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ASSESSMENT OF THE ANTIBACTERIAL POTENTIAL OF GINGER AND GARLIC EXTRACTS AGAINST CLINICALLY RELEVANT BACTERIAL ISOLATES FROM OKADA, NIGERIA

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ABSTRACT

The increasing prevalence of antimicrobial resistance (AMR) has necessitated the exploration of plant-derived alternatives as potential sources of antibacterial agents. This study evaluated the antibacterial activity of aqueous extracts of ginger (*Zingiber officinale*) and garlic (*Allium sativum*) against selected clinical bacterial isolates (*Escherichia coli*, *Staphylococcus aureus*, and *Klebsiella* spp.). Fresh ginger and garlic were obtained from Okada community, Edo State, Nigeria, processed into powdered form, and extracted using sterile distilled water. The extracts were tested at varying concentrations (stock, 1:2, 1:4, and 1:8) using the Kirby-Bauer disc diffusion method. Ofloxacin served as the control antibiotic. Results showed that garlic extract exhibited minimal inhibitory activity against *S. aureus* at the highest concentration (8 mm and 3 mm zones at stock and 1:2 respectively), while no activity was observed against *Klebsiella* spp. and most concentrations of *E. coli*. Ginger extract showed no observable inhibitory effect against all tested isolates across all concentrations. In contrast, ofloxacin demonstrated significant antibacterial activity with inhibition zones ranging from 16–24 mm. The findings indicate that aqueous extracts of ginger and garlic possess limited antibacterial activity under the conditions used in this study, suggesting that extraction method, concentration, and compound stability may significantly influence their efficacy. This study highlights the need for further research using alternative extraction solvents and optimized processing methods to better evaluate the antimicrobial potential of these medicinal plants.

Keywords: Antibacterial activity; aqueous extracts; Garlic (*Allium sativum*); Ginger (*Zingiber officinale*); Antimicrobial resistance

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Introduction

Ginger (*Zingiber officinale*), commonly referred to as "cithar" in Hausa, "jinja" in Igbo, and "atale" in Yoruba, is a slim, erect, herbaceous perennial plant characterized by a fleshy, thick underground rhizome and one or more aerial leafy stems, growing up to about 1.25 m in height (lotsor et al., 2019). It is widely cultivated in tropical regions including Australia, Brazil, China, India, Jamaica, West Africa, and parts of the United States (Suruchi et al., 2016). In its first year, ginger produces a green, upright pseudostem arising from the rhizome, while leaves measuring 12-30 cm grow annually before senescing. The crop thrives in warm, sunny environments with well-distributed rainfall of about 2500-3000 mm, although light shading may be beneficial for young plants. Ginger is aromatic with a characteristic pungent taste (Shubha, 2015).

Ginger is widely used as a spice in fresh, powdered, and preserved forms. Fresh ginger is commonly used in cooking and beverages such as ginger ale, while dried ginger is used in processed foods and confectioneries including cakes, jams, and marmalades (Sharifi-Rad et al., 2017). Medicinally, ginger has long been used in traditional medicine systems for the treatment of conditions such as nausea, cough, asthma, colic, dyspepsia, and inflammatory disorders. Its therapeutic potential is attributed to bioactive compounds such as gingerol, shogaol, paradol, zerumbone, terpenoids, and flavonoids (Rahmani et al., 2014). Ginger essential oil also exhibits antimicrobial activity due to constituents such as eugenol, thymol, and linalool (Suruchi et al., 2016; Karupiah & Rajaram, 2012).

Garlic (*Allium sativum*), known locally as "ayo-ishi" in Igbo, "aayu" in Yoruba, and "tafarunua" in Hausa, is a perennial bulbous plant believed to have originated from Central Asia and now cultivated globally. The plant may grow up to 2 feet or more in height, with its bulb serving as the primary medicinal part. Each bulb consists of 4 to 20 cloves, which may weigh about 1 g each (El-Saber et al., 2020). Garlic is consumed in fresh, dried, aged, or supplement forms and is widely recognized for its pharmacological properties. Antimicrobial resistance (AMR) is a major global public health concern, contributing to an estimated 700,000 deaths annually (Qassadi et al., 2023). In Africa and Asia, inappropriate antibiotic use and weak healthcare systems have accelerated the emergence of multidrug-resistant organisms (Depta & Niedźwiedzka-Rystwej, 2023). Medicinal plants such as garlic and ginger have therefore gained attention as potential alternatives or complementary therapies due to their broad antimicrobial properties (Bitrus et al., 2018).

Both garlic and ginger have been reported to exhibit antibacterial, anti-inflammatory, and immunomodulatory effects, supporting their traditional use in the treatment of infections and chronic diseases (El-Saber et al., 2020; Bitrus et al., 2018). Therefore, this study aimed to evaluate the antibacterial activity of aqueous extracts of garlic and ginger against *Staphylococcus aureus*, *Escherichia coli*, and *Klebsiella* species.

Study location

This study was carried out in Okada, a rural Community which is the headquarters of Ovia North East Local Government Area of Edo state, Nigeria. Its geographical coordinates are 6° 44' 0" North, 5° 23' 0" East. Its houses institutions such as Igedion University Okada (IUO), Igbinedion University Teaching Hospital (IUTH) which provides the community with both laboratory and clinical services and Nigerian Youth Service Corp (NYSC) Orientation camp, Edo state chapter. The major residents of Okada are farmers, traders, Students, lecturers, health workers and few civil servants. The study was carried out in IUTH from the month of March through April 2024

Collection of sample

Fresh and healthy ginger roots and garlic rhizomes were gotten from Okada community market and confirmed by a Botanist. The skin of the garlic was peeled and the rhizomes were detached; the ginger was cut into smaller pieces and they were both allowed to dry under room temperature. The dried ginger and garlic were then grounded into powdered form.

Preparation of Ginger and Garlic extracts

The extracts were prepared based on the method adopted by Akullo *et al.*, 2022.

Procedure:

- i. Using a weighing balance, 100 gram of ginger and garlic was measured respectively.
- ii. Each was then dissolved in 100 ml of distilled water inside a clean cylindrical flask
- iii. The mixture was left to stand for days to ensure complete dissolution
- iv. The mixture was then filtered to get the extract
- v. The extract was sterilized using a hot air oven.

Collection of isolates

Isolates confirmed by the Medical Laboratory Scientist of Igbinedion University Teaching Hospital, Okada were obtained after ethical consent from the Hospital Ethical

Committee. The isolates were *S. aureus*, *E. coli* and *klebsiella species* and were preserved in Nutrient agar slants prior to usage. Isolates were confirmed based on procedures adopted by Lupindu, 2017 and Aryal, 2022.

Production of paper disc

Paper disc of wattman filter paper 1 were punched to a size of 5mm in diameter using a puncher and then sterilized at 160°C for about 30 minutes and then placed in different containers labeled as stock (Undiluted extracts), '1:2' dilutions, '1:4' dilutions and '1:8' dilutions respectively for both ginger and garlic extracts.

Preparation of dilutions

1. Unto sets of different tubes labeled stock, '1:2', '1:4' and '1:8' dilutions, 1ml of sterile distilled water were added to tubes labeled '1:2' to tube '1:8' in the order of arrangement.
2. 1ml of the extract was transferred to tube labeled "1:2" and carefully agitated to create a homogenous suspension and a final concentration of 0.5g/ml (vol/vol) was obtained.
3. From tube labeled stock, 1ml of the extract suspension was transferred to the next tube labeled 1:2 and carefully agitated to obtain a concentration of 0.25g/ml.
4. From tube labeled '1:2', 1ml was transferred into tube labeled '1:4' dilution containing 1ml of sterile distilled water to obtain a concentration of 0.125g/ml
5. Likewise, 1ml from the 1:4 tube was added to the next tube containing 1ml of sterile distilled water, and mixture carefully mixed to obtain a concentration of 0.063g/ml
6. 1ml from each dilution was transferred into labeled bottles containing sterilized paper disc

and allowed to stand for 30 minutes to allow for absorption of extracts. The produced disc (each one) have the ability to absorb about 0.01ml (Kirby Bauer, 1996).

Susceptibility test

The susceptibility test using the disc diffusion technique was done based on Kirby Bauer's disc diffusion method.

Procedure

1. Each of the test organism was diluted to obtain a turbidity equivalent to 0.5 McFarland standard.
2. By means of a swab stick, the diluted organisms were inoculated into the surface of a well dried Muller Hilton agar.
3. Aseptically, each paper disc labeled 'stock', '1:2', '1:4' and '1:8' were placed 3mm apart on the agar plates.
4. Ofloxacin disc (5 microgram) was placed at the centre of the plates to serve as control.
5. This procedure was carried out for both ginger and garlic extracts disc, and all plates were incubated at 37°C overnight.
6. Zone of inhibitions produced after incubation were measured using a metre rule in millimeter.

Results

The bacterial isolates identified and characterized are as *Escherechia coli*, *Staphylococcus aureus* and *Klebsiella specie*.

The inhibition zones obtained by the garlic and ginger extracts against the different bacteria isolates is as seen in table 1

Table 1: Antibacterial activity of aqueous extracts of ginger and garlic against selected bacterial isolates

Isolate	Concentration	Garlic extract (mm)	Ginger extract (mm)	Ofloxacin (mm)
<i>E. coli</i>	Stock (100%)	4	R	24
	1:2 (0.5 g/mL)	R	R	
	1:4 (0.25 g/mL)	R	R	
	1:8 (0.125 g/mL)	R	R	
<i>Klebsiella spp.</i>	Stock (100%)	R	R	20
	1:2 (0.5 g/mL)	R	R	
	1:4 (0.25 g/mL)	R	R	
	1:8 (0.125 g/mL)	R	R	
<i>Staphylococcus aureus</i>	Stock (100%)	8	R	16
	1:2 (0.5 g/mL)	3	R	
	1:4 (0.25 g/mL)	R	R	
	1:8 (0.125 g/mL)	R	R	

Discussion

Many researchers over the years have tried to identify the antibacterial effect of *Zingiber officinale* and *Allium sativum*; whether with the aqueous or alcohol based extract (Akullo *et al.*, 2022), the essential oil from the spices (Wang *et al.*, 2020), on different bacterial isolates regarding its antibacterial activity.

In this study however, the effect of aqueous ginger extract at (100%) did not produced inhibitory zones on *Escherichia coli*, *Staphylococcus aureus* and *Klebsiella* species in all dilutions. Garlic extract in its undiluted concentration (100%) however produced mild inhibitory effect of about 4mm on *E. coli* while at further dilutions no effect was seen on the tested isolates.

Research conducted by Akullo *et al.*, (2022) reported that the diameter of inhibition zone DIZ of aqueous (water based) extract of local garlic with a concentration of 5.0mg/ml was ± 4 mm against *S. aureus*, while at 10mg/ml it was ± 5 mm. The minimum inhibitory concentration MIC was 5.0mg/ml. While the inhibitory zone against *E. coli* was ± 4 mm at 5.0mg/ml concentration and ± 6 mm at ± 10 mg/ml. The inhibition zone of aqueous (water) extract of ginger at 25mg/ml was 2mm against *S. aureus* and ± 3 mm against *E. coli*. The above work by Akullo *et al.*, (2022), therefore revealed that there was inhibition effect of ginger against *S. aureus* and *E. coli* however small which also matches

previous reports by Abdalla & Abdallah, (2018) that ginger possesses antibacterial effects. The lack of antibacterial activity exhibited by these extract may be as a result of the handling process, the plant have been exposed to a considerable degree of heat in the processing process which may have effect on its antibacterial activity.

However the antibacterial effect is reportedly dependent on the chemical composition, extraction solvent and method and of course, the concentration. (Beristain-Bauza *et al.*, 2019).

This study observed no inhibitory effect of aqueous ginger to *E. coli* which is in correlation to another study by Akintobi *et al.*, (2013), while another study observed low inhibitory effect(Akullo *et al.*, 2022). The extraction solvent may be a factor to consider when observing for the antibacterial effect of ginger. In other studies, ethanol and methanol extracts of ginger were effective on both *E. coli* and *S. aureus* (Beristain-Bauza *et al.*, 2019). However, the effect of the heated extract was lower than that of the non-heated extracts (Akullo *et al.*, 2022).

The type of ginger extraction may also be attributed to its antibacterial effect; raw, acetone and methanol extracts of hybrid ginger had a very high inhibitory at 25mg/ml while water and ethanol had slight inhibitory effect on *S. aureus*. Antimicrobial activity of ginger could be attributed to the presence of shogal and gingerol which are present in ginger as active ingredients (Akullo *et al.*, 2022).

Akullo *et al.*, (2022) reported that garlic exhibited a strong antibacterial effect against all the selected microorganisms at 25mg/ml. Compared to the aqueous extracts, organic solvent extracts of the hybrid variety were more effective on *S. aureus*. This was similar to the report by El-Sayeed *et al.*, (2017) where white and purple skin garlic cultivars in organic solvents and water based emulsions were compared. These results could inform the choice of extracts to be used in food applications. However aqueous extracts produced the best inhibition activity against *E. coli* compared to organic solvent (Akullo *et al.*, 2022). In a previous study water extraction of garlic at low pH produced the best antimicrobial activity compared to methanol and ethanol (Chen *et al.*, 2018). The may be due to the effect of allicin, the active ingredient present in garlic which is reportedly unstable during processing of garlic due to varying temperature, pH, extraction medium and light.(Wang *et al.*, 2015).

In this study however, the effect of water based extract of garlic against *S. aureus* was higher than that of *E. coli*, while it was resistant against *Klebsiella species*. The MIC of garlic against *S. aureus* was 0.5g/ml while that of Akullo *et al.*, (2022) was 2.5mg/ml which is

0.0025g/ml. Deviations in MIC are attributed to the chemical variations within the different extracts, type of garlic and concentration of bioactive compounds within extracts. For example variation in chemical characteristics and antimicrobial activity were noted when three different cultivars of Australian grown garlic were compared (Phan *et al.*, 2019).

Conclusion

There is no significant antibacterial effect of aqueous garlic against *Escherichia coli* and *Staphylococcus aureus* in all varying concentrations since the extracts had failed to produce desirable inhibition against the isolates when compared to the control. The antimicrobial effect of water based ginger extract against the selected organisms could not be proved, which may also be due to factors like the pH, temperature, as well as the crude method of extraction of the ginger which might have destroyed the active gingerol and shogal constituents. However, these findings need to be correlated with other forms of processing alongside using other solvents for extraction.

Author's Contribution

Conceptualization of this work by M.O; Data analysis and editing by ZCS

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Conflict of Interest

The authors declared no conflict of interests.

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