**In vitro Assessment of Antibacterial Activity of *Citrus aurantifolia* Extracts**

Mohammed, A. H., Na’inna, S. Z., Yusha’u, M., Salisu, B., Adamu, U. and Garba, S. A.

1Department of Biology, Science and Technical College, P.M.B. 008, Hadejia
2Department of Biological Sciences, Federal University, Kashere, P.M.B. 0183, Gombe state
3Department of Microbiology, Bayero University, P.M.B. 3011, Kano
4Department of Microbiology, Umaru Musa Yar’adua University, Katsina
5Medical Laboratory Department, Hadejia General Hospital, Jigawa State
6Chemistry Department, Sule Lamido University, Kafin Hausa

*Correspondence author email: khsabdul@gmail.com, khsabdul@yahoo.com*

**Abstract**

Leaf extracts of *Citrus aurantifolia*, was investigated for antibacterial activity against *Salmonella typhi*, *Salmonella Paratyphi A* and *Salmonella Paratyphi B* using agar-well diffusion and gradient serial dilution methods. Phytochemical screening was conducted in order to detect secondary metabolites. The in vitro antibacterial activity of the extracts showed antibacterial activity against *S. typhi* and *S. Paratyphi B*. Watersoluble leaf extracts demonstrates higher zone of inhibition (19mm) against *S. Paratyphi A*. *S. Typhi* was found resistant to both water and chloroform soluble leaf extracts but sensitive to ethanolic leaf extracts at 50µmlconcentration. Both *S. Paratyphi A* and *S. Paratyphi B* were found resistant to ethanolic leaf extract. The occurrence of alkaloids, flavonoids, tannins, saponins, steroids, terpenoids and phenols in the aqueous leaf extracts of *C. aurantifolia* justifies its use in the folklore medicine.

**Keywords:** Antibacterial activity, *Salmonella typhi*, *Salmonella Paratyphi A*, *Salmonella Paratyphi B*, Resistance, Susceptibility, *Citrus aurantifolia*.

**INTRODUCTION**

*C. aurantifolia* alleviates anxiety and nervousness, relieves stress related disorders such as insomnia or nervous originated digestive disorders, also possesses anti-inflammatory potential, has antispasmodic virtues that are being experienced during spasm of the digestive system (distension, diarrhoea), has an anticoagulant property, which renders it very valuable for people with cardiovascular risks. It is also used against fever, headaches and cold (Chellaiah et al., 2006).

*Citrus aurantifolia* belongs to the family Rutaceae (orange family) (Bakare et al., 2012). *Citrus aurantifolia* is a Perennial Tree, with evergreen leaves, thorny stem, whitish flowers, globase fruits with many seeds, green when unripe and greenish-yellow when ripe, with sour taste (Ikeyi and Omeh, 2014). *Citrus* plants are medicinal due to the high level of flavonoid content. Flavonoids are of particular importance in the human diet as there is evidence that they act as free radical scavengers, antioxidants, diuretic, antiviral, antibacterial, antimicrobial, anti-inflammatory, anti-tumor and anti-platelets agents (Njoku and Obi, 2009; Sofowora, 1993).

Juice extract of *C. aurantifolia* is mixed with honey for catarrh, cough and respiratory problems, stomach aches, flatulence, nausea and anemia(Ikeyi and Omeh, 2014). *C. aurantifolia* contains alkaloids, vitamin C, flavonoids, tannins, phenols, saponins, niacin, carotenoids as well as P, K, Mg, Na, and C which were reported to possess antimicrobial properties (Ikeyi and Omeh, 2014).

*C. aurantifolia* is used in the folklore medicine as an antiseptic, anthelmintic, mosquito bite repellent, for stomach ailments, tonic, antiscorbutic, astringent, diuretic, headache, arthritis, digestive and appetite stimulant, and for colds, coughs and sore throats (Morton, 1987; Aliyu, 2006).
This study was aimed to determine antibacterial activity of C. aurantifolia leaf extracts.

MATERIALS AND METHODS
Sample Collection and Handling
The leaves of C. aurantifolia were collected from staff quarters in Bayero University, Old campus, Kano, Nigeria. The identity of the study plant was confirmed by a Botanist at the Department of Plant Science, Bayero University, Kano. Voucher specimen numbered; BUKHAN 0113 was deposited in the departmental herbarium. The leaves were air-dried under shade for 3 weeks. The air dried leaves were pulverized into fine powder using mortar and pestle (Aliyu, 2006).

Extraction
Fifty grammes (50g) of C. aurantifolia dried leaves powder was weighed using electric weighing balance and put in a conical flask (500ml). Two hundred and fifty ml of ethanol was added and allowed to percolate for one week, with regular shaking. Similar method was employed to extract the leaf using chloroform (250ml) and water (500ml). The extracts were filtered using Whatman No. 1 filter paper. The filtrates were concentrated by complete evaporation of solvent in a water bath at 100°C. The crude extracts of the C. aurantifolia leaf were stored appropriately until used (Fatope et al., 1993).

Physical properties of C. aurantifolia leaf extracts
Physical properties observed in the case of this study were colour, odour and texture as well as percentage yields of the water, ethanolic and chloroform extracts of the C. aurantifolia.

Phytochemical Screening
Test for Flavonoids
To 4 mg/ml of each of the fractions, a piece of magnesium ribbon was added this was followed by drop wise addition of concentrated HCl. A colour change ranging from orange to red indicated flavones while red to crimson indicated flavonoids (Sofowora, 1993).

Test for Tannins
Two milliliters of each of the extract was diluted with distilled water in separate test tube and 2 to 3 drops of 5% ferric chloride (FeCl₃) solution was added to it. A green – black or blue colouration indicated the presence of tannins (Ciulci, 1994).

Test for Steroids
Two milliliters of the extracts were evaporated to dryness in separate test tubes and the residues dissolved in acetic anhydride followed by addition of chloroform. Concentrated sulphuric acid was added by means of a pipette via the side of the test tubes. Formation of brown ring at the interface of the two liquids and violet colour in the supernatant layer denoted the presence of steroids (Ciulci, 1994).

Test for Cardiac Glycosides
Ten millilitre (10mL) of 50% H₂SO₄ was added to each 1ml of the C. aurantifolia leaf extracts (for both water, ethanol and chloroform fractions) in separate test tubes and the mixture heated for 15 minutes followed by addition of 10ml of Fehling’s solution and boiled. A brick red precipitate indicated the presence of Glycosides (Sofowara, 1993).

Test for Alkaloids
Samples aliquots of extract (0.1ml) were added in test tubes and then 2 to 3 drops of Dragendorff’s reagent were added. An orange red precipitate indicated the presence of alkaloids (Ciulci, 1994).

Test for Saponins
5ml of distill water was added to 2ml of the extract and shaken vigorously. Formation of foam following shaking indicates the presence of saponins (Sofowara, 1993).

Test for Terpenoids
To 0.5g of the plant extracts 2ml of chloroform was added followed by additional 3 ml of concentrated sulphuric acid resulting in the formation of two layers. A reddish brown colouration at the interface indicated the presence of terpenoids (Ayoola et al., 2008).
Test for Phenols
A millilitre of each plant extract filtrate was shaken in 10 ml of distilled water for 30 seconds. Persistent frothing indicated the presence of saponins (Sowofora, 1993).

BIOASSAY
Test isolates
Isolates comprising Salmonella typhi, Salmonella paratyphi A, and Salmonella paratyphi B, were collected from Department of Microbiology, Aminu Kano Teaching Hospital, Kano, Nigeria. The test bacterial isolates were characterized by observing their cultural growth characteristics and various biochemical tests for identification of catalase, oxidase, indole, motility, citrate utilization, urease production, hydrogen sulfide production as well as acid and gas production, according to standard procedures (Cheesbrough, 2006).

Standardization of inocula
Each of the test bacteria were cultured onto Mueller Hilton agar plates and incubated for 18 – 24 hours at 37°C to obtain colonies. After overnight incubation, 4 colonies were selected with a sterile disposable inoculating loop and transferred to a glass tube of sterile physiological saline and vortex thoroughly until the turbidity of the suspension matched the turbidity of the 0.5 McFarland standard containing about 1.5 × 10^8 CFU/mL (NCCLS, 2008).

Sensitivity Testing
Agar well diffusion method was used for the antibacterial susceptibility test. Using sterile swab stick, standardized inocula (1.5 × 10^8 cells/mL) of each isolate was swabbed onto the surface of Mueller Hinton Agar in separate Petri dishes. Wells of 6 mm diameter were made with cork borer. Into each well 0.15 mL of the plant extract was dispensed. The extracts were allowed to diffuse into the medium for 30 minutes at room temperature. This was then incubated at 37°C for 24 hours after which the zones of growth inhibition were measured and recorded in millimeter. Standard antibiotic was used as positive control while sterile distilled water was used as the negative control (Dahiru et al., 2008).

Determination of Minimum Inhibitory Concentration
MIC was determined by preparing various concentrations of the extracts by serial doubling dilution using Dimethyl Sulfoxide (DMSO) and incorporated into test tubes containing 2 ml nutrient broth. Specifically 0.1 ml of standardized inocula was added to each of the test tubes and incubated at 37°C for 24 hours observed for the least concentration without turbidity. Tube containing broth and extracts without inocula served as a positive control while tubes containing broth and inocula without extract served as negative control (Fatope et al., 1993).

Determination of Minimum Bactericidal Concentration
MBC was determined by inoculating samples from the MIC tubes that showed no bacterial growth on Mueller Hilton agar plates separately and then incubated at 37°C for 24 hours. After the incubation the plates were observed for presence or absence of growth. The least concentration of the extract that showed no bacterial growth was considered as the MBC (Fatope et al., 1993).

RESULTS AND DISCUSSION
The physical properties and percentage yield of the aqueous, ethanolic and chloroform extract of C. aurantifolia are shown in (Table 1). The highest percentage yield of the extract was observed in aqueous extract (9.96% w/w), chloroform extracts (6.18% w/w) and ethanolic extracts with (2.70% w/w). Table 2 shows the result of phytochemical screening, Alkaloids, tannins, flavonoids, and phenols are the main phytochemical constituents of C. aurantifolia. These phytochemicals have been reported for antimicrobial activity (Singh and Bhat 2003).
This finding corroborates the work of Ikeyi and Omeh, (2014) who reported that *C. aurantifolia* contains a lot of phytochemical constituents including alkaloids, flavonoids, tannins, phenols which were reported to possess antimicrobial properties. The metabolism and pharmacokinetics of flavonoids has been an area of active research in the last decade (Crozier et al., 2006). Harborne and Williams (2000) revealed that Terpenoids are attributed for analgesic and anti-inflammatory activities and flavonoids have been reported to possess many useful properties, including anti-inflammatory, estrogenic, enzyme inhibition, antimicrobial, antiallergic, antioxidant, vascular and cytotoxic anti tumour activity. Pritesh and Žara (2015) reported that although alkaloids sometimes help in important cure, they have pain killing and poisonous effect.

Table 3 shows antibacterial activity of *C. aurantifolia*. The aqueous extract produces highest zone of inhibition of (19mm) against *S. paratyphi A*, followed by chloroform extract with zone of inhibition of 13mm against the same bacteria. *S. typhi* was resistant to both aqueous and chloroform extract of *C. aurantifolia* while been sensitive to ethanolic extract of *C. aurantifolia* even at lowest concentration. Both *S. paratyphi A* and *S. paratyphi B* showed resistance to ethanolic extracts of *C. aurantifolia*.

Odunbaku *et al.* (2012) reported that *Citrus aurantifolia* and *Mangifera indica* plant extracts have considerable inhibitory effects on *Staphylococcus albus*, *Pseudomonas aeruginosa*, *Aspergillus terreus*, *Aspergillus niger* and *Penicillium oxalicum*.

Table 4 shows that water extracts of *C. aurantifolia* had MIC of (12.5µg/ml - 25µg/ml), ethanolic extracts had (12.5µg/ml - 50µg/ml) while chloroform extracts had MIC range of (25µg/ml - 100µg/ml). Both the extracts had MBC range of (25µg/ml - 100µg/ml). While the standard antibiotic (amoxicillin) had MIC and MBC ranges of (6.25µg/m-12.5µg/m) and (12.5µg/m-25µg/m) respectively.

### Table 1: Some Physical Properties of *C. aurantifolia* Extracts

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Color</th>
<th>Odor</th>
<th>Texture</th>
<th>WSU (g)</th>
<th>Amount Recovered (g)</th>
<th>% Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroform</td>
<td>Dark green</td>
<td>Lemony</td>
<td>Thick and Oily</td>
<td>50</td>
<td>3.09</td>
<td>6.18</td>
</tr>
<tr>
<td>Ethanol</td>
<td>Yellowish Green</td>
<td>Fragrant</td>
<td>Slightly slimy</td>
<td>50</td>
<td>1.35</td>
<td>2.70</td>
</tr>
<tr>
<td>Aqueous</td>
<td>Reddish Brown</td>
<td>Pungent</td>
<td>Gummy</td>
<td>50</td>
<td>4.98</td>
<td>9.96</td>
</tr>
</tbody>
</table>

Key: WSU = Weight of Sample Used

### Table 2: Phytochemical composition of *C. aurantifolia* Extracts

<table>
<thead>
<tr>
<th>Extracts</th>
<th>Alk</th>
<th>Sap</th>
<th>Tan</th>
<th>Flavonoids</th>
<th>Steroids</th>
<th>Glycosides</th>
<th>Terpenoids</th>
<th>Phenols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aqueous</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Ethanolic</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Chloroform</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

Key: += present, -= absent, Alk = alkaloids, Sap = saponins, tan = tannins

### Table 3: Antibacterial Activity of *C. aurantifolia* Extracts

<table>
<thead>
<tr>
<th>Test Organisms</th>
<th>AE (µg/ml)</th>
<th>EE (µg/ml)</th>
<th>CE (µg/ml)</th>
<th>Amx (µg/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zone of Inhibition Diametre (mm)</td>
<td>50</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td><em>S. typhi</em></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>S. par. A</em></td>
<td>8</td>
<td>9</td>
<td>11</td>
<td>19</td>
</tr>
<tr>
<td><em>S. par. B</em></td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

Key: AE = Aqueous Extract, EE = Ethanolic Extract, CE = Chloroform Extract, Amx = Amoxicillin

### Table 4: MIC and MBC of *C. aurantifolia* Against the Test Bacteria

<table>
<thead>
<tr>
<th>S/N</th>
<th>Test Organisms</th>
<th>Aqueous Extract</th>
<th>Ethanolic Extract</th>
<th>Chloroform Extract</th>
<th>Amoxicillin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIC</td>
<td>MBC</td>
<td>MIC</td>
<td>MBC</td>
<td>MIC</td>
</tr>
</tbody>
</table>

UMYU Journal of Microbiology Research
CONCLUSION
From the result of this research it can be concluded that C. aurantifolia presents potential of producing new drugs for the treatment of typhoid fever. Further research should be carried out on this plant to determine its safety for consumption.

REFERENCES

<table>
<thead>
<tr>
<th>Key: MIC= Minimum Inhibitory Concentration, MBC= Minimum Bactericidal Concentration</th>
<th>µg/ml</th>
<th>µg/ml</th>
<th>µg/ml</th>
<th>µg/ml</th>
<th>µg/ml</th>
<th>µg/ml</th>
<th>µg/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 S. typhi</td>
<td>25</td>
<td>50</td>
<td>50</td>
<td>100</td>
<td>50</td>
<td>100</td>
<td>12.5</td>
</tr>
<tr>
<td>2 S. paratyphi A</td>
<td>12.5</td>
<td>50</td>
<td>12.5</td>
<td>25</td>
<td>50</td>
<td>100</td>
<td>6.25</td>
</tr>
<tr>
<td>3 S. paratyphi B</td>
<td>25</td>
<td>50</td>
<td>12.5</td>
<td>25</td>
<td>25</td>
<td>50</td>
<td>6.25</td>
</tr>
</tbody>
</table>
