Evaluation of Antifungal and Antibacterial Activity and Analysis of Bioactive Phytochemical Compounds of *Cinnamomum zeylanicum* (Cinnamon bark) using Gas Chromatography-Mass Spectrometry

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ABSTRACT

Phytochemicals are chemical compounds often referred to as secondary metabolites. Thirty nine bioactive phytochemical compounds were identified in the methanolic extract of Cinnamon bark. The identification of phytochemical compounds is based on the peak area, retention time molecular weight and molecular formula. GC-MS analysis of *Cinnamomum zeylanicum* revealed the existence of the 6-Oxa-bicyclo[3.1.0]hexan-3-one, Benzaldehyde, Cyclohexene, 4-isopropenyl-1-methoxymethoxymethyl, Benzoic acid- methyl ester, Benzaldehyde dimethyl acetal, Benzenepropanal, Benzylidenemalonaldehyde, 3-Phenylpropanol, Cinnamaldehyde, (E), 2-Propan-1-ol, 3-phenyl, 9-Methoxybicyclo[6.1.0]nona-2,4,6-triene, 1,3-Bis(cinnamoyloxymethyl) adamantane, Alfa-Copaene, Naphthalene, 2,3,3,5,6,7,8a-octahydro-1,8a-dimethyl-7-(1-methyl), Cis – 2-Methoxyxannumic acid, Bicyclo[3.1.1]hept-2-ene, 3-phenyl, 9-Octadecenamide, 17.alfa.-21ß-28,30-Bisnorhopane, 17.alfa.-21ß-28,30-Bisnorhopane, Androstane-3-one, cyclic 1,2-ethanediyl mercaptol, [5a], (4H)3a,5,6,7,8,8a-Hexahydrobenzopyran-5-one-3-carboxamide, 2,4H-Cyclopropa[5,6]benz[1,2,7,8]azulen-4-one-4,8,8a, (22S)-21-Acetoxy-6á,11ß-dihydroxy-16á,17á-propylmethylenediox, (+)-ã-Tocopherol, O-methyl and Stigmasterol.

*Cinnamomum zeylanicum* contain chemical constitutions which may be useful for various herbal formulation as anti-inflammatory, analgesic, antipyretic, cardiac tonic and antiasthamatic. *Cinnamomum zeylanicum* was highly active against *Aspergillus flavus* (6.16±0.42). Methanolic extract of bioactive compounds of *Cinnamomum zeylanicum* was assayed for in vitro antibacterial activity against *Pseudomonas aerogenosa*, *Escherichia coli*, *Proteus mirabilis*, *Staphylococcus aureus* and *Klebsiella pneumonia* by using the diffusion method in agar. The zone of inhibition were compared with different standard antibiotics. The diameters of inhibition zones ranged from 6.12±0.52 to 0.39±0.17 mm for all treatments.

**Keywords:** Antifungal, Antibacterial, *Cinnamomum zeylanicum*, Gas chromatography-mass spectrometry, Fourier-transform infrared spectroscopy.
INTRODUCTION

*Cinnamomum zeylanicum* Blume (Lauraceae), is called true cinnamon. Cinnamon is an evergreen of tropical area reaching about nine meters high and covered with a smooth, pale bark\(^1\). It is considered to be the native of Sri Lanka and Malabar Coast of India\(^2,3\). Cinnamon mainly contains essential oils and important compounds like cinnamaldehyde, eugenol, cinnamic acid and cinnamate. It has traditionally been used to treat toothache, fight bad breath and treatment common cold\(^6,9\). The bark of tree consists of volatile oil, possesses many medicinal properties like antibacterial, anti-oxidant, anti-ulcer, anti-diabetic\(^10-12\) and antifungal (Bruneton et al., 1998). Cinnamaldehyde is the most prevalent with concentration of 6,000 – 30,000 ppm\(^13,14\). The aims of this study were analysis of chemical compounds of *Cinnamomum Zeylanicum* (Cinnamon bark) and evaluation of antifungal and antibacterial activity.

MATERIALS AND METHODS

Collection and preparation of plant material

*Cinnamomum zeylanicum* (Cinnamon bark) were purchased from local market in Hilla city, middle of Iraq. After thorough cleaning and removal of foreign materials, the Cinnamon bark was stored in airtight container to avoid the effect of humidity and then stored at room temperature until further use\(^15-17\).

Preparation of sample

About eighteen grams of methanolic extract of *Cinnamomum zeylanicum* powdered were soaked in thirty three ml methanol for ten hours in a rotary shaker. Whatman No.1 filter paper was used to separate the extract of plant\(^18-22\). The filtrates were used for further phytochemical analysis. It was again filtered through sodium sulphate in order to remove the traces of moisture.

Gas chromatography – mass spectrum analysis

The GC-MS analysis of the plant extract was made in a (QP 2010 Plus SHIMADZU) instrument under computer control at 70 eV. About 1\(\mu\)L of the methanol extract was injected into the GC-MS using a micro syringe and the scanning was done for 45 minutes. As the compounds were separated, they eluted from the column and entered a detector which was capable of creating an electronic signal whenever a compound was detected\(^23\). The greater the concentration in the sample, bigger was the signal obtained which was then processed by a computer. The time from when the injection was made (Initial time) to when elution occurred referred to as the Retention time (RT)\(^24\). While the instrument was run, the computer generated a graph from the signal called Chromatogram. Each of the peaks in the chromatogram represented the signal created when a compound eluted from the Gas chromatography column into the detector. The X-axis showed the RT and the Y-axis measured the intensity of the signal to quantify the component in the sample injected. As individual compounds eluted from the Gas chromatographic column, they entered the electron ionization (mass spectroscopy) detector, where they were bombarded with a stream of electrons causing them to break apart into fragments. The fragments obtained were actually charged ions with a certain mass\(^25-27\). The M/Z (mass/charge) ratio obtained was calibrated from the graph obtained, which was called as the Mass spectrum graph which is the fingerprint of a molecule. Before analyzing the extract using Gas Chromatography and Mass Spectroscopy, the temperature of the oven, the flow rate of the gas used and the electron gun were programmed initially. The temperature of the oven was maintained at 100°C. Helium gas was used as a carrier as well as an eluent. The flow rate of helium was set to 1ml per minute. The electron gun of mass detector liberated electrons having energy of about 70eV. The column employed here for the separation of components was Elite 1 (100% dimethyl poly siloxane). The identity of the components in the extracts was assigned by the comparison of their retention indices and mass spectra fragmentation patterns with those stored on the computer library and also with published literatures. Compounds were identified by comparing their spectra to those of the Wiley and NIST/EPA/NIH mass spectral libraries\(^28\).

Determination of antibacterial activity of crude bioactive compounds of *Cinnamomum zeylanicum*

The test pathogens (*E. coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumonia* and *Staphylococcus aureus*) were swabbed in Muller
Table 1: Phytochemical compounds identified in methanolic extract of Cinnamomum zeylanicum

<table>
<thead>
<tr>
<th>S No.</th>
<th>Phytochemical compound</th>
<th>RT (min)</th>
<th>Formula</th>
<th>Molecular Weight</th>
<th>Exact Mass</th>
<th>Chemical structure</th>
<th>MS Fragment-ions</th>
<th>Pharmacological actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6-Oxa-bicyclo[3.1.0]hexan-3-one</td>
<td>3.419</td>
<td>C₆H₆O₂</td>
<td>98</td>
<td>98.0368</td>
<td><img src="image1.png" alt="Image" /></td>
<td>55,69,98</td>
<td>New chemical compound</td>
</tr>
<tr>
<td>2</td>
<td>Benzaldehyde</td>
<td>3.67</td>
<td>C₆H₅O</td>
<td>106</td>
<td>106.042</td>
<td><img src="image2.png" alt="Image" /></td>
<td>51,63,77,86,106</td>
<td>Anti-convulsant activity; anti-microbial, anti-diabetic, and antiobesity</td>
</tr>
<tr>
<td>3</td>
<td>Cyclohexene, 4-isopropenyl-1-methoxymethoxymethyl-</td>
<td>3.859</td>
<td>C₁₂H₂₀O₂</td>
<td>196</td>
<td>196.146</td>
<td><img src="image3.png" alt="Image" /></td>
<td>53.79,91,119,164,196</td>
<td>New chemical compound</td>
</tr>
<tr>
<td>4</td>
<td>Benzoic acid methyl ester</td>
<td>5.095</td>
<td>C₈H₈O₂</td>
<td>136</td>
<td>136.052</td>
<td><img src="image4.png" alt="Image" /></td>
<td>51,59,65,77,92,105,118,136</td>
<td>New chemical compound</td>
</tr>
<tr>
<td>5</td>
<td>Benzoic acid methyl ester</td>
<td>5.284</td>
<td>C₉H₁₂O₂</td>
<td>152</td>
<td>152.084</td>
<td><img src="image5.png" alt="Image" /></td>
<td>51,59,65,77,91,105,121,136,151</td>
<td>Anti-cancer activity</td>
</tr>
<tr>
<td>6</td>
<td>Benzenepropanal</td>
<td>5.942</td>
<td>C₉H₁₀O</td>
<td>134</td>
<td>134.073</td>
<td><img src="image6.png" alt="Image" /></td>
<td>51,65,78,91,105,115,134</td>
<td>Antimutagenic and anti-malarial</td>
</tr>
<tr>
<td>7</td>
<td>Benzylidenemalonaldehyde</td>
<td>6.715</td>
<td>C₁₀H₁₂O₂</td>
<td>160</td>
<td>160.052</td>
<td><img src="image7.png" alt="Image" /></td>
<td>51,63,77,91,103,115,131,159</td>
<td>Anti-inflammatory</td>
</tr>
<tr>
<td>8</td>
<td>3-Phenylpropanol</td>
<td>7.121</td>
<td>C₁₀H₁₆O</td>
<td>136</td>
<td>136.089</td>
<td><img src="image8.png" alt="Image" /></td>
<td>51,77,91,105,117,136</td>
<td>Antineoplastic and anti-inflammatory</td>
</tr>
<tr>
<td>No.</td>
<td>Molecule Description</td>
<td>Formula</td>
<td>Molecular Weight</td>
<td>PubChem IDs</td>
<td>Activity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------------------------------------------------------------</td>
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<td>----------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Cinnamaldehyde, (E)-</td>
<td>C_{8}H_{10}O</td>
<td>132</td>
<td>132.058</td>
<td>Anti-tyrosinase activity; anti-inflammatory and anti-termitic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>2-Propen-1-ol, 3-phenyl-</td>
<td>C_{8}H_{12}O</td>
<td>134</td>
<td>134.073</td>
<td>New chemical compound</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>9-Methoxybicyclo[6.1.0]hena – 2, 4,6-triene</td>
<td>C_{8}H_{12}O</td>
<td>148</td>
<td>148.089</td>
<td>New chemical compound</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>1,3-Bis(cinnamoyloxy)methyl)adamantine</td>
<td>C_{9}H_{16}O_{4}</td>
<td>456</td>
<td>456.23</td>
<td>New chemical compound</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Alfa.– Copaene</td>
<td>C_{12}H_{20}</td>
<td>204</td>
<td>204.188</td>
<td>New chemical compound</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Naphthalene , 1,2,3, 5,6,7,8,8a-octahydro-1, 8a-dimethyl-7-(1-methyl)</td>
<td>C_{14}H_{16}</td>
<td>204</td>
<td>204.188</td>
<td>New chemical compound</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Cis – 2-Methoxycinnamic acid</td>
<td>C_{10}H_{18}O_{3}</td>
<td>178</td>
<td>178.063</td>
<td>Anti-tyrosinase activities; anti-tyrosinase and anti-melanogenic activities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Bicyclo[3.1.1]hept-2-ene, 2,6- dimethyl-6-(4-methyl-3-pentenyl)</td>
<td>C_{13}H_{20}</td>
<td>204</td>
<td>204.188</td>
<td>New chemical compound</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
17 Trans-2-Hydroxy-9,701 C10H10O3 178 178.063
innamic acid, methyl ester

51, 65, 75, 91, 103, 118, 131, 146, 161, 178
Anti-inflammatory activity

18 γ-Murolene 10.497 C30H34 204 204.188
methyl ester

55, 79, 93, 105, 119, 133, 147, 161, 175, 189, 204
New chemical compound

20 β-Guaiene 10.771 C30H34 204 204.188

55, 67, 81, 91, 105, 119, 133, 161, 175, 189, 204
New chemical compound

21 Cadala-1(10),10.88 C15H22 202 202.172
3,8-triene

53, 65, 66, 91, 105, 115, 131, 142, 157, 183, 200
New chemical compound

22 Isolongifolene,4,5,11.069 C15H20 200 200.157
9,10-dehydro-

51, 91, 115, 128, 143, 157, 185
New chemical compound

23 Cubenol 11.841 C15H26O 222 222.198

59, 81, 93, 119, 161, 189, 204
Antifungal and anti-HIV

24 Tau-Muurolol 12.002 C15H26O 222 222.198

55, 79, 95, 121, 134, 161, 189, 204, 222
Anti-wood-decay fungal activity and moderate antimicrobial activity
25 1-Cadinol 12.139 C_{13}H_{26}O 222 222.198 79.95, 121, 137, 161, 204, 222 Anti-fungal and as hepatoprotective and cytotoxic activities

26 Spiro[tricyclo[4.4.0.0^{13}.48]decane-10.2oxirane], 1-methyl-4-isopropyl 15.484 C_{19}H_{26}O 252 252.173 55.81, 91, 105, 123, 145, 161, 173, 191, 205, 221, 234, 252 New chemical compound

27 6-Isopropenyl-4,8q-dimethyl-1,2,3,5,6,7,8, 8a-octahydronaphthalen 14.611 C_{15}H_{24}O 236 236.178 55.79, 91, 107, 149, 175, 218, 236 New chemical compound

28 Ethyl9,9-difomynona-2,4,6,8-tetraenaoate 14.857 C_{19}H_{30}O 234 234.089 51.65, 77, 103, 131, 160, 188, 205, 234 New chemical compound

29 Trans-13-Octadecenoic acid 16.968 C_{18}H_{34}O 282 282.256 55.69, 83, 123, 180, 222, 264, 282 Good anti-inflammatory activity

30 Tributyl acetylcitrate 17.952 C_{20}H_{34}O 402 402.225 ####### Anti-Feeding effect: Larvae

31 9,12,15-Octadecatrienoic acid, 2, 3-dihydroxypropyl ester, (z,z,z) 18.176 C_{21}H_{36}O 352 352.261 57.67, 79, 95, 109, 135, 155, 173, 232, 261, 291, 321, 352 New chemical compound

32 9-Octadecenamide 18.834 C_{19}H_{34}N 281 281.272 59.72, 83, 114, 184, 212, 264, 281 Anti-inflammatory activity and, antibacterial activity
<table>
<thead>
<tr>
<th>No.</th>
<th>Compound Description</th>
<th>Molecular Formula</th>
<th>Molecular Weight</th>
<th>Important Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>17.alfa.-218-28, 30-Bisnorhopane</td>
<td>C_{28}H_{48}O_{10}</td>
<td>520</td>
<td>81,95,109,149,163,177,191, Important for anti-MRSA activity</td>
</tr>
<tr>
<td>34</td>
<td>Androstan-3-one, cyclic 1,2-ethanediyl mercaptone, (5±)</td>
<td>C_{28}H_{48}O_{10}</td>
<td>520</td>
<td>55,67,81,95,132,189, New chemical compound</td>
</tr>
<tr>
<td>35</td>
<td>(4H)4a,5,6,7,8,8a-Hexahydrobenzopyran-5-one-3-carboxamide,2</td>
<td>C_{27}H_{36}O_{10}</td>
<td>488</td>
<td>53,69,83,109,124,149,193, New chemical compound</td>
</tr>
<tr>
<td>36</td>
<td>4H-Cyclopropa[5<code>,6</code>] benz[1<code>,2</code>,7,8]azuleno [5,6]oxiren-4-one,8,8a-</td>
<td>C_{27}H_{36}O_{10}</td>
<td>488</td>
<td>55,91,121,149,223,279,297, New chemical compound</td>
</tr>
<tr>
<td>37</td>
<td>(22S)-21-Acetoxy-6±, 118-dihydroxy-16±, 17±-propylmethylenediox</td>
<td>C_{29}H_{48}O_{10}</td>
<td>488</td>
<td>57,91,137,165,205,260, Anti-oxidant activity</td>
</tr>
<tr>
<td>38</td>
<td>(+)-³-Tocopherol, O-methyl-</td>
<td>C_{29}H_{50}O_{10}</td>
<td>430</td>
<td>55,69,83,133,213,255, Anti-platelet</td>
</tr>
<tr>
<td>39</td>
<td>Stigmasterol</td>
<td>C_{29}H_{48}O_{10}</td>
<td>412</td>
<td>55,69,83,133,213,255, Anti-platelet</td>
</tr>
</tbody>
</table>
Table 2: Zone of inhibition (mm) of test bacterial strains to *Cinnamomum zeylanicum* bioactive compounds and standard antibiotics

<table>
<thead>
<tr>
<th>Plant</th>
<th>Proteus mirabilis</th>
<th>Pseudomonas eurogenosa</th>
<th>Bacteria Escherichia coli</th>
<th>Klebsiella pneumonia</th>
<th>Staphylococcus aureus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant</td>
<td>4.92±0.22</td>
<td>3.99±0.31</td>
<td>5.39±0.22</td>
<td>6.12±0.52</td>
<td>5.19±0.02</td>
</tr>
<tr>
<td>Rifambin</td>
<td>0.70±0.3</td>
<td>0.96±0.11</td>
<td>1.00±0.13</td>
<td>0.90±0.20</td>
<td>0.93±0.50</td>
</tr>
<tr>
<td>Streptomycin</td>
<td>2.00±0.10</td>
<td>1.20±0.18</td>
<td>0.97±0.53</td>
<td>1.34±0.47</td>
<td>1.80±0.38</td>
</tr>
<tr>
<td>Kanamycin</td>
<td>0.39±0.17</td>
<td>0.60±0.33</td>
<td>1.00±0.19</td>
<td>0.98±0.40</td>
<td>0.50±0.12</td>
</tr>
<tr>
<td>Cefotaxime</td>
<td>0.89±0.6</td>
<td>1.40±0.26</td>
<td>1.36±0.40</td>
<td>0.96±0.39</td>
<td>1.90±0.36</td>
</tr>
</tbody>
</table>

Table 3: Zone of inhibition (mm) of *Aspergillus Spp.* test to *Cinnamomum zeylanicum* bioactive compounds and standard antibiotics

<table>
<thead>
<tr>
<th>Plant</th>
<th>Aspergillus niger</th>
<th>Aspergillus terreus</th>
<th>Aspergillus flavus</th>
<th>Aspergillus fumigatus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant</td>
<td>3.00±0.120</td>
<td>4.71±0.52</td>
<td>6.16±0.42</td>
<td>5.19±0.02</td>
</tr>
<tr>
<td>Amphotericin B</td>
<td>2.61±0.270</td>
<td>4.28±0.610</td>
<td>3.95±0.5</td>
<td>4.00±0.820</td>
</tr>
<tr>
<td>Fluconazol</td>
<td>4.79±0.211</td>
<td>3.21±0.25</td>
<td>2.90±0.451</td>
<td>4.70±0.930</td>
</tr>
<tr>
<td>Control</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Fig. 1: GC-MS chromatogram of methanolic extract of *Cinnamomum zeylanicum*
Hinton agar plates. 60̊l of plant extract was loaded on the bored wells. The wells were bored in 0.5cm in diameter. The plates were incubated at 37°C for 24 hrs and examined. After the incubation the diameter of inhibition zones around the discs was measured

**Determination of antifungal activity**

Five-millimeter diameter wells were cut from the agar using a sterile cork-borer, and 50̊l of the samples solutions (*Cinnamomum zeylanicum*) was delivered into the wells. Antimicrobial activity was evaluated by measuring the zone of inhibition against...
the test microorganisms. Methanol was used as solvent control. Amphotericin B and fluconazole were used as reference antifungal agents\textsuperscript{30,31}. The tests were carried out in triplicate. The antifungal activity was evaluated by measuring the inhibition-zone diameter observed after 48 h of incubation.

**Fig. 6:** Structure of Benzaldehyde dimethyl acetal present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

**Fig. 7:** Structure of Benzenepropanal present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

**Fig. 8:** Structure of Benzylidenemalonaldehyde present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

**Fig. 9:** Structure of 3-Phenylpropanol present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

**Statistical analysis**

Data were analyzed using analysis of variance (ANOVA) and differences among the means were determined for significance at $P < 0.05$ using Duncan’s multiple range test (by SPSS software) Version 9.1.
Fig. 10: Structure of Cinnamaldehyde, (E) present in the methanolic extract of C. zeylanicum using GC-MS analysis

Fig. 11: Structure of 2-Propen-1-ol, 3-phenyl present in the methanolic extract of C. zeylanicum using GC-MS analysis

Fig. 12: Structure of 9-Methoxybicyclo[6.1.0]nona-2,4,6-triene present in the methanolic extract of C. zeylanicum by using GC-MS analysis

Fig. 13: Structure of 1,3-Bis(cinnamoyloxymethyl)adamantane present in the methanolic extract of C. zeylanicum using GC-MS analysis
Fig. 14: Structure of Alfa - Copaene present in the methanolic extract of *C. zeylanicum* using GC-MS analysis.

Fig. 15: Structure of Naphthalene, 1,2,3,5,6,7,8,8a-octahydro-1,8a-dimethyl-7-(1-methyl) present in the methanolic extract of *C. zeylanicum* using GC-MS analysis.

Fig. 16: Structure of Cis - 2-Methoxycinnamic acid present in the methanolic extract of *C. zeylanicum* using GC-MS analysis.

Fig. 17: Structure of Bicyclo[3.1.1]hept-2-ene, 2,6-dimethyl-6-(4-methyl-3-pentenyl) present in the methanolic extract of *C. zeylanicum* using GC-MS analysis.
RESULTS AND DISCUSSION

Analysis of phytochemical compounds of methanolic extract of *Cinnamomum zeylanicum* was carried out by gas chromatography-mass spectrometry (Table1). The GC-MS chromatogram of the thirty nine peaks of the compounds detected are shown in Figure 1. Chromatogram GC-MS analysis of the methanolic extract of *Cinnamomum zeylanicum* showed the presence of thirty nine
major peaks and the components corresponding to the peaks were determined as follows. The first set of peaks were determined to be 6-Oxa-bicyclo[3.1.0]hexan-3-one Figure 2. The second peak indicated to be Benzaldehyde Figure 3.

The next peaks considered to be Cyclohexene, 4-isopropenyl-1-methoxymethoxymethyl, Benzoic acid, methyl ester, Benzaldehyde dimethyl acetal, -Oxa-bicyclo[3.1.0]hexan-3-one, Benzenepropanal, Benzyldenemalonaldehyde, 3-Phenylpropanol,
Fig. 26: Structure of Á-Cadinol present in the methanolic extract of *C. zeylanicum* using GC-MS analysis.

Fig. 27: Structure of Spiro[tricyclo[4.4.0.0(5.9)]decane-10,2-oxirane] present in the methanolic extract of *C. zeylanicum* using GC-MS analysis.

Fig. 28: Structure of 6-Isopropenyl-4,8a-dimethyl-1,2,3,5,6,7,8,8a-octahydronaphthalene present in the methanolic extract of *C. zeylanicum* using GC-MS analysis.

Fig. 29: Structure of Ethyl9,9-difomylnona-2,4,6,8-tetraenoate present in the methanolic extract of *C. zeylanicum* using GC-MS analysis.
Fig. 30: Structure of Trans-13-Octadecenoic acid present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

Fig. 31: Structure of Tributyl acetylcitrate present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

Fig. 32: Structure of 9,12,15-Octadecatrienoic acid, 2,3-dihydroxypropyl ester present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

Fig. 33: Structure of 9-Octadecenamide present in the methanolic seeds extract of *C. zeylanicum* using GC-MS analysis
Fig. 34: Structure of 17,alfa.-21ß-28,30-Bisnorhopane present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

Fig. 35: Structure of Androstan-3-one,cyclic 1,2-ethanediyl mercaptole , (5a) present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

Fig. 36: Structure of (4H)4a,5,6,7,8,8a-Hexahydrobenzopyran-5-one-3-carboxamide,2 present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

Fig. 37: Structure of 4H-Cyclopropa[5,6'] benz[1',2',7,8]azuleno[5,6]oxiren-4-one,8,8a present in the methanolic extract of *C. zeylanicum* using GC-MS analysis
Fig. 38: Structure of (22S)-21-Acetoxy-6α,11β-dihydroxy-16α,17α-propylmethylenediox present in the methanolic extract of C. zeylanicum using GC-MS analysis

Fig. 39: Structure of (+)-ã-Tocopherol, present in the methanolic extract of C. zeylanicum using GC-MS analysis

Fig. 40: Structure of Stigmasterol present in the methanolic extract of C. zeylanicum using GC-MS analysis
and Stigmasterol. Figure 4-40. Five clinical pathogens were selected for antibacterial activity namely, (*Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *E. coli*, *Staphylococcus aureus* and *Proteus mirabilis*). Maximum zone formation was against *Klebsiella pneumoniae*, Table 2. Methanolic extraction of plant showed notable antifungal activities against *Aspergillus niger*, *Asp. terreus*, *Asp. flavus*, and *Asp. fumigatus* Table 3. *Cinnamomum zeylanicum* was very highly active against *Aspergillus flavus* (6.16±0.42). *Aspergillus* was found to be sensitive to all test medicinal plants and mostly comparable to the standard reference antifungal drug amphotericin B and fluconazole to some extent.

**CONCLUSION**

From the results obtained in this study, it could be concluded that *Cinnamomum zeylanicum* acts possesses remarkable antimicrobial activity, which is mainly due to (E)-cinnamaldehyde. According to these findings, it could be said that the methanolic extract of *Cinnamomum zeylanicum* acts as antifungal and antibacterial agents.

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**REFERENCES**