureus* (250 mg/mL), and *P. aeruginosa* (500 mg/mL). *Allium sativum* garlic aqueous extract had weak killing ability all tested bacteria (*E. coli, Streptococcus* sp*., K. pneumoniae, S. typhi, P. aeruginosa*) required 500 mg/mL.

Table 4. Minimum inhibitory concentration (MIC) of active extracts

S/No	Organism	Negro pepper D- ETHER	Negro pepper H 2 O	Negro pepper Ethanol	Negro pepper N-HEXANE	Garlic D- ETHER	Garlic H 2 O	Ginger N-HEXANE	Ginger N-HEXANE	Kolanut H 2 O	Kolanut Ethanol	Kolanut H2O	Kolanut H 2 O
1	*Escherichia coli*	500mg	-	125mg	125mg	-	500mg	500mg	500mg	-		-	-
2	*Staphiyococcus aureous*	500mg	500mg	125mg	125mg	500mg	125mg	500mg	500mg	250mg	125mg	250mg	250mg
3	*Streptococcus sp*	-	-	125mg	500mg	-	500mg	500mg	500mg	500mg	125mg	500mg	500mg
4	*Salmonella typhi*	-	-	500mg	500mg	500mg	500mg	500mg	500mg	-	500mg	-	-
5	*Kelebsiella pneumonia*	125mg	500mg	500mg	500mg	-	500mg	125mg	125mg	-	500mg	-	-
6	*Pseudomonas aureginosa*	125mg	-	125mg	125mg	-	125mg	250mg	250mg	500mg	-	500mg	500mg

Table 5. Result of Minimum Bacterial Concentration (MBC) for active extracts

S/N	EXTRACT	ORGANISM	MBC
1.	Negro pepper D/ether	*Kelebsiella pneumonia*	250mg
2.	Negro pepper D/ether	*Streptococcus pneumonia*	250mg
3.	Negro pepper D/ether	*Staphylococcus aureous*	250mg
4.	Negro pepper D/ether	*Salmonella thyphi*	250mg
5.	Negro pepper D/ether	*Pseudomonas aureginosa*	500mg
6.	Kola nut ethanol	*Staphylococcus aureous*	125mg
7.	Kola nut ethanol	*Streptococcus pneumonia*	125mg
8.	kola nut ethanol	*Kelebsiella pneumonia*	500mg
9.	kola nut H_2O	*Salmonella thyphi*	500mg
10.	kola nut H_2O	*Staphylococcus aureous*	250mg
11.	KolanutH_2O	*Pseudomonas aureginosa*	500mg
12.	Garlic H_2O	*Escherichia coli*	500mg
13.	Garlic H_2O	*Streptococcus pneumonia*	500mg
14.	Garlic H_2O	*Kelebsiella pneumonia*	500mg
15.	Garlic H_2O	*Salmonella thyphi*	500mg
16.	Garlic H_2O	*Pseudomonas aureginosa*	500mg

DISCUSSION

M. indica ethanolic extract inhibited *E. coli* (17.7 ± 2.4 mm), *S. aureus* (13.0 ± 1.0 mm), *Streptococcus* spp. (16.0 ± 2.0 mm), *K. pneumoniae* (8.7 ± 2.4 mm); other solvents had little or no effect. *C. nitida* showed only moderate inhibition of *K. pneumoniae* (ethanol: 12.7 ± 2.9 mm; aqueous: 13.3 ± 4.0 mm), no activity against other organisms as shown in table 1. Maharaj *et al*. (2022) evaluated methanolic *M. imdica* leaf extracts showing inhibition zones of ~14.2 mm against *S. aureus* and ~18.1 mm against *E. coli* very similar to this study on *E. coli* and *S. aureus*, confirming moderate antibacterial activity of phenolic-rich extracts. Similarly, El-Sayed *et al*. (2025) assessed mango peel (not leaves) ethanolic extracts and reported 95% inhibition of *S. aureus* and MRSA suggesting peel may be more potent, but supports overall mango's antimicrobial potential. Ibe *et al*., 2023) acknowledge Cola species contain tannins and flavonoids with modest antibacterial activity the current study's moderate activity against *K. pneumoniae* aligns with this modest efficacy.

In table 2, *X. aethiopica* ethanolic extract showed strong activity *Streptococcus* spp. (22.0 ± 4.0 mm), *S. aureus* (20.7 ± 6.0 mm), *P. aeruginosa* (15.3 ± 0.7 mm), showed moderate inhibition against E. *coli*, *S. typhi*. N-hexane: moderate against *E. coli* (6.0 ± 2.9 mm), weak against *S. aureus*, *Streptococcus*. Diethyl ether extract also gave a significant inhibition against *S. aureus, Streptococcus, S. typhi*, but aqueous had no activity. *Z. officinale* a minimal to moderate activity was observed on ethanolic extract on *Streptococcus* spp. (5.7 ± 2.0 mm), n-hexane was active against *K. pneumoniae* (8.0 ± 2.0 mm) and *P. aeruginosa* (4.3 ± 1.7 mm) but other extracts were inactive. *Xylopia aethiopica* Osei-Asare *et al*. (2025) formulated ethanol and aqueous extracts into topical creams/ointments that were potent against *S. aureus* and *P. aeruginosa* they reported MICs of 2.5–10 mg/mL and emphasized the ethanolic extract's strong activity. This aligns very well with this study that observed a strong zone for ethanolic extract. Ndoye *et al*. (2024) studied essential oil from dried seeds, confirming antimicrobial activity due to terpenoid or piperine content this agrees with *X. aethiopica's* pronounced activity in non-polar fractions.

Ethanol extract of *Alluim sativum* in table 3 showed moderate activity only against *K. pneumoniae* (20.3 ± 4.7 mm) while otherwise inactive. Similarly, N-hexane gave a strong inhibition on *E. coli* (23.0 ± 6.0 mm), and weak for *S. typhi* and *K. pneumoniae*. Diethyl ether extract on the other hand showed moderate inhibition on *Streptococcus* (19.0 ± 4.3 mm), but no inhibition for other organisms. Aqueous extract was mild on *E. coli*. This is in agreement with the study of (Artawinata *et al*., 2025) due to the presence of allicin and sulfur compounds which have broad antibacterial effects but that activity strongly depends on extract preparation, as allicin is unstable and extraction method matters.

In table 4 and table 5: MIC and MBC *X. aethiopica*, *Allium sativum, Zingiber officinale*, and *Cola nitida X. aethiopica* ethanol and n-hexane gave a MIC of 125 mg/mL for *E. coli, S. aureus, K. pneumoniae, P. aeruginosa*. Diethyl ether gave MIC of up to 500 mg/mL for some, but MBC for *S. aureus, S. pneumoniae, K. pneumoniae, S. typhi* was 250 mg/mL. Similarly MBC for *P. aeruginosa* was 500 mg/mL. *Allium sativum* aqueous extract MIC or MBC for several pathogens was 500 mg/mL. similarly, *Zingiber officinale* n-hexane MIC was 500 mg/mL for *E. coli*. *Cola nitida* ethanolic extract MIC was 125 mg/mL for *S. aureus and Streptococcus*, likewise the aqueous extract of *C. nitida* gave higher MBCs whalso varied (125–500 mg/mL). Osei-Asare *et al*. (2025) reported significantly lower MICs (2.5–10 mg/mL) for *X. aethiopica* ethanol and aqueous extracts against *S. aureus* and *P. aeruginosa*, far more potent than this study with MICs of 125–500 mg/mL. This suggests differences in extraction, concentration, or assay methodology. In mango leaves, Pramusita *et al*. (2023) found an MBC of 25% w/v for mango leaf ethanol extract against *S. mutans* again far more potent than your crude extract results, indicating purified or higher-strength preparations yield lower MIC/MBC.

CONCLUSION

This study confirms the antibacterial efficacy of *Xylopia aethiopica*, *Mangifera indica*, *Allium sativum*, *Zingiber officinale*, and *Cola nitida* against various ENT pathogens. The ethanol extracts, particularly of *X. aethiopica and M. indica*, showed the most potent activity. The observed MIC and MBC values validate the traditional use of these plants for treating ENT infections and highlight their potential as sources for novel antimicrobial agents. Their activity against

resistant strains reinforces the importance of exploring plant-based alternatives in the fight against antibiotic resistance.

Recommendations

1. Further phytochemical analyses should be conducted to isolate and characterize the active compounds responsible for the antibacterial activity.
2. In vivo studies should be carried out to validate the therapeutic potential and safety of these plant extracts.
3. Development of topical and oral formulations from these plants should be considered to manage ENT infections.
4. Collaborative research with pharmacologists and traditional healers should be encouraged to bridge the gap between traditional and modern medicine.

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