Antibacterial Activity of Zingiber officinale (Ginger) against Clinical Bacterial Isolates

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Authors’ contributions

This work was carried out in collaboration among all authors. Author BHS designed the study, wrote protocol and wrote the first draft of the manuscript. Author WFM and Author RNI performed statistical analysis and managed the analyses of the study. Author MBH managed the literature searches. All authors read and approved the final manuscript.

Article Information

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ABSTRACT

Aims: The objective of the present study was to investigate the phytochemical constituents and antibacterial activity of ginger extracts against some pathogenic bacteria responsible for Urinary tract infection.

Study Design: A total of 35 samples were collected from patients with UTIs and wound infections.

Place and Duration of Study: The study was conducted at 2 hospitals in Baghdad from 1/7/2017 to 1/9/2017

Methodology: The urine sample was collected using a sterile container, while a swap from the infected wound was also taken. The classical methods for diagnosis pathogenic bacteria in urine and wound are based on culture on different microbiological media including; Blood agar, nutrient agar, then incubated at 37°C for 24 hrs. The diagnostic procedures consisted of direct microscopy observation, Gram staining, Biochemical tests, Catalase and coagulase tests.

Results: Results show that 30.55%, 38.8%, 19.46% and 11.11% isolates gave typical morphological characteristics and biochemical test for Escherichia coli, Pseudomonas aeruginosa,

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1. INTRODUCTION

Ginger (Zingiber officinale), Roscoe belongs to the Family Zingiberaceae. It is a perennial herb with thick tuberous rhizomes. The erect leafy aerial stem grows up to approximately 1 meter in height and has purple flowers [1]. Its roots are used as a spice in cooking throughout the world. The ginger plant has a long history of cultivation known to originate in China and then spread to India, South East Asia, West Africa and the Caribbean. Ginger contains up to 3% of essential oil that causes the fragrance of the spice. The main constituent is zingiberene. Other components include β-sesquiphellandrene [2].

Antibiotic resistance has limited ability of physicians to treat some infectious diseases. Incidence and spread of drug resistance in major infectious diseases lead to use a plant extract. The water extract of ginger roots has direct anti-infectious diseases lead to use a plant extract. Incidence and spread of drug resistance in major infectious diseases lead to use a plant extract. The water extract of ginger roots has direct anti-

Klebsiella pneumoniae and Staphylococcus aureus respectively. Antibiotic susceptibility test reveals that Escherichia coli isolates were 100% sensitive to gentamicin, tetracycline, streptomycin. Pseudomonas aeruginosa isolates reveal that 100% of them were sensitive to gentamicin, Imipenem, ampicillin and streptomycin. Staphylococcus aureus isolates reveal that 100% of them were sensitive to Gentamycin, tetracycline and streptomycin. Klebsiella pneumoniae isolates reveal that 100% of them were sensitive to nitrofurantoin and Imipenem. Ginger roots extract at high concentration (250,500 mg/ml) have strong antibacterial activity against pathogenic bacteria (Staphylococcus aureus, Escherichia coli and Klebsiella pneumoniae).

Conclusion: This study has shown that ginger extracts possess medicinal properties, antibacterial activity and that the inhibition of bacterial growth was dose dependent. The results of the present study show that ginger extracts are more effective against all tested bacterial strains. The results of present study have provided the justification for therapeutic potential of ginger and also used as dietary supplement for food preservation.

Keywords: Zingiber officinale (Ginger); ginger water extract; antibacterial activity of Zingiber officinale (Ginger) water extract; UTI and wound infection; antibiotic sensitivity test of clinical isolates.

2. MATERIALS AND METHODS

2.1 Isolation of Bacteria

For isolation of bacteria causes UTI infection and wound infection, (35) samples were collected from patients with UTIs and wound infections from (2) hospital in Baghdad from 1/7/2017 to 1/9/2017.

The urine sample was collected using a sterile container, while a swap from the infected wound was also taken. The classical methods for diagnosis pathogenic bacteria in urine and wound are based on culture on different microbiological media including. Blood agar, nutrient agar, then incubated at 37°C for 24 hrs.

For further diagnosis of gram-negative bacteria E. coli and Klebsiella, Pseudomonas aeruginosa, samples were cultured on MacConkey Agar, also selected isolated colonies were further streaked on EMB agar plates for diagnosis of E. coli, also non-lactose fermenting colonies on MacConkey agar were streaked on King A, King B medium for isolation of Pseudomonas aeruginosa. For isolation of gram-positive Staphylococcus spp in samples, selected colonies from blood agar were subcultured on Mannitol salt agar and incubated at 37°C for 24 hrs.

2.2 Identification of Bacteria

The diagnostic procedures consisted of direct microscopy observation, Gram staining, Biochemical tests, Catalase and coagulase tests.
A. Gram stain: Colonies that were able to grow on the selective media were further identified by studying their morphological characteristics (Gram stain, shape, spore formation).

B- Identification of Gram-negative bacteria by API 20E system: Gram-negative bacteria were identified by sub-culturing pure colonies from MacConkey Agar plates on the API 20E microtubes system. This system contains 20 standard biochemical tests. Each gallery contains 20 microtubes. 5ml of tap water was put into the incubation tray. A single colony from the inoculation medium was transferred, and suspended in 5 ml of saline and mixed thoroughly. With a sterile Pasteur pipette, the twenty microtubes were inoculated according to the manufactures instruction, both the tubes and couple section of CIT, VP and GEL microtubes were filled to the end of the tube, also couple section of the ADH, LDC, ODC, H2S and URE microtubes were completely filled with sterile mineral oil. After inoculation, the plastic lid was placed on the tray and the galleries were incubated for 18-24 hours at 37°C.

Identification of the isolates using the analytical profile index (Numerical Coding) for rapid identification of species that were done as supplied by the manufacturer and the identification is determined.

C- Identification of Staph aureus: A selective isolated colony from blood agar were further identified by Catalase test and Coagulase test.

Antimicrobial susceptibility Test: All aspects of this procedure were standardized according to NCCLS to ensure consistent and accurate results.

A- Preparation of bacterial samples: Inoculum from test bacteria (Klebsiella pneumoniae, E.coli, Pseudomonas and Staphylococcus aureus) were cultured in a broth media and incubated at 37°C for 24hrs, then a broth culture was diluted to match a 10² McFarland turbidity standard, which is roughly equivalent to 150 million cells/ mL.

B- Incubation Procedure: Media used in this test was Mueller-Hinton agar, poured into Petri dishes at only 4 mm depth. The pH level of the agar must be between 7.2. Using an aseptic technique, place a sterile swab into the broth culture of a specific organism and then gently remove the excess liquid. Using the swab, streak on the Mueller-Hinton agar plate to form a bacterial lawn. To obtain uniform growth, streak the plate with the swab in one direction, rotate the plate 90° and streak the plate again in other direction. Repeat this rotation 3 times. Allow the plate to dry for approximately 5 minutes, then used a flame-sterilized forceps and gently press each disc containing specific antibiotics to the agar to ensure that the disc is attached to the agar and incubated overnight at 37°C before reading the results.

Preparation of aqueous extract of ginger roots: Dry roots of ginger were obtained from the market and grained to powder for preparation of an aqueous extract of ginger by mixing 10.0gm of dry powder with 100 ml of boiled sterile distilled water ina250ml sterile conical flask with occasional shaking at 37°C for 24hrs. The extract was filtered through a gauze for coarse residue and finally filtered through Whatman filter paper No.1. The filtrates were then concentrated by using rotavapor , then filtered through a Millipore filter (0.45) mm and (0.22) mm, then stored in universal bottles at 4°C in the refrigerator prior to use.

Detection of antibacterial Susceptibility test for aqueous extract of ginger roots: Antibacterial Susceptibility testing for an aqueous extract of ginger roots was done by using well diffusion method. Sterile Muller Hinton agar plates were prepared and autoclaving at 121°C for 15 minutes. After solidification, with Pasteur pipette3 well were made in which the centre well was used to put the negative control (normal saline), while others wells were used to put the ginger roots water extract, then 0.2 ml of inoculum suspension was inoculated with micropipette and spread uniformly with a sterile cotton swab over agar surface, the inoculum was allowed to dry for 5 minutes. 0.1 ml of different concentrations of aqueous extracts (250,500) mg/ml were loaded in individual wells, while 0.1 ml of normal saline were used as negative control in the centre well. Plates were observed after 24hrs of incubation at 37°C for the appearance of zones of inhibition around the wells. Antibacterial activity was evaluated by measuring the diameter of zones of inhibition in(millimetres) of bacterial growth.

3. RESULTS AND DISCUSSION

3.1 Isolation and Identification of Enteropathogenic Escherichia coli, Klebsiella pneumoniae, Staph aureus and Pseudomonas aeruginosa

Results showed that among the total of (35) samples that were collected, only (11) isolate
Strains were gave negative results in B, gives variable results in Gelatin liquefaction utilization (CIT), Arabinose results in Arginine Dihydrolase (ADH), Citrate identified by API Pseudomonas inositol, amylase fermentation. fermentation but give negative results in sucrose, mannitol, Sorbitol, Rhamnose,sucrose, Melibiose, Amygdalin, Glucose Fermentation. Klebsiella also results were in agreement with those mentioned by Warren et al. 2000. Staphylococcus aureus were given positive results for coagulase and catalase enzymes.

Diagnosis of Escherichia coli is depended upon isolation and laboratory identification of the bacterium. The samples were streaked on MacConkey and EMB agar and incubated at 37°C for 24 hrs. On MacConkey agar, lactose fermented colonies are produced, as the organism is lactose-positive, and fermentation of this sugar will cause the medium’s pH to become acid. Growth on EMB agar produces colonies with a greenish metallic sheen. Also, Klebsiella pneumoniae were given large, mucoidness, lactose fermented colonies on MacConkey agar. Further diagnosis of Pseudomonas aeruginosaa loopful of non-fermented colonies was streaked further on selective medium (King A, king B) agar plates and incubated at 37°C for 24 hours. Bacteria form blue-green pyocyanin pigment onking, also produced pyoveridine pigments on King B media that Fluorescence under ultraviolet light.

Gram-negative bacteria revealed as the rod or Slenders shaped, pink coloured that arranged in single or in pairs, while Staphylococcus aureus appears as gram-positive, blue grape-like clusters.

In API 20E system, Escherichia coli colonies give negative results in Arginine Dihydrolase (ADH), Citrate utilization (CIT), H2S production, urease production (URE), Tryptophane deaminase (TDA), Voges Proskauer (VP), Gelatin liquefation (GEL). Isolates were given positive results in Indole production (IND), B-lactamase test (ONPG), lysine decarboxylase (LDC), ornithine Decarboxylase (ODC), H2S production, urease production (URE), Indole production (IND), Tryptophane Deaminase (TDA), Voges-Proskauer (VP), Mannitol, inositol, Sorbitol, Rhamnose,sucrose, Melibiose, Amygdalin, Glucose Fermentation. Klebsiella also results were in agreement with those mentioned by Warren et al. 2000. Staphylococcus aureus were given positive results for coagulase and catalase enzymes.

3.2 Antibiotic Susceptibility Test

Results of Antibiotic susceptibility test for pathogenic bacteria isolated from UTI and wound infections reveals that Escherichia coli isolates were 100% sensitive to gentamycine, tetracycline, streptomycin, also 50% of them were sensitive to imipenem and trimethoprim as shown in the Table 1. Results also reveal that 100% of isolates were resistant to ampicillin, Aztreonam, and nitrofurantoin.

Results of Antibiotic susceptibility test for Pseudomonas aeruginosaa isolates reveals that 100% of them were sensitive to gentamycine, Imipenem, ampicillin and streptomycin. Results also reveal that 100% of isolates were resistant tetracycline, nitrofurantoin, Aztreonam, and Trimethoprim as shown in the Table 1.

Results of Antibiotic susceptibility test for staph aureus isolates reveals that 100% of them were sensitive to gentamycine, tetracycline and streptomycin also 50% of them were sensitive tolmpinem, and nitofurantion. Results also reveal that 100% of isolates were resistant to ampicillin, Trimethoprime and Aztreonam.

Results of Antibiotic susceptibility test for Klebsiella pneumoniae isolates reveals that 100% of them were sensitive to nitofurantion and Imipenem also 50% of them were sensitive to ampicillin, Aztreonam, and streptomycin. Results also reveal that 100% of isolates were resistant to Trimethoprime, Gentamycine, and tetracycline.

In another survey, a total of 17 Escherichia coli isolates were collected from urine specimens of patients with urinary tract infection. Antibiotics sensitivity test indicated that amikacin followed by chloramphenicol and ciprofloxacin are the most effective antibiotics [6].

The susceptibility studies showed 37% E. coli strains isolated from urine samples were resistant to amoxycillin+clavulanate, 33% to
cotrimoxazole and 22% to ciprofloxacin. 30% strains were resistant to cefuroxime but only (1%) to fosfomycin. Also, 13% of Staphylococcus aureus isolated from urine samples, were methicillin-resistant [7]. Other studies have shown higher resistance to ampicillin (86%) for staph spp isolated from UTI infections [8].

In addition to this intrinsic resistance, P. aeruginosa easily develops acquired resistance either by a mutation in chromosomally-encoded genes or by the horizontal gene transfer of antibiotic resistance determinants [13].

3.3 Study the Antibacterial Activity of Gingerroots Water Extract against Pathogenic Bacteria Isolated from UTI and Wound Infection

Detection antibacterial activity of ginger roots water extract against different pathogenic bacteria isolated from patients with UTI and wound infection was done by using well diffusion methods and different concentration of ginger water extract (250,500) mg/ml was used. Results reveals that ginger roots water extract at different concentrations have strong antibacterial activity against pathogenic bacteria (Staphylococcus aureus, E. coli and Klebsiella pneumoniae) isolated from UTI and wound infections in which the diameter of zone of inhibition was increased respectively with the increased concentration of ginger water extract that ranged from (12-26) mm for Klebsiella pneumoniae as shown in Plate 2 and from (14-25) mm for Staphylococcus aureus and from (15-19) mm for E. coli. While the ginger water extract at two concentrations (250,500)mg/ml have no antibacterial activity against pseudomonas isolates. Also, PBS has no antibacterial activity against all isolates as shown in the Table 2.

Table 1. Antimicrobial susceptibility test for E. coli, Klebsiella pneumoniae, Pseudomonas aeruginosa and Staph aureus isolates

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>CN 10 mg/ml</th>
<th>TE 10 mg/ml</th>
<th>F 100 mg/ml</th>
<th>IPM 10 mg/ml</th>
<th>ATM 30 mg/ml</th>
<th>TMP 10 mg/ml</th>
<th>AM 25 mg/ml</th>
<th>S 25 mg/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>I</td>
<td>S</td>
<td>R</td>
<td>I</td>
<td>R</td>
<td>R</td>
<td>I</td>
<td>S</td>
</tr>
<tr>
<td>E2</td>
<td>S</td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>PS1</td>
<td>I</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>I</td>
</tr>
<tr>
<td>PS2</td>
<td>S</td>
<td>S</td>
<td>I</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>SA1</td>
<td>I</td>
<td>S</td>
<td>I</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>SA2</td>
<td>S</td>
<td>I</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>K1</td>
<td>R</td>
<td>R</td>
<td>I</td>
<td>S</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>K2</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>I</td>
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<td>I</td>
<td>I</td>
</tr>
</tbody>
</table>

NO. number; PS. Pseudomonas; SA. Staph aureus; E. Escherichia coli, S. sensitive, R. resistant, I. intermediate
Table 2. Antimicrobial activity of ginger roots on the growth of *E. coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* isolates

<table>
<thead>
<tr>
<th>Bacteria Spp</th>
<th>Conc. of ginger roots water extract</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>250 Mg/ml</td>
</tr>
<tr>
<td>St1</td>
<td>14</td>
</tr>
<tr>
<td>St2</td>
<td>15</td>
</tr>
<tr>
<td>K1</td>
<td>23</td>
</tr>
<tr>
<td>K2</td>
<td>12</td>
</tr>
<tr>
<td>E1</td>
<td>15</td>
</tr>
<tr>
<td>E2</td>
<td>16</td>
</tr>
<tr>
<td>PS1</td>
<td>0</td>
</tr>
<tr>
<td>PS2</td>
<td>0</td>
</tr>
</tbody>
</table>

St: Staph aureus, K: Klebsiella pneumoniae, E1: Escherichia coli, PS: Pseudomonas aeruginosa

Plate 2. Antimicrobial activity of ginger water extract against *Klebsiella pneumoniae*

In a study ginger was extracted at boiling temperature, then the antibacterial activity of the extract was detected against many pathogenic bacteria isolated from clinical cases. Results indicate the thermostable antibacterial property of ginger extracts protect the antimicrobial activity of ginger at high temperature and as a result, good antimicrobial activity was found against *Klebsiella pneumoniae*, *Escherichia coli* [14]. Synergistic antimicrobial effect of soybean and ginger at boiling temperature against foodborne pathogens indicates the thermostable antibacterial property of ginger extracts [15].

Also, the synergistic effect of water extract of ginger and garlic against pathogenic spp revealed that antimicrobial activity of the water extract of ginger and garlic was strong against a broad range of bacteria including *Bacillus spp.*, *Staphylococcus aureus*, *Escherichia coli*, and *Salmonella spp*. The diameter of the zone of inhibition varied ranging from (18-20) mm for ginger extract as compared to (23.33±3.51 mm) for gentamicin [16]. The minimum inhibitory concentration (MIC) of ginger extracts on *Klebsiella pneumoniae*, *Escherichia coli* ranged from 0.1-0.2 gm showing that ginger was more effective and produced marked inhibitory effect on the two test organisms compared to the onion extracts [17]. Ginger has the capacity to eliminate harmful bacteria, such as *Escherichia coli*, responsible for most of the diarrhoea, especially in children, Gingerols have analgesic, sedative, antipyretic, antibacterial and gastrointestinal tract motility effects [3].

**4. CONCLUSION**

In conclusion, this study has shown that ginger extracts possess medicinal properties, antibacterial activity and that the inhibition of bacterial growth was dose dependent. The results of the present study show that ginger extracts are more effective against all tested bacterial strains. The results of present study have provided the justification for therapeutic potential of ginger and also used as dietary supplement for food preservation.

**CONSENT**

As per international standard or university standard written participant consent has been collected and preserved by the authors.

**ETHICAL APPROVAL**

As per international standard or university standard written ethical permission has been collected and preserved by the author(s).

**COMPETING INTERESTS**

Authors have declared that no competing interests exist.
REFERENCES


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