Abstract

In search for alternative ways to control microbial infections, plant essential oils from clove, fenugreek, garlic, neem, eucalyptus and lemongrass were extracted using Soxhlet apparatus and petroleum ether as a solvent. Phytochemical screening of the oils/extracts revealed the presence of alkaloids, flavonoids, saponins, reducing sugars, steroids, tannins, glycosides and triterpenoids. The oils/extracts were then evaluated for their in vitro antimicrobial properties against Klebsiella pneumoniae, Escherichia coli, Pseudomonas aeruginosa, Proteus vulgaris, Staphylococcus aureus and Candida albicans of Urinary Tract Infection and meat (suya) origins using disc diffusion and broth dilution techniques. Essential oil from clove was found to have the strongest inhibitory effect being able to inhibit growth of all assayed organisms followed by lemongrass extract, garlic oil, eucalyptus extract and neem oil while essential oil from fenugreek showed no inhibitory effect against all organisms tested. Highest and lowest susceptibility to these oils/extracts was demonstrated by S. aureus (mean zone= 11.7mm) and E. coli (mean zone= 5.8mm) respectively. Organisms isolated from urine showed more resistance than those isolated from meat. The LC$_{50}$ analysis of the oils/extracts showed relatively high cytotoxic effects against brine shrimps, (<100 ppm). Maximum mortalities took place at a concentration of 1000 ppm whereas least mortalities were at 10 ppm concentration, which means that lethality of the oils/extracts was concentration-dependant.

Key words: Antimicrobial activity, essential oils, UTI, Roasted meat

INTRODUCTION

Essential oils (also called volatile or ethereal oils, because they evaporate when exposed to heat in contrast to fixed oils) are odorous and volatile compounds found only in 10% of the plant kingdom. They are stored in plants in special brittle secretory structures, such as glands, secretory hairs, secretory ducts, secretory cavities or resin ducts (Ahmadi et al., 2002). They can be obtained from plant materials (flowers, buds, seeds, leaves, twigs, bark, herbs, wood, fruits and roots) by expression, fermentation or extraction (Prabuseenivasan et al., 2006). Many investigators have demonstrated the antimicrobial activity of the constituents of some higher plants (Hablemariam et al., 1993) and quite a number of chemical compounds of plant origin have been shown to possess antimicrobial activities (Corthout et al., 1992).

The use of essential oils as functional ingredients in foods, drinks, toiletries, and cosmetics is gaining momentum, both for the growing consumers’ interest in the ingredients coming from natural sources, and also because of the increasing concern with harmful synthetic additives (Sacchetti et al., 2005). Due to their bioactive components, essential oils are indeed promising in view of their use as effective antibacterial, antifungal, and anti-oxidant agents.

Urinary tract infections are among the most prevailing infectious diseases with a substantial financial burden on society. Urinary Tract Infections represent at least 40% of all hospital acquired infections and are, in the majority of cases, catheter associated (Ruden et al., 1997).
Meat is a flesh of animals which serves as food. It is obtained from sheep, cattle, goat and swine (Haman, 1977). Meat plays an important role in human diet by contributing both macro and micro nutrients that are required for growth and good health maintenance. The rate of increase in per capita consumption of meat was found to be very high in developed countries when compared with developing nations (Anjaneyulu et al., 2007). Due to its chemical compositions and characteristics, meat is a highly perishable food. This provides an excellent medium for growth of many microorganisms that can cause infection in man and also lead to meat spoilage and economic loss (Hassan et al., 2014). Microorganisms that have been incriminated in food borne illness resulting from consumption of meat and meat products include; S. aureus, Salmonella spp, Listeria monocytogenes, Yersinia enterocolitica, Bacillus cereus, E. coli, Clostridium perfringens as well as yeast and moulds (Saide-Alboronz et al., 1995).

The aim of this study was to evaluate the sensitivity profile of some bacterial strains isolated from urinary tract infections and from meat (suya) to some plant essential oils/extracts with emphasis for their possible future use as alternative strategies to control infectious microorganisms.

MATERIALS AND METHODS
Ethical approval
Ethical approval was obtained from Ethical and Research Committee of Aminu Kano Teaching Hospital (AKTH), Kano.

Sample Collection
Plants, urine and meat samples were collected and used for the study.

Plant collection and identification
Clove (Botanical name: Syzygium aromaticum, Hausa name: Kanumfari), Eucalyptus (Botanical name: Eucalyptus camaldulensis, Hausa name: Turare), Fenugreek (Botanical name: Trigonella foenum-graecum, Hausa name: Hulba), Garlic (Botanical name: Allium sativum, Hausa name: Tafarnuwa), Lemongrass (Botanical name: Cymbopogon citratus, Hausa name: Tsabrenkamshi) and Neem (Botanical name: Azadirachta indica, Hausa name: Darbejiya) plant parts were collected, Identified by a taxonomist at the Department of plant Biology, Bayero University, Kano and voucher specimen numbers were provided as Accession Numbers (BUKHAN 0342, BUKHAN 0347, BUKHAN 0384, BUKHAN 0297, BUKHAN 0234, and BUKHAN 0312), from their herbarium. Samples were dried at room temperature and ground into fine powder using mortar and pestle (Mukhtar and Tukur, 1999).

Urine collection
Urine samples (freshly collected clean-catch specimen) were collected from Aminu Kano Teaching Hospital hospitalized (Intensive Care Unit (ICU) patients. Two skewers of suya meat were obtained randomly from three different suya spots in Gandu, Kano metropolis. The samples were immediately wrapped in sterile aluminum foil to prevent contamination and then transported to Microbiology laboratory of Department of Microbiology Bayero University, Kano for analysis.

Extraction of Plant Materials
The technique adopted by Adepoju et al. (2014) was followed with slight modifications. A 250-ml Soxhlet extractor apparatus and petroleum ether as solvent were used for this work. The quantity of the oil yield was determined gravimetrically as the ratio of the weight of the extracted oil to the weight of the plant powder sample used. The obtained oil was kept in a refrigerator before use.

Phytochemical screening of essential oils
The extracts obtained were subjected to some phytochemical screening assays in order to detect the presence of the Alkaloids, Flavonoids, Saponins, , Reducing Sugars, Steroids and Tannins (Harbone, 1984, Sofowora,1984, Ciulci, 1994, Brain and Turner, 1975;).

Urine culture
Urine was mixed by rotating the container. Using a sterile wire loop,
a loopful of urine was inoculated on a plate of cystine lactose electrolyte-deficient (CLED) agar and incubated aerobically at 37°C overnight (Cheesbrough, 2006).

**Meat sample culture for bacteria and yeast**

Meat sample (suya) was removed from the skewers, and mashed in a sterile laboratory mortar and pestle. One gram (1g) of the mashed suya meat was weighed and then aseptically introduced into 9ml of sterile distilled water, properly shaken and a tenfold serial dilution was performed. Loopful of the samples were inoculated aseptically using streak technique on Nutrient agar, MacConkey agar and Mannitol salt agar plates and incubated at 37°C for 24 hours (Hassan et al., 2014). The colonies formed were counted to obtain total viable, coliform and staphylococcal counts.

Inoculation was also done on Potato Dextrose Agar for the isolations of fungi (yeast). Isolated colonies were purified (by subculturing) to obtain pure cultures which were subsequently identified using standard methods (Buchanan and Gibbons, 1974).

**Identification of isolates**

The isolated organisms were subjected to various biochemical tests viz: Catalase test, Coagulase test, Oxidase test, Urease test, Indole test, Methyl Red test, Voges-proskauer test, Citrate utilization test, Gram staining and Motility test (Cheesbrough, 2006, Fawole and Oso, 2007).

**Examining fungi in wet preparation**

A colony from fungal culture plate was emulsified in sterile distilled water on a slide to make a wet preparation. It was then covered with a cover slip and examined under ×10 and ×40 objectives. Sprouting yeast cell that was tube-like outgrowth from the cells indicated germ tube formation (Cheesbrough, 2006).

**Bioassay studies**

Bioassay was carried out in order to test the bioactivity or other wise of the essential oils on the test organisms.

**Disc preparation for plant essential oils**

Filter paper discs were punched from Whatman No. 1 filter paper and sterilized in separate bijou bottles (100 discs per bottle). The different concentration solutions used in the assay were 10 µl (1ml of essential oil), 7.5µl (0.75ml of essential oil and 0.25ml of DMSO), 5.0µl (0.5ml of essential oil and 0.5ml of DMSO) and 2.5µl (0.25ml of essential oil and 0.75ml of DMSO) with each disc capable of adsorbing 0.01 ml of the solution (Serban et al., 2011).

**Standardization of inoculum**

Using inoculation loop, enough material from an overnight culture of the test organism was transferred into a test tube containing normal saline until the turbidity of the suspension matched the turbidity of the 0.5 McFarland Standard as described by the National committee for clinical laboratory standard (NCCLS, 2008).

**Sensitivity testing by disc diffusion test**

Standardized inocula of the isolates were swabbed on to the surface of prepared and solidified Mueller Hinton agar and Sabrauld Dextrose Agar in duplicates for bacteria and fungi respectively. The prepared discs of the extracts and the standard antibiotic discs (Ciprofloxacin for bacteria and fluconazole for fungi) were placed onto the surface of the inoculated media at intervals by means of sterile syringe needle. The plates were incubated at 37°C for 24 h before observation and measurement of zones of inhibition (NCCLS, 2008).

**Determination of Lethal Concentration 50 (LC50)**

Artificial Sea Water- Sodium Chloride (38g) was dissolved in 100ml of distilled water and the pH adjusted to 8.5 using 1N NaOH (Ramachandran et al., 2010). This test was carried out according to procedure described by Krishnaraju et al. (2005) in Owokotuma et al. (2012).

Brine Shrimp Lethality Test (BSLT)

This test was carried out according to procedure described by Olowa and Nuneza, (2013).

Hatching- About 50 mg of Artemisia salina (Leach) eggs, (Interpet. Ltd. England) was added to about 150 mL solution of sea water in a beaker.
The mixture was allowed to incubate for 48 h in a warm well ventilated room (22-29°C) under a light source. Larvae (nauplii) were collected with a Pasteur pipette after they had been attracted by the light source.

**Preparation of samples’ test solutions**

Stock solution was prepared by emulsifying 20 mg of the essential oils/extracts separately in 0.3ml of dimethylsulphoxide (DMSO) and the volume was made up with 1.7ml of fresh sea water to equal 1000 ppm concentration. After this, serial dilution was done to obtain two additional Concentrations of 100ppm and 10 ppm.

**Stationing the Brine Shrimps**

Fresh sea water (3.0ml) was transferred into the specimens’ vials prepared in triplicates. Then, 0.5ml of each prepared concentrations was introduced into the specimen vials followed by introduction of ten brine shrimps into each specimen vial including the control vial containing 10 nauplii in 5ml sea water. Finally, each specimen vial was topped up with sea water until it reached 5.0ml. All the vials containing the shrimps were left opened for 24 hours. Using probit analysis, the lethality concentration (Lc50) was assessed at 95% confidence intervals. Lc50 of less than 100 ppm was considered as potent (active) Gupta et al., 1996) as mentioned by Meyer et al., 1982. Lc50value of less than 1000 ppm is toxic while Lc50 value of greater than 1000 ppm is non-toxic (inactive). The percentage mortality (%M) was also calculated by dividing the number of dead nauplii by the total number and then multiplied by 100. This is to ensure that the death (mortality of the nauplii) is attributed to the bioactive compounds present in the plant oils/extracts.

**RESULTS**

**Physical properties of the plant essential oils**

The physical properties and percentage yields of the essential oils are shown in Table 1. Phytochemical screening for the bioactive components present in the essential oils revealed the presence of numerous secondary metabolites as presented in Table 2. The bacteria were characterized based on their reactions to the various biochemical tests and subsequently identified using Bergey’s Manual of Determinative Bacteriology (Buchanan and Gibbons, 1974) as shown in Table 3.

**Antimicrobial activity of plant essential oils against UTI and meat isolates**

The results of antimicrobial activity of the essential oils against UTI and meat isolates at concentrations of 10µl/disc, 7.5µl/disc, 5.0µl/disc and 2.5µl/disc are shown in Tables 4 and 5 respectively. Clove essential oil showed inhibitory activity against all the tested organisms. Neem essential oil showed a weak inhibitory activity against *P. vulgaris* and *P. aeruginosa* and garlic essential oil showed weak inhibitory activity against *P. aeruginosa* only at 100% concentration, while fenugreek oil showed no inhibitory activity against all tested organisms.

**Comparison of antimicrobial sensitivity pattern of organisms of UTI and meat origins**

Comparative statistical analysis of antimicrobial sensitivity pattern of organisms of UTI and meat origins was carried out using one-way ANOVA. Comparison of sensitivity pattern of individual species of organisms of UTI and meat origins is presented in the Table 6.

**Table 1: Physical properties of the oils/extracts**

<table>
<thead>
<tr>
<th>Plant</th>
<th>State</th>
<th>Colour</th>
<th>Odour</th>
<th>Quantity recovered(g)</th>
<th>% yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clove</td>
<td>Liquid</td>
<td>Yellowish</td>
<td>Warm Strong sp icy</td>
<td>19.24</td>
<td>16</td>
</tr>
<tr>
<td>Fenugreek</td>
<td>Liquid</td>
<td>Dark green</td>
<td>Maple/curry</td>
<td>18.9</td>
<td>15.7</td>
</tr>
<tr>
<td>Garlic</td>
<td>Liquid</td>
<td>Pale yellow</td>
<td>Pungent</td>
<td>12.4</td>
<td>10</td>
</tr>
<tr>
<td>Neem</td>
<td>Liquid</td>
<td>Golden yellow</td>
<td>Pungent</td>
<td>25.7</td>
<td>21</td>
</tr>
</tbody>
</table>
Table 2: Phytochemical constituents of some plant essential oils/extracts

<table>
<thead>
<tr>
<th>Plant</th>
<th>Alk</th>
<th>Flav</th>
<th>Sap</th>
<th>Reducing sugars</th>
<th>Steroids</th>
<th>Tannins</th>
<th>Glycosides</th>
<th>Triterpenoids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clove</td>
<td>_</td>
<td>+</td>
<td>+</td>
<td>_</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Fenugreek</td>
<td>+</td>
<td>_</td>
<td>+</td>
<td>_</td>
<td>+</td>
<td>_</td>
<td>+</td>
<td>_</td>
</tr>
<tr>
<td>Garlic</td>
<td>_</td>
<td>_</td>
<td>+</td>
<td>_</td>
<td>_</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Neem</td>
<td>_</td>
<td>_</td>
<td>+</td>
<td>_</td>
<td>+</td>
<td>_</td>
<td>_</td>
<td>_</td>
</tr>
</tbody>
</table>

+= Presence, _= Absence, Alk = alkaloids, Sap = saponins, Flav = flavonoids

Table 3. Biochemical characterization of bacteria associated with urinary tract of patients at AKTH Kano

<table>
<thead>
<tr>
<th>Gram</th>
<th>Cell morphology</th>
<th>Catalase</th>
<th>Coagulase</th>
<th>Oxidase</th>
<th>Indole</th>
<th>Motility</th>
<th>MR</th>
<th>VP</th>
<th>Urease</th>
<th>Citrate</th>
<th>Slope e</th>
<th>But</th>
<th>H₂S</th>
<th>Gas</th>
<th>Organism</th>
</tr>
</thead>
<tbody>
<tr>
<td>_</td>
<td>Rods</td>
<td>+</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>K. pneumoniae</td>
</tr>
<tr>
<td>_</td>
<td>Rods</td>
<td>+</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>E. coli</td>
</tr>
<tr>
<td>_</td>
<td>Rods</td>
<td>+</td>
<td>_</td>
<td>_</td>
<td>_</td>
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<td>_</td>
<td>_</td>
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<td>_</td>
<td>_</td>
<td>_</td>
<td>P. aeruginosa</td>
</tr>
<tr>
<td>_</td>
<td>Coci</td>
<td>+</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>R</td>
<td>Y</td>
<td>_</td>
<td>_</td>
<td>_</td>
<td>S. aureus</td>
</tr>
</tbody>
</table>

Key: + = positive, Y= yellow, _ = negative, R= red

Table 4: Antimicrobial activity of plant essential oils against UTI pathogens

<table>
<thead>
<tr>
<th>Test organisms</th>
<th>Clove</th>
<th>Fenugreek</th>
<th>Garlic</th>
<th>Neem</th>
</tr>
</thead>
<tbody>
<tr>
<td>K. pneumoniae</td>
<td>12</td>
<td>11</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>E. coli</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>P. aeruginosa</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>P. vulgaris</td>
<td>11</td>
<td>9</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>S. aureus</td>
<td>13</td>
<td>13</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>C. albicans</td>
<td>22</td>
<td>20</td>
<td>15</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 5: Antimicrobial activity of some plant essential oils against roasted meat isolates

<table>
<thead>
<tr>
<th>Test organisms</th>
<th>Clove</th>
<th>Fenugreek</th>
<th>Garlic</th>
<th>Neem</th>
</tr>
</thead>
<tbody>
<tr>
<td>K. pneumoniae</td>
<td>15</td>
<td>14</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>E. coli</td>
<td>15</td>
<td>14</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>P. aeruginosa</td>
<td>15</td>
<td>13</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>P. vulgaris</td>
<td>15</td>
<td>14</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>S. aureus</td>
<td>18</td>
<td>16</td>
<td>15</td>
<td>13</td>
</tr>
</tbody>
</table>
Table 6: Comparison of Antimicrobial Sensitivity Pattern of Organisms of UTI and Meat Origins

<table>
<thead>
<tr>
<th>Organisms isolated from UTIs</th>
<th>Organisms isolated from meat</th>
<th>P value</th>
<th>Mean variation</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>K. pneumoniae</em></td>
<td><em>K. pneumoniae</em></td>
<td>&lt; 0.0001</td>
<td>Extremely significant</td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td><em>E. coli</em></td>
<td>0.0334</td>
<td>Significant</td>
</tr>
<tr>
<td><em>P. aeruginosa</em></td>
<td><em>P. aeruginosa</em></td>
<td>0.0005</td>
<td>Extremely significant</td>
</tr>
<tr>
<td><em>P. vulgaris</em></td>
<td><em>P. vulgaris</em></td>
<td>0.0043</td>
<td>Very significant</td>
</tr>
<tr>
<td><em>S. aureus</em></td>
<td><em>S. aureus</em></td>
<td>&lt; 0.0001</td>
<td>Extremely significant</td>
</tr>
</tbody>
</table>

Brine Shrimp Lethality Test (BSLT)
Statistical analysis of Toxicity test (LC$_{50}$) of plant essential oils using brine shrimps has shown that, the oils presented relatively low LC$_{50}$ values. Clove oil had the lowest LC$_{50}$ value of 60.203 followed by neem oil with LC$_{50}$ value of 60.203 and garlic oil with LC$_{50}$ value of 80.493.

DISCUSSION
Yields of the essential oils was highest in neem (21%) followed by clove (16%) and fenugreek (15.7%) while garlic oil had the least yield of 10%. Low oil yield from garlic bulb could be due to the solvent used (petroleum ether) in the extraction process or less oil content of garlic bulbs. Gafar et al. (2012) reported high yield of 22.5% using n-Hexane as a solvent for extraction of garlic oil.

Phytochemical screening of the oils revealed the presence of alkaloids, flavonoids, saponins, reducing sugars, steroids, tannins, glycosides and triterpenoids. Many plants have been reported to synthesize secondary metabolites as part of their defence system (Phan et al., 2012).

*Klebsiella pneumoniae*, *E. coli*, *P. aeruginosa*, *P. vulgaris*, *S. aureus* and *C. albicans* were isolated from urine samples from hospitalized patients in intensive care units. This is in agreement with the work of Manikandan and Amsath (2016) where they isolated same organisms from UTI’s. These organisms are those usually implicated in nosocomial UTI and are, in the majority of cases, catheter associated (Richards et al., 1999).

*Klebsiella pneumoniae*, *E. coli*, *P. aeruginosa*, *P. vulgaris*, *S. aureus* and *C. albicans* were also isolated and identified from meat (suya) which is in line with the work of Yusuf et al. (2012) who also reported the presence of these organisms from meat products. The presence of *Enterobacteriaceae* in heat-processed foods indicates inadequate cooking or post-processing contamination (Food Safety Authority of Ireland, 2014). On the whole, the major sources of microbial contamination of suya meat appear to come from butchers and the use of contaminated water and equipment as reported by Hassan et al. (2014).

Among the essential oils tested against UTI and roasted meat pathogens, clove oil presented highest activity by inhibiting the growth of all assayed organisms at all tested concentrations while fenugreek oil showed no inhibitory activity at all. Oils of garlic and neem presented no inhibitory activity against UTI isolates but active against proteus and *S. aureus* from meat. Pathogens causing nosocomial infections have been reported to be resistant to most antimicrobial agents (Hsueh et al., 2002). This result is similar to that observed by Khan et al. (2009) where they reported that even multi drug resistant strains of bacteria and fungi were sensitive to clove but exhibited strong resistance to other extracts tested.

All organisms demonstrated strong sensitivity to control antibiotics with *P. vulgaris* and *E. coli* being less susceptible. The organisms’ sensitivity to clove essential oil could be due to higher number of phytochemicals detected in the oil as it was reported that phytochemicals vary in their antimicrobial potency (Bama et al., 2012).
The work of Barbosa et al. (2009) also showed that clove essential oil, among all tested oils presented highest antimicrobial activity against bacteria and fungi isolated from minced meat. Sensitivity test results of organisms isolated from meat to eucalyptus and lemongrass extracts showed that all tested organisms were sensitive to both extracts with lemongrass being more potent. This could be due to higher number of phytochemicals detected in lemongrass extract, tannin in particular was absent from eucalyptus, this phytochemical has been reported to possess antibacterial activity (Scalbert, 1999). This is in line with the work of Hamza et al. (2009) and Potdar et al. (2015) where they reported that extracts of lemongrass and eucalyptus had a broad spectrum of activity against both Gram positive and Gram negative bacteria and fungi. All tested organisms were highly sensitive to the control (Ciprofloxacin) with S. aureus being the most susceptible and E. coli the least susceptible.

Although same species of microorganisms were isolated from both urine and meat, a significant difference in their sensitivity patterns to the tested oils was observed using one-way ANOVA statistical analysis. This is in agreement with the work of Singh et al. (2011) where they reported that varying sensitivity patterns exist between microorganisms of the same species depending on the strains and origin of the organisms. Organisms isolated from urine showed high degree of resistance to the tested oils/ex except for clove essential oil which was active against all assayed organisms. In contrast, organisms isolated from meat showed high degree of sensitivity to most of the tested oils/extracts except for fenugreek oil which was inactive against all assayed organisms. This finding is in agreement with the results obtained from the work of Khan et al. (2009), which reported that microbial strains isolated from nosocomial infection were more resistant than community acquired ones. It was also reported earlier that the resistance to antibiotics as well as mortality is almost two times higher in case of nosocomial infections than in community-acquired infections (Kang et al., 2006).

Lethality assay results evaluated by brine shrimp lethality test. All oils tested showed relatively high cytotoxicity with LC50 values of 60.203, 80.493, and 64.801 for clove, garlic, and neem respectively. The cytotoxicity of these oils indicates their potentiality for containing bioactive compounds (having LC50 of <100) Meyer et al. (1982).

CONCLUSION
The plants contain essential oils which contain various phytochemical constituents, most were found to have inhibitory activity against isolates from UTIs and ready to eat meat (suya). The results from this study showed high toxicity of the oils.

RECOMMENDATIONS
More in vitro and in vivo tests are required to ascertain their pharmacological features and possible medicinal properties of essential oils of the neem, garlic and fenugreek plants with special consideration to their high toxicity.

REFERENCES


Food Safety Authority of Ireland (2014). Guidelines for the interpretation of results of microbiological testing of ready-to-eat foods placed on the market.


