

Antimicrobial Activity Of *Zingiber Officinale* (Ginger) Extract Against Some Selected Pathogenic BacteriaAkintobi OA¹, Onoh CC², Ogele JO¹, Idowu AA³, Ojo OV¹, Okonko IO³¹Department of Microbiology, Lead City University, Ibadan, Nigeria²Department of Pharmacology and Therapeutics, Igbinedion University, Okada, Edo State, Nigeria³Department of Microbiology, University of Ibadan, Ibadan, Nigeria⁴Medical Microbiology & Virology Unit, Department of Microbiology, University of Port Harcourt, East-West Road, P.M.B. 5323, Choba, Port Harcourt, Rivers State, Nigeria;
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Abstract: This study investigated the antimicrobial activity of ginger (*Zingiber officinale*) extracts on six pathogenic microorganisms using the agar well diffusion method. These bacteria include; *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Proteus mirabilis*, *Escherichia coli*, *Bacillus subtilis* and *Salmonella typhi*. Four different extracts were obtained from the rhizomes of ginger (water-soluble and ethanol-soluble extracts). There were zones of inhibitions around the wells which indicate that the organisms were sensitive to both water and ethanol extracts of ginger. The result showed that the isolates behaved differently in their sensitivity to the different extracts added to their growth medium. Water extract of *Zingiber officinale* produced the highest zone of inhibition on *Salmonella typhi* (13mm) and a slightly inhibitory effect on *Staphylococcus aureus* (9mm) and *Proteus mirabilis* (11mm). Water extract of *Zingiber officinale* was ineffective against *Escherichia coli* (0mm), *Bacillus subtilis* (0mm) and *Pseudomonas aeruginosa* (0mm). The result also showed that ethanol extract of *Zingiber officinale* produced the highest zone of inhibition on *Proteus mirabilis* (17mm) and a slightly inhibitory effect on *Salmonella typhi* (10mm), *Staphylococcus aureus* (13mm), and *Pseudomonas aeruginosa* (14mm). Ethanol extract of *Zingiber officinale* were ineffective against *Escherichia coli* (0mm) and *Bacillus subtilis* (0mm). *Escherichia coli*, *Bacillus subtilis* and *Pseudomonas aeruginosa* were resistant to *Zingiber officinale* extracts. Comparison of the inhibitory activity of the *Zingiber officinale* extracts with both gram-positive and gram-negative antibiotics revealed that gentamycin and chloramphenicol has the highest zone of inhibition against the susceptible bacterial strains used. Gram-negative antibiotic discs showed significantly higher antimicrobial activity against *Pseudomonas aeruginosa* and *Salmonella typhi* when compared to the ethanol and water extracts of ginger. The quantitative and qualitative phytochemical tests indicate that the extract of *Zingiber officinale* (ginger) constitutes antimicrobial activity. This study shows that the extracts of *Zingiber officinale* possess antimicrobial compounds which could be used as substitutes for the antibiotics.

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1. Introduction

Herbs and spices are very important and useful as therapeutic agent against many pathological infections (Gull et al., 2012). The spices have a unique aroma and flavour which are derived from compounds known as phytochemicals or secondary metabolites (Avato et al., 2002; Melvin et al., 2009). The phytochemicals are antimicrobial substances present in the spices which are capable of attracting benefits and repel harmful organisms; they also serve as photoprotectants and responds to environmental changes (Melvin et al., 2009). Numerous classes of phytochemicals including the isoflavones, anthocyanins and flavonoids are found associated with the spices (Chang, 1988; Melvin et al., 2009).

Increasing multidrug resistance of pathogens forces to find alternative compounds for treatment of infectious diseases (Gull et al., 2012). Antimicrobial

agents with selective toxicity are especially useful as a chemotherapeutic agent in treating infectious diseases and may be a function of specific receptor requirement for drug attachment or it may depend on the inhibition of biochemical events essential to the pathogen but not to the host (Omoya and Akharaiyi, 2010).

Many investigators have demonstrated the antimicrobial activity of the constituents of some higher plants and quite a number of chemical compounds of plant origin have been shown to possess antimicrobial activities (Rocio, 1982). Presently, the search for antifungal and antibacterial drugs has received attention mainly as a result of considerable drawbacks in the use of major antibiotics. These include those of limited antimicrobial spectrum that will cause serious side effects and high incidence of resistance in bacteria (Olayemi and Opaleye, 1999).

Ginger is the rhizome of the plant *Zingiber officinale*, consumed as a delicacy, medicine, or spice. It lends its name to its genus and family (Zingiberaceae). Other notable members of this plant family are turmeric, cardamom, and galangal (NPGS/GRIN, 2011). Preliminary research indicates that nine compounds found in ginger may bind to human serotonin receptors, which may explain ginger's extensive effects on the gastro-intestinal tract and suggesting a mechanism for its effects on anxiety (Nievergelt et al., 2010).

Many scientists have reported antimicrobial properties of several plants. The antimicrobial, anti-tumour (Khalil et al., 2005; Akroum et al., 2009; Omoya and Akharaiyi, 2012), anti-inflammatory and anti-necrotic (Lin and Huang, 2002; Omoya and Akharaiyi, 2012) activities have been reported from the use of plants extracts. The most well-known member of *Zingiber* (ginger) is *Zingiber officinale*. In many parts of the world, *Z. officinale* has medicinal and culinary values (Omoya and Akharaiyi, 2012). The volatile oil gingerol and other pungent principles not only give ginger its pungent aroma, but are the most medically powerful because they inhibit prostaglandin and leukotriene formation, which are products that influence blood flow and inflammation (Longe et al, 2005; Omoya and Akharaiyi, 2012).

Ginger has been found to be more effective than placebo in multiple studies for treating nausea caused by seasickness, morning sickness and chemotherapy (Ernst and Pittler, 2000), though ginger was not found superior to placebo for presumptively treating post-operative nausea (Omoya and Akharaiyi, 2012). These studies also show superiority of ondansetron over ginger in the treatment of chemotherapy related nausea. Ginger compounds are active against a form of diarrhea which is the leading cause of infant death in developing countries. Zingerone is likely to be the active constituent against enterotoxigenic *Escherichia coli* heat-labile enterotoxin-induced diarrhea (Ernst and Pittler, 2000; Chen et al., 2007).

The aim of this study is to determine the antimicrobial activity of *Zingiber officinale* (ginger) extracts on different pathogenic bacteria and to carry out phytochemical screening of the extracts so as to evaluate the bioactive constituents responsible for their antimicrobial activity.

2. Materials and Methods

2.1. Collection of *Zingiber officinale*

The fresh forms of *Zingiber officinale* (ginger rhizomes) were purchased from Aleshiloye market, Ibadan.

2.2. Collection of the Test Organisms

The test organisms used in this research consisted of two Gram-positive and four Gram-negative bacteria

isolates obtained from the Department of Microbiology, University of Ibadan. Microorganisms used to assess the antimicrobial properties of the plants extracts are as shown in Table 1. The test organisms were cultured on agar slants and stored in the refrigerator at 4°C. Subcultures were made at two-week intervals.

Table 1: Microorganisms used to assess the antimicrobial properties of *Zingiber officinale* extracts

| Microorganisms | Relevant Properties |
|-------------------------------|-------------------------------|
| <i>Staphylococcus aureus</i> | Gram-positive bacteria |
| <i>Bacillus subtilis</i> | Gram-positive bacteria GPB |
| <i>Proteus mirabilis</i> | Gram-negative bacteria |
| <i>Pseudomonas aeruginosa</i> | Gram-negative bacteria |
| <i>Escherichia coli</i> | Gram-negative bacteria |
| <i>Salmonella typhi</i> | Gram-negative bacteria |

2.3. Preparation of Water Extract of *Zingiber officinale*

The method of Olayemi and Opaleye (1999) was adopted for the extraction of the plant. This was carried out by measuring 20g of each of fine grounded powder of rhizome of *Zingiber officinale* on an electronic weighing balance. This was dispensed into two beakers, each containing 80ml of distilled water. These were soaked for 72hours after which the solution was carefully filtered with muslin cloth into a sterilized conical flask of 100ml and the filtrates obtained were stored in the refrigerator at a temperature of 4°C until required.

2.4. Preparation of Ethanol Extract

This also followed the method in 2.3 above. Twenty grammes of each fine grounded powder of *Zingiber officinale* was dispensed into a beaker containing 80ml of 95% ethanol. They were soaked for 72hours while the resulting supernatant was decanted into a conical flask of 100ml and kept in the refrigerator for further study. The extraction of the plants was carried out according to the method of Olayemi and Opaleye (1999).

2.5. Antibacterial Tests of *Zingiber officinale* Extracts

2.5.1. Inhibitory Test for Ethanol Extract of *Zingiber officinale*

The agar diffusion method of Olayemi and Opaleye (1999) was used. From the 48h old cultures of the test organisms with the aid of six sterile syringes, 0.5ml of each of the test organisms was inoculated into 6 different sterile Petri dishes. About 20ml of sterile media was aseptically poured into each dish. The dishes were gently rocked for proper mixture and the nutrient agar was allowed to solidify. Afterwards, wells were

dug in the plates with the aid of a sterilized cork borer of 6mm diameter. Five wells were bored on each plate; two wells for the ethanol extract of *Zingiber officinale*, two wells for the water extract and the fifth well served as the control. Ethanol was used as the control. With the proper labeling of wells, 0.5ml of each of the ethanol extract of the plant was introduced into the first and third wells while 0.5ml of ethanol was introduced into the fifth well as the control. They were allowed to stand for one hour for proper diffusion and then incubated at 37°C for 24hours. The sensitivity of the test organisms to ethanol and water extract of *Zingiber officinale* was indicated by a clear zone of inhibition around the wells. The diameter of the clear zone (Zone of inhibition) was measured to the nearest millimeter using a transparent ruler. This was taken as an index of the degree of sensitivity of the test organisms to both ethanol and water extracts.

2.5.2. Inhibitory Tests for Aqueous Extract of *Zingiber officinale*

This also followed the method in 2.5.1 above. 0.5ml of each of the test organism from the 48hour-old culture was poured into six different sterile Petri dishes. About 20ml of sterile media was aseptically poured into each dish. The dishes were gently rocked together for proper mixture and the nutrient agar was allowed to solidify. Afterwards, wells were dug in the plates with the aid of a sterilized cork borer of 6mm diameter. Five wells were bored on each plate; two wells for the water extracts of garlic and ginger, two wells for the aqueous extracts and the fifth well served as the control. Ethanol was used as the control. With the properly labeling of the wells, 0.5ml of each of the water extracts of the plant was introduced into the second and fourth well while 0.5ml of ethanol was introduced into the fifth well (control). They were allowed to stand for one hour for proper diffusion and then incubated at 37°C for 24hours. The sensitivity of the test organisms to ethanol and water extracts of *Zingiber officinale* was indicated by a clear zone of inhibition around the wells. The diameter of the clear zone (Zone of inhibition) was measured to the nearest millimeter using a transparent ruler. This was taken as an index of the degree of sensitivity of the test organisms to both ethanol and water extracts of *Zingiber officinale*.

2.6. Antibiotic Sensitivity Test

The Kirby-Bauer method was used to test the bacterial isolates susceptibility to antibiotics. A sensitive disc impregnated with various broad spectrum antibiotics namely tetracycline, cloxacillin, gentamycin, erythromycin, chloramphenicol and ampicillin were employed to compare and contrast the antimicrobial activities of *Zingiber officinale* extracts. About 2.8 grams of nutrient agar powder was weighed and

dissolved into a conical flask containing 100ml of distilled water. The solution was then sterilized in an autoclave at a temperature of 121°C for 15minutes and at a pressure of 15lb/sq inch. The sterile agar which was cooled to a temperature of about 50°C was poured into different sterile Petri dishes already inoculated with test organisms. The Petri dishes were rocked gently to allow distribution of the inocula. The Petri dishes were then left for 45 minutes on the laboratory bench to solidify. Thereafter, antibiotic discs were laid on the seeded agar. The plate was incubated at 37°C for the 24hours. Appearance of clear zones around the disc, indicative of inhibition was therefore observed.

2.7. Determination of Minimum Inhibitory Concentration of *Zingiber officinale*

The minimum bactericidal concentration of *Zingiber officinale* extracts was carried out by concentrating *Zingiber officinale* into the solvents 95% ethanol and distilled water used. *Zingiber officinale* samples were measured differently into 1.3 and 1.6 grams and soaked in 8.7, and 8.4ml of ethanol and water respectively. This was soaked for 72 h while the extract obtained was used to determine the minimum inhibitory concentration of the extracts of *Zingiber officinale* against the test organisms, using the earlier method mentioned above. The least concentration of *Zingiber officinale* extracts that show inhibitory effects on the test organisms was taken as the minimum inhibitory concentration.

2.8. Qualitative Phytochemical Screening of *Zingiber officinale*

Simple standard chemical tests were carried out for the qualitative phytochemical screening of *Zingiber officinale*. These tests were used to detect the presence of bioactive agents such as the alkaloids, tannins, saponins, cardiac glycosides, phenols and phlobatanins. The phyto-constituents were assayed for using standard methods described by Trease and Evans (1978). The phytochemical analysis was carried out in the Department of Biochemistry, Lead University, Ibadan, Oyo State. Other phyto-constituents of *Zingiber officinale* assayed include: saponins; tannins; alkaloids; phlobatanins; anthraquinones; cardiac glycosides; Legal test; Lieberman's test; Salkowskis test

2.8.1. Alkaloid Test

Five grams each of the ginger extracts and 5 ml honey were stirred with 5 ml of 1% aqueous hydrochloric acid on a steam bath at 60 oC for 5 minutes. The sample was filtered with a 3 layered muslin cloth. One millilitre of the filtrate was treated with few drops of Dragendoff's reagent. Blue black turbidity serves as preliminary evidence of alkanoids.

2.8.2. Saponins Test

Five grams each of the extracts and 5 ml of honey were shaken separately with distilled water in a test tube.

Frothing which persists on warming was taken as preliminary evidence of the presence of the saponins.

2.8.3. Tannins Test

Five grams each of the extracts and 5 ml of honey were stirred separately with 100 ml distilled water and filtered. One millilitre ferric chloride reagent was added to the filtrate. A blue-black or blue green precipitate was an indication of the presence of tannins (Trease and Evans, 1989).

2.8.4. Phlobotannins Test

Deposition of red precipitate when an aqueous extract of the test samples was boiled with 1% hydrochloric acid indicated the presence of phlobotannins (Trease and Evans, 1989).

2.8.5. Flavonoids Test

Five millilitres of diluted ammonia solution was added to aqueous filtrate of the test samples followed by the addition of 1 ml concentrated H₂SO₄. A yellow colouration indicates the presence of flavonoids (Harborne and Williams, 2000).

2.8.6. Cardiac Glycosides (Keller-Killiani Test)

Five grams of each of the extracts and 5 ml of honey were dissolved separately in 2 ml glacial acetic acid containing a drop of ferric chloride solution. This was underplayed with 1 ml concentrated H₂SO₄. A brown ring at the interface indicates a deoxy-sugar characteristic of cardenolides. A violet ring may appear below the brown ring, while in the acetic acid layer, a green ring may form which just gradually spreads throughout the layer (Trease and Evans, 1989).

2.8.7. Legal Test

Five grams of each extract and 5 ml of honey was dissolved in pyridine separately and few drops of 2% sodium nitroprusside together with few drops of 20% sodium hydroxide were added. A deep red colour, which fades to yellowish-brown, indicates the presence of Cardinolides (Trease and Evans, 1989).

2.8.8. Salkoski Test

Five grams of the extracts and 5 ml of honey were dissolved in 20 ml of chloroform. Few drops of sulphuric acid were carefully added to form a layer at the lower part. A reddish-brown colour at the interface indicates the presence of steroids nucleus (Trease and Evans 1989).

2.8.9. Lieberman's Test

Five grams of the extracts and 5 ml of honey were mixed with 2 ml of acetic anhydride and cooled. Later one, 0.5 ml of sulphuric acid was carefully added. A colour change from violet to blue to green indicates the presence of a steroids nucleus (i.e. a glycone portion of the cardiac glycoside) (Trease and Evans, 1989).

2.9. Quantitative Phytochemical Screening of *Zingiber officinale*

The quantitative phytochemical screening of *Zingiber officinale* was carried out to determine the actual amount of the bioactive constituents present in *Zingiber officinale* extracts. The bioactive constituents worked on were saponins, tannins, alkaloids and flavonoids.

3. RESULTS ANALYSIS

Table 2 shows the result obtained from the antimicrobial activity of the water and ethanol extracts of *Zingiber officinale*. The result showed that water extract of *Zingiber officinale* produced the highest zone of inhibition on *Salmonella typhi* (13mm). Water extract of *Zingiber officinale* had a slightly inhibitory effect on *Staphylococcus aureus* (9mm) and *Proteus mirabilis* (11mm). Water extract of *Zingiber officinale* was ineffective against *Escherichia coli* (0mm), *Bacillus subtilis* (0mm) and *Pseudomonas aeruginosa* (0mm) as shown in Table 2.

The result showed that ethanol extract of *Zingiber officinale* produced the highest zone of inhibition on *Proteus mirabilis* (17mm). Ethanol extract of *Zingiber officinale* had a slightly inhibitory effect on *Salmonella typhi* (10mm), *Staphylococcus aureus* (13mm), and *Pseudomonas aeruginosa* (14mm). Ethanol extract of *Zingiber officinale* were ineffective against *Escherichia coli* (0mm) and *Bacillus subtilis* (0mm) as shown in Table 2.

Table 2: Zone of Inhibition (mm) of Water Extracts of *Zingiber officinale* on Tested Organisms

| Test Organisms | Water extract | Ethanol extract |
|-------------------------------|---------------|-----------------|
| <i>Escherichia coli</i> | 0.00 | 0.00 |
| <i>Staphylococcus aureus</i> | 9.00 | 13.00 |
| <i>Proteus mirabilis</i> | 11.00 | 17.00 |
| <i>Bacillus subtilis</i> | 0.00 | 0.00 |
| <i>Salmonella typhi</i> | 13.00 | 10.00 |
| <i>Pseudomonas aeruginosa</i> | 0.00 | 14.00 |

Table 3 shows the zone of inhibition of the antibiotic sensitivity disc on the selected test organisms. *Pseudomonas aeruginosa* and *Salmonella typhi* were observed to be very sensitive to the Gram – negative antibiotic disc. *S. typhi* however showed high degree of sensitivity (16mm and 11mm) to gentamycin and chloramphenicol while the other tested organisms

showed variation in their sensitivity to the antibiotic discs. There was no zone of inhibition among the Gram – positive bacteria. The Gram – negative antibiotic disc recorded significantly higher antimicrobial activity against *P. aeruginosa* and *S. typhi* which was very

similar to the potency of the water and ethanol extracts of *Zingiber officinale* as shown in Table 3. This shows that the extracts of *Zingiber officinale* possess antimicrobial compounds which could be used as substitutes for the antibiotics.

Table 3: Antibigrams: Zone of Inhibition (mm) of Antibiotic Discs on Tested Organisms

| Pathogens | Zone of Inhibition (mm) | | | | | | | | | | |
|-------------------------------|-------------------------|-----|------|-----|------|-----|------|-----|-----|-----|--|
| | Gram Negative Bacteria | | | | | | | | | | |
| | NIT | AUG | NFL | TET | GEN | CIP | CHL | AMP | NAL | CEF | |
| <i>Escherichia coli</i> | 0.0 | 0.0 | 0.0 | 0.0 | 5.0 | 4.0 | 0.0 | 0.0 | 6.0 | 0.0 | |
| <i>Pseudomonas aeruginosa</i> | 0.0 | 3.0 | 11.0 | 5.0 | 7.0 | 9.0 | 6.0 | 4.0 | 5.0 | 4.0 | |
| <i>Proteus mirabilis</i> | 0.0 | 0.0 | 0.0 | 0.0 | 6.0 | 0.0 | 8.0 | 0.0 | 0.0 | 0.0 | |
| <i>Salmonella typhi</i> | 3.0 | 6.0 | 10.0 | 6.0 | 16.0 | 4.0 | 11.0 | 7.0 | 6.0 | 5.0 | |
| Gram Positive Bacteria | | | | | | | | | | | |
| | DRO | CEP | NFL | GEN | ERY | CIP | CLD | SEP | AMX | AMC | |
| <i>Staphylococcus aureus</i> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| <i>Bacillus subtilis</i> | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |

Key: NIT= Nitrofurantoin, AUG= Augmentin, NFL= Norfloxacin, TET= Tetracycline, GEN= Gentamycin, CIP= Ciprofloxacin, CHL= Chloramphenicol, AMP= Ampicillin, NAL= Nalidixic acid, CEF= Cefuroxime, DRO= Drovid, CEP= Cephalexin, ERY= Erythromycin, CLD= Clindamycin, SEP= Seprin, AMX= Amoxil, AMC= Amplicox, 0.0= No inhibition.

Table 4 shows the minimum inhibitory concentration of ethanol and water extracts of *Zingiber officinale* on the tested organism. The results showed that at 1.3g of the ethanol extract was the least

concentration that had inhibition zone of 0.40mm against *Salmonella typhi* while the extract of the same concentration was effective against *Staphylococcus aureus* (0.50mm) as shown in Table 4.

Table 4: Minimum Inhibitory Concentration of Extracts of *Zingiber officinale* on test organisms

| Pathogens | Minimum Inhibitory Concentration (1.3gm) | | Minimum Inhibitory Concentration (1.6gm) | |
|--------------------------|--|-----------------|--|-----------------|
| | Zones of inhibition (mm) | | Zones of inhibition (mm) | |
| | Water extract | Ethanol extract | Water extract | Ethanol extract |
| <i>Escherichia coli</i> | 0.00 | 0.00 | 0.00 | 0.00 |
| <i>S. aureus</i> | 0.50 | 0.50 | 2.20 | 2.20 |
| <i>Proteus mirabilis</i> | 2.00 | 2.00 | 3.00 | 3.00 |
| <i>Bacillus subtilis</i> | 0.00 | 0.00 | 2.00 | 2.00 |
| <i>Salmonella typhi</i> | 0.90 | 0.40 | 0.00 | 0.00 |
| <i>P. aeruginosa</i> | 0.00 | 0.00 | 3.00 | 3.00 |

Table 5 shows the result of the phytochemical contents of the water and ethanol extracts of *Zingiber officinale*. It was observed that all the constituents screened were present in both water and ethanol extracts of *Zingiber officinale* except saponins and cardiac glycosides (Table 5).

Table 5: Phytochemical Compounds Present in the Extracts of *Zingiber officinale*

| Phyto-Constituents | Ethanol Extracts | Water Extracts |
|--------------------|------------------|----------------|
| Alkaloids | + | + |
| Saponins | - | - |
| Tannins | + | + |
| Phlobatannins | + | + |
| Anthraquinones | + | + |
| Cardiac glycosides | - | - |
| Legal Test | + | + |
| Lieberman's Test | - | - |
| Salkowski's Test | - | - |

Key: + = Present; - = Absent

Table 6 shows the quantitative result of the phytochemical contents of the ethanol and water extracts of *Zingiber officinale*. It was observed that all the quantitative phytochemical constituents screened for were present in both extracts (Table 6).

Table 6: Quantitative Determination of the Common Bioactive Constituents of the Extracts of *Zingiber officinale*

| Bioactive Constituents (%) | Ethanol Extracts | Water Extracts |
|----------------------------|------------------|----------------|
| Alkaloids | 1.46 | 0.11 |
| Saponins | 1.02 | 0.82 |
| Tannins | 3.27 | 1.35 |
| Flavonoid | 1.97 | 0.24 |

4. DISCUSSION

The antimicrobial activity of spices is due to specific phytochemicals or essential oils (Avato et al.,

2000; Gull et al., 2012). The main factors that determine the antimicrobial activity are the type and composition of the spice, amount used, type of microorganism, composition of the food, pH value and temperature of the environment (Sagdic, 2000; Gull et al., 2012). Several reports had been published that describe the antibacterial and antifungal properties of different herbs and spices (Gull et al., 2012). However, still there is little information about the exact mechanism of their antimicrobial action (Yin et al., 2002; Gur et al., 2006; Pattaratanawadee et al., 2006; Yusha'u et al., 2008; Oskay et al., 2009; Belguith et al., 2010; Poeloengan et al., 2011; Gull et al., 2012).

The results of this study showed that of the water and ethanol extracts of *Zingiber officinale* screened, the ethanol extracts had a higher inhibitory activity against the test organisms than that of the water extracts. This could be as a result of better extraction with alcohol solvents. The effect of water extracts of *Zingiber officinale* used on these test organisms *in vitro* cannot be predicted from this study. This is in conformity with the work of Gomaa and Hashish (2003) in which the inhibitory property of ginger extracts on the growth of some microorganisms including *Salmonella typhi* was reported. Gomaa and Hashish (2003) reported that water extracts of *Zingiber officinale* produced higher antimicrobial reduction than the ethanol extract on the test organisms.

The result showed that the isolates behaved differently in their sensitivity to the different extracts added to their growth medium. In this study, the water extract of ginger did not show any inhibitory effect against *Escherichia coli*, *Bacillus subtilis* and *Pseudomonas aeruginosa*. Also, the ethanol extract of *Zingiber officinale* did not produce any inhibitory activity against *Escherichia coli* and *Bacillus subtilis*. Although the reason for this variation is not clear, it could be assumed to be as a result of genetic differences between *Zingiber officinale* and microbial strains used in this study. All tested bacterial strains showed poor susceptibility to the ginger aqueous extract in a study by Gull et al. (2012).

The result also showed that ethanol extract of *Zingiber officinale* produced the highest zone of inhibition on *Proteus mirabilis* (17mm) and a slightly inhibitory effect on *Salmonella typhi* (10mm), *Staphylococcus aureus* (13mm), and *Pseudomonas aeruginosa* (14mm). Ethanol extract of *Zingiber officinale* were ineffective against *Escherichia coli* (0mm) and *Bacillus subtilis* (0mm). *Escherichia coli*, *Bacillus subtilis* and *Pseudomonas aeruginosa* were resistant to *Zingiber officinale* extracts. Though all the test organisms were susceptible to the antibacterial samples with inhibition measure between 6-3 mm in that study by Omoya and Akharaiyi (2012), *E. coli* was the most inhibited where an inhibitory measure of 20

mm was recorded with honey, 18 mm with ginger ethanol extract and 32 mm with the mixture of honey and ginger ethanol extract.

Also in a study by Melvin et al. (2009), the ginger extract, however, showed only a moderate antimicrobial activity against *S. aureus*.

In this study, ethanol extract of ginger did exhibited maximum inhibitory effect against *P. aeruginosa* while the water extract did not while it showed no effect against *E. coli*. In a study by Melvin et al. (2009), it was found that the ginger extract exhibited maximum inhibitory effect against *P. aeruginosa* while the antimicrobial activity against *E. coli* was found to be moderate. Our findings compare well with the findings of Patumaraj (2000), who reported the antimicrobial activity of ginger against *S. aureus* and *Salmonella* sp and are on par with the findings of Indu et al. (2006).

In this study, it was also observed that the water extract of *Zingiber officinale* produces a slightly low inhibitory activity against the test organisms. In addition to highlighting the importance of extraction solvents, it also adds *Zingiber officinale* to the list of potential plant materials possessing inhibitory property against the tested organisms. In fact, the ethanol extract of *Zingiber officinale* produced a high zone of inhibition zone (diameter) on *Salmonella typhi*. The inhibitory property of *Zingiber officinale* against *S. typhi*, *E. coli*, and *B. subtilis* has been demonstrated by Arora and Kaur (1999). In a study by Omoya and Akharaiyi (2012), the inhibitory potency of the honey, methanol and ethanol extracts of ginger (*Zingiber officinale*) on the test organisms varied in the halos as inhibition effects.

Furthermore, comparison of the inhibitory activity of *Zingiber officinale* extracts with both Gram-positive and Gram-negative antibiotics revealed that gentamycin and chloramphenicol had the highest zones of inhibition against the susceptible bacterial strains used. Gram-negative antibiotics recorded a significantly higher antimicrobial activity against *P. aeruginosa* and *S. typhi* compared to the ethanol and aqueous extracts of *Zingiber officinale*. The (minimum inhibitory concentration) MIC of different bacterial species varied from 0.05 mg/ml to 1.0 mg/ml in a study by Gull et al. (2012). While some of the commercial antibiotics (positive control) were not effective on the test organisms in the study by Omoya and Akharaiyi (2012), gentamycin and streptomycin were effective with inhibitory halos ranging between 8-25 mm.

The quantitative and qualitative phytochemical tests carried out on *Zingiber officinale* indicated that the extracts of *Zingiber officinale* constitute antimicrobial properties. It was observed that all the constituents screened were present in both water and ethanol extracts of *Zingiber officinale* except saponins

and cardiac glycosides. This is in conformity with the work of previous studies by some other authors. However, in the study by Omoya and Akharaiyi (2012), the pasture honey, the ethanol and methanol extracts of ginger were both positive for saponin and cardiac glycosides among the phytochemicals identified. The ginger extracts having chemical compounds such as saponin, alkanoids and flavonoids have been reported to have antifungal and antibacterial activities in-vitro (Barasch et al, 2004) and so effective in combating postoperative nausea and vomiting (Ernst and Pittler, 2000; Omoya and Akharaiyi, 2012).

The results of antimicrobial effect of ginger in the study are in accordance with most of the reports published regarding ginger antimicrobial activity (Akoachere et al., 2002; Malu et al., 2008; Yu et al., 2009; Gao and Zhang, 2010; Sebiomo et al., 2011; Gull et al., 2012). The antimicrobial activity of ginger may be attributed to the fact that it contains antimicrobial substances such as zingiberol, zingiberine and bisabolene (Michael derrida, 1999; Melvin et al., 2009). The rhizome of ginger contains pungent vanillyl ketones including gingerol and paradole, etc (Douglas and Miller, 1999; Melvin et al., 2009). Gingerol is a mixture of crystal gingerone and it is the major cause of acidity of ginger and plays a role in inhibiting bacteria such as *S. aureus*, *Trichomonas vaginalis* and help to cure bacterial vaginosis and skin diseases (Michael derrida, 1999; Melvin et al., 2009).

The antibacterial activities of the extracts are expected perhaps due to the compounds like flavonoids and volatile oil which were dissolved in organic solvents. It is reported that sesquiterpenoids are the main component of ginger which attributes its antibacterial activity (Malu et al., 2008; Gull et al., 2012). The results obtained in our study corroborate with the report of Roy et al. (2006), which explains that bioactive compounds of ginger rendering antimicrobial activity are volatile in nature and antimicrobial activity of ginger extract decreases upon storage. In addition to water, methanol and ethanol were also used for extract preparation as de Boer et al. (2005) has reported that bioactive compounds show better solubility in water miscible organic solvents.

This study emphasized ginger extract as having antibacterial activity on some pathogenic bacteria isolated from human samples. Use of garlic and ginger as a natural supplement is considered healthy choice for the treatment of cardiovascular diseases (Bordia et al., 1997; Mahmoodi et al., 2006; Gull et al., 2012), hypertension (Benavides et al., 2007; Gull et al., 2012), diabetes (Banerjee and Maulik, 2002; Gull et al., 2012), Alzheimer's disease (Peng et al., 2002; Chauhan, 2006; Gull et al., 2012), inflammation, thrombosis (Fukao et al., 2007; Gull et al., 2012) and even for cancer (Hsing et al., 2002; Gull et al., 2012).

Recently ginger was also reported for treatment of nonalcoholic fatty liver diseases, (Sahebkar, 2011; Gull et al., 2012). With the increasing awareness of population toward natural therapies, spices can be considered as obvious alternate medication (Sofia et al., 2007; Gull et al., 2012).

5. Conclusion

The result of the study emphasizes the usefulness of *Zingiber officinale* (ginger) in the treatment of diseases and the need to enhance its exploitation on this regard. This is particularly of urgent interest when the growth rate of multi-resistant drug strains of bacteria worldwide is considered (Prescott *et al.*, 2005). The results of present study have provided the justification for therapeutic potential of spices. The practice of using spices as supplementary or alternative medicine in developing countries like Nigeria will not reduce only the clinical burden of drug resistance development but also the side effects and cost of the treatment with allopathic medicine. This study also showed that ginger extracts possess differences in antibacterial activities. Ginger in its spicy nature with free radical inhibitions index performs other toxic factors which of course responded to the antibacterial effect observed in the study.

While some phytochemical constituents known for inhibition of microorganisms were observed in *Zingiber officinale*, it did not possess traces of saponin and cardiac glycoside. However, the importance of ginger (*Zingiber officinale*) cannot be over emphasized as regards their role in health remedy. In fact, the findings revealed that the knowledge of the antimicrobial activity of the extracts obtained from ginger can be very useful and can be applied in different areas of research such as the pharmaceutical and food industries.

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