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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-Propen- 1- ol,3-phenyl, 9-Methoxybicyclo[6.1.0]nona – 2,4,6- triene , 1,3-Bis(cinnamoyloxymethyl) adamantine, Alfa.– Copaene, Naphthalene , 1,2,3,5,6,7,8,8a-octahydro-1,8a-dimethyl-7-(1-methyl), Cis – 2-Methoxycinnamic acid, Bicyclo[3.1.1]hept-2-ene,2,6- dimethyl-6-(4-methyl-3-pentenyl), Trans-2-Hydroxycinnamic acid , methyl ester, y-Muurolene, ß-Guaiene, Cadala-1(10),3,8-triene, Isolongifolene,4,5,9,10-dehydro, Cubenol, Tau-Muurolol, Á-Cadinol , Spiro[tricyclo[4.4.0.0(5.9)] decane-10.2oxirane],1-methyl-4-isoprol, 6-Isopropenyl-4,8q-dimethyl-1,2,3,5,6,7,8,8a-octahydronaphthalen, Ethyl9,9-difomylnona-2,4,6,8-tetraenoate, Trans-13-Octadecenoic acid, Tributyl acetylcitrate, 9,12,15-Octadecatrienoic acid ,2,3-dihydroxypropyl ester, 9-Octadecenamide, 17.alfa.-21ß-28,30-Bisnorhopane, 17.alfa.-21ß-28,30-Bisnorhopane, Androstan-3-one,cyclic 1,2-ethanediyl mercaptole , (5á), (4H)4a,5,6,7,8,8a-Hexahydrobenzopyran-5-one-3-carboxamide,2, 4H-Cyclopropa[5´,6´]benz [1´,2´,7,8]azuleno[5,6]oxiren-4-one,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 reachingabout nine meters high and covered with a smooth, pale bark[1-3]. It is considered to be the native of Sri Lanka and Malabar Coast of India[4,5]. 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, antidiabetic[10-12] and antifungal (Bruneton et al., 1998). Cinnamaldehye 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 rotatory 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 1ìL 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

S No.	Phytochemical compound	RT (min)	Formula	Molecular Weight	Exact Mass	Chemical structure	MS Fragment- ions	Pharmacological actions
1	6-Oxa-bicyclo[3.1.0] hexan-3-one	3.419	$C_5H_6O_2$	98	98.0368		55,69,98	New chemical compound
2	Benzaldehyde	3.67	C_7H_6O	106	106.042		51,63,77,86,106	Anti- convulsant activity; anti-microbial, anti-daibtic, and antiobesity
3	Cyclohexene, 4-isopropenyl-1-methoxymethoxymethyl-	3.859	$C_{12}H_{20}O_2$	196	196.146		53.79.91.119.164.196	New chemical compound
4	Benzoic acid methyl ester	5.095	$C_8H_8O_2$	136	136.052		51,59,65,77,92,105, 118,136	New chemical compound
5	Benzaldehyde dimethyl acetal	5.284	$C_9H_{12}O2$	152	152.084		51,59,65,77,91,105, 121,136,151	Anti-cancer activity
6	Benzenepropanal	5.942	$C_9H_{10}O$	134	134.073		51,65,78,91,105, 115,134	Antimutagenic and *anti*-malarial
7	Benzylidenema-lonaldehyde	6.715	$C_{10}H_8O_2$	160	160.052		51,63,77,91,103, 115,131,159	Anti-inflammatory
8	3-Phenylpropanol	7.121	$C_9H_{12}O$	136	136.089		51,77,91,105,117,136	Antineoplastic and anti- inflammatory

9	Cinnamaldehyde, (E)-	7.619	C_9H_8O	132	132.058		51,63,74,77,91,103, 115,131	Antityrosinase activity; anti-inflammatory and antitermitic
10	2-Propen- 1- ol, 3-phenyl-	8.082	$C_9H_{10}O$	134	134.073		51,63,78,92,105, 115,134	New chemical compound
11	9-Methoxybicyclo [6.1.0]nona – 2, 4,6- triene	8.219	$C_{10}H_{12}O$	148	148.089		51,63,77,91,105, 115,133,148	New chemical compound
12	1,3-Bis(cinnamoy-loxymethyl)adamantine	8.414	$C_{30}H_{32}O_4$	456	456.23		51,77,91,103,119,131, 147,160,204,250,280	New chemical compound
13	Alfa.– Copaene	8.797	$C_{12}H_{24}$	204	204.188		55,69,77,91,105,119, 133,147,161,175,189,204	New chemical compound
14	Naphthalene , 1,2,3, 5,6,7,8,8a-octahydro-1, 8a-dimethyl-7-(1-methyl)	8.935	$C_{15}H_{24}$	204	204.188		55,67,79,107,119,133, 147,175,189,204	New chemical compound
15	Cis – 2-Methoxycinnamic acid	9.181	$C_{10}H_{10}O_3$	178	178.063		51,63,77,85,91,103, 118,131,147,161,178	Anti-tyrosinase activities; *anti*- tyrosinase and anti-melanogenic activities
16	Bicyclo[3.1.1]hept-2 -ene,2,6- dimethyl-6 -(4-methyl-3-pentenyl)	9.455	$C_{15}H_{24}$	204	204.188		55,69,77,93,107,119, 133,148,161,189,204	New chemical compound

17	Trans-2-Hydroxyc-innamic acid , methyl ester	9.701	$C_{10}H_{10}O_3$	178	178.063		51,65,75,91,103,118, 131,146,161,178	Anti-inflammatory activity
18	y-Muurolene	10.497	$C_{15}H_{24}$	204	204.188		55,79,93,105,119,133, 147,161,175,189,204	New chemical compound
20	ß-Guaiene	10.771	$C_{15}H_{24}$	204	204.188		55,67,81,91,105,119, 133,161,175,189,204	New chemical compound
21	Cadala-1(10), 3,8-triene	10.88	$C_{15}H_{22}$	202	202.172		53,65,66,91,105,115, 131,142,157,183,200	New chemical compound
22	Isolongifolene,4,5, 9,10-dehydro-	11.069	$C_{15}H_20$	200	200.157		51,91,115,128,143,157,185	New chemical compound
23	Cubenol	11.841	$C_{15}H_{26}O$	222	222.198		59,81,93,119,161,189,204	Antifungal and anti-HIV
24	Tau-Muurolol	12.002	$C_{15}H_{26}O$	222	222.198		55,79,95,121,134,161, 189,204,222	Anti-wood-decay fungal activity and moderate antimicrobial activity

25	'-Cadinol	12.139	$C_{15}H_{26}O$	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 (5.9)]decane-10.2oxirane], 1-methyl-4-isoprol	13.484	$C_{15}H_{24}O_2$	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	$C_{15}H_{24}O_2$	236	236.178		55,79,91,107,149,175, 218,236	New chemical compound
28	Ethyl9,9-difomylnona -2,4,6,8-tetraenoate	14.857	$C_{13}H_{14}O_4$	234	234.089		51,65,77,103,131,160, 188,205,234	New chemical compound
29	Trans-13-Octadecenoic acid	16.968	$C_{18}H_{34}O_2$	282	282.256		55,69,83,123,180, 222,264,282	Good anti-inflammatory activity
30	Tributyl acetylcitrate	17.952	$C_{20}H_{34}O_8$	402	402.225		#######	Anti-Feeding effect: Larvae
31	9,12,15-Octadecatrienoic acid ,2, 3-dihydroxypropyl ester , (z,z,z)	18.176	$C_{21}H_{36}O_4$	352	352.261		57,67,79,95,109,135,155, 173,232,261,291,321,352	New chemical compound
32	9-Octadecenamide	18.834		281	281.272		59,72,83,114,184, 212,264,281	Anti-inflammatory activity and, antibacterial activity

33	17.alfa.-21ß-28, 30-Bisnorhopane	20.287	$C_{28}H_{48}$	384	384.376		81,95,109,149,163,177,191, 217,246,313,369,384	Important for anti-MRSA activity
34	Androstan-3-one, cyclic 1,2-ethanediyl mercaptole , (5±)	20.447		384	384.376		55,67,81,95,132,189, 219,241,257,289,350	New chemical compound
35	(4H)4a,5,6,7,8,8a-Hexahydrobenzopyran-5-one-3-carboxamide,2	20.562		325	325.189		#######	New chemical compound
36	4H-Cyclopropa[5´,6´] benz[1´,2´,7,8]azuleno [5,6]oxiren-4-one,8,8a-	20.831	$C_{27}H_{36}O_{10}$	520	520.231		53,69,83,109,124,149,193, 215,308,340,383,400,442	New chemical compound
37	(22S)-21-Acetoxy-6±, 11ß-dihydroxy-16±, 17±-propylmethylenediox	25.031	$C_{27}H_{36}O_8$	488	488.241		55,91,121,149,223,,279,297, 351,387,416,445,488	New chemical compound
38	(+)-³-Tocopherol,O-methyl-	26.427	$C_{29}H_{50}O_2$	430	430.381		57,91,137,165,205,260, 302,344,486,430	Anti-oxidant activity
39	Stigmasterol	28.841	$C_{29}H_{48}O$	412	412.371		55,69,83,133,213,255, 300,351,369,412	Anti-platelet

Table 2: Zone of inhibition (mm) of test bacterial strains to *Cinnamomum zeylanicum* bioactive compounds and standard antibiotics

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

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

Plant Antibiotics	*Aspergillus Spp.*			
	Aspergillus niger	***Aspergillus terreus***	***Aspergillus flavus***	***Aspergillus fumigatus***
Plant	3.00±0.120	4.71±0.52	6.16±0.42	5.19±0.02
Amphotericin B	2.61±0.270	4.28±0.610	3.95±0.5	4.00±0.820
Fluconazol	4.79±0.211	3.21±0.25	2.90±0.451	4.70±0.930
Control	0.00	0.00	0.00	0.00

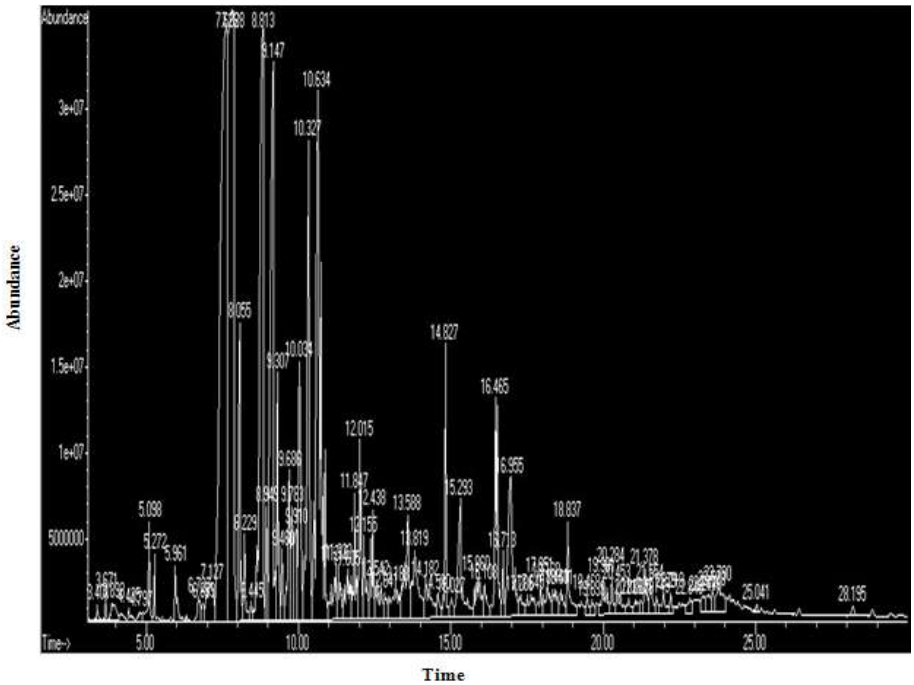

Fig. 1: GC-MS chromatogram of methanolic extract of *Cinnamomum zeylanicum*

Hinton agar plates. 60ìl of plant extract was loaded on the bored wells. The wells were bored in 0.5cm in diameter. The plates were incubated at 37C° for 24 hrs and examined. After the incubation the diameter of inhibition zones around the discs was measured[29].

Determination of antifungal activity

Five-millimeter diameter wells were cut from the agar using a sterile cork-borer, and 50 ìl of the samples solutions (*Cinnamomum zeylanicum*) was delivered into the wells. Antimicrobial activity was evaluated by measuring the zone of inhibition against

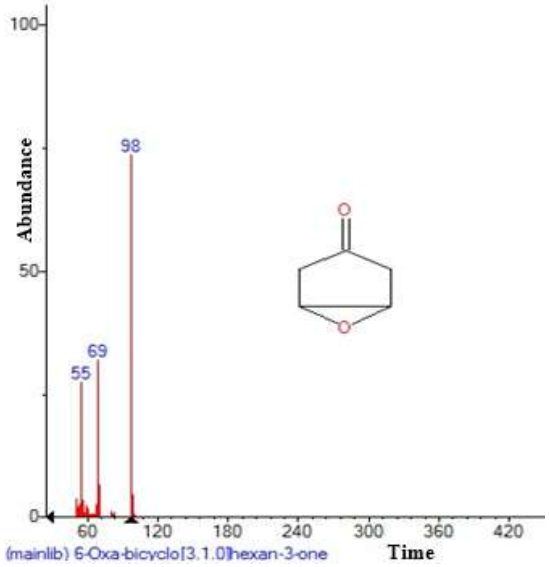

Fig. 2: Structure of 6-Oxa-bicyclo[3.1.0]hexan-3-one present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

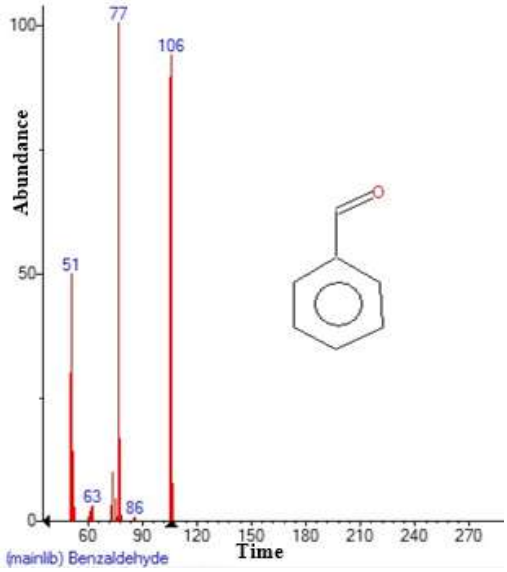

Fig. 3: Structure of Benzaldehyde present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

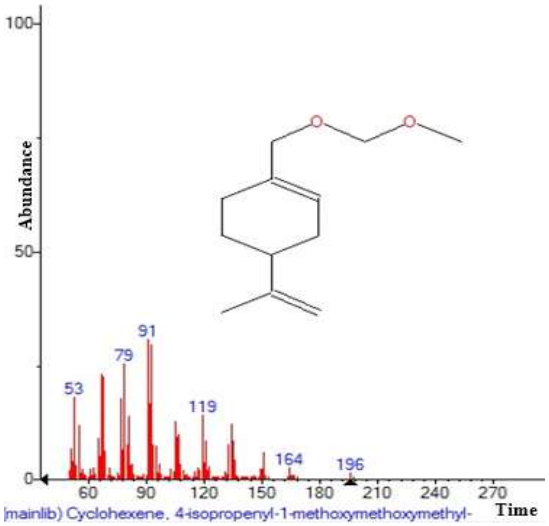

Fig. 4: Structure of Cyclohexene,4-isopropenyl-1-methoxymethoxymethyl present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

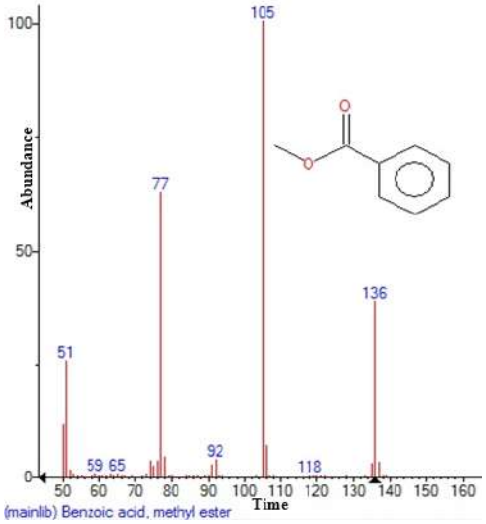

Fig. 5: Structure of Benzoic acid, methyl ester present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

the test microorganisms. Methanol was used as solvent control. Amphotericin B and fluconazole were used as reference antifungal agent[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.

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 .

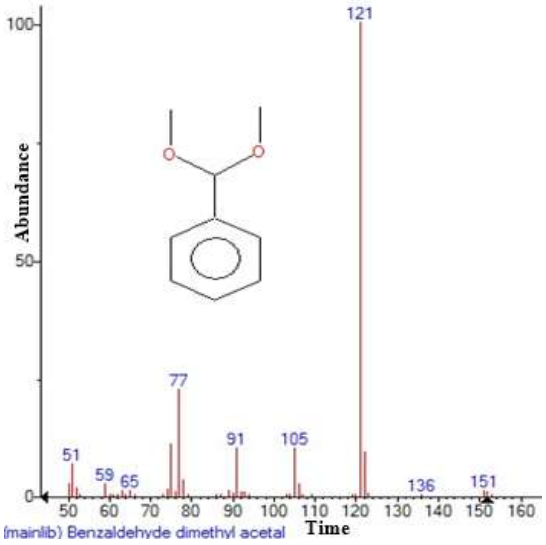

Fig. 6: Structure of Benzaldehyde dimethyl acetal present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

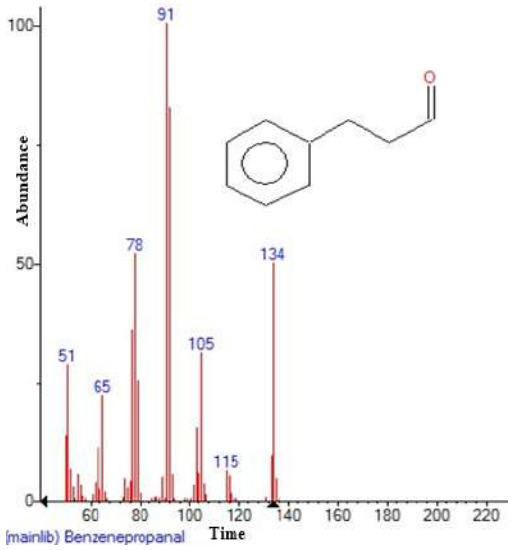

Fig. 7: Structure of Benzenepropanal present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

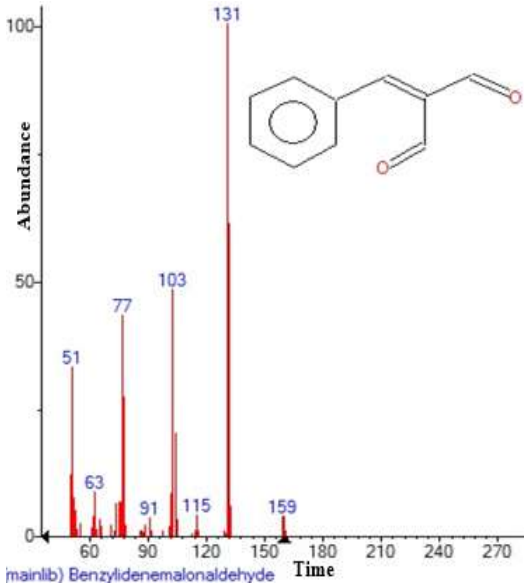

Fig. 8: Structure of Benzylidenemalonaldehyde present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

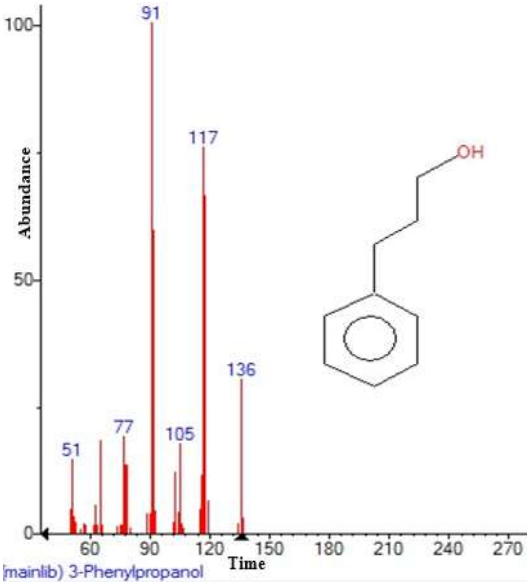

Fig. 9: Structure of 3-Phenylpropanol present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

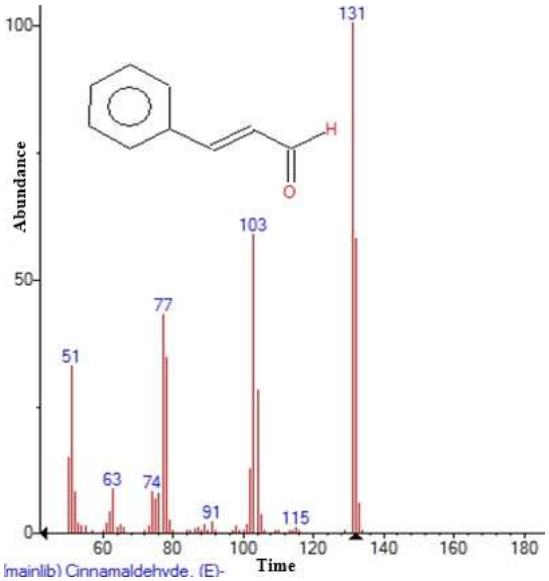

Fig. 10: Structure of Cinnamaldehyde, (E) present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

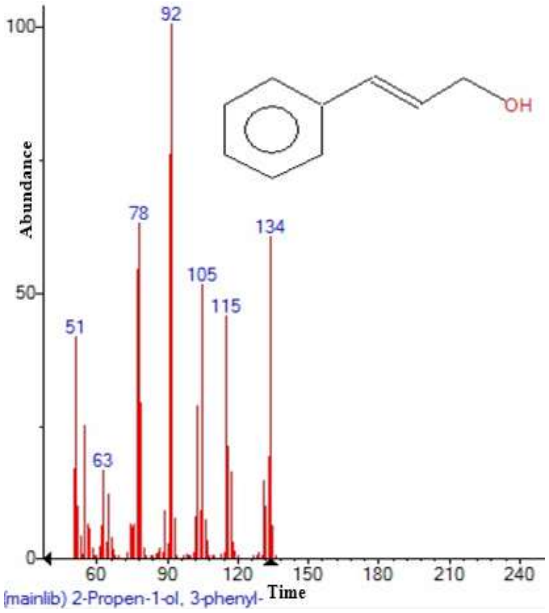

Fig. 11: Structure of 2-Propen- 1- ol,3-phenyl present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

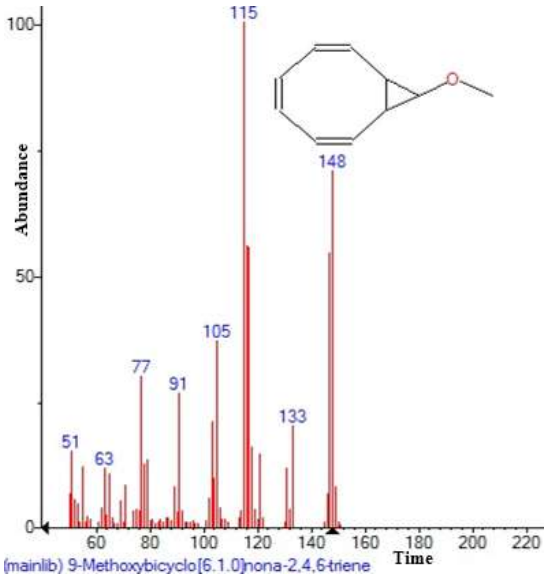

Fig. 12: Structure of 9-Methoxybicyclo[6.1.0] nona – 2,4,6- triene present in the methanolic extract of *C. zeylanicum* by using GC-MS analysis

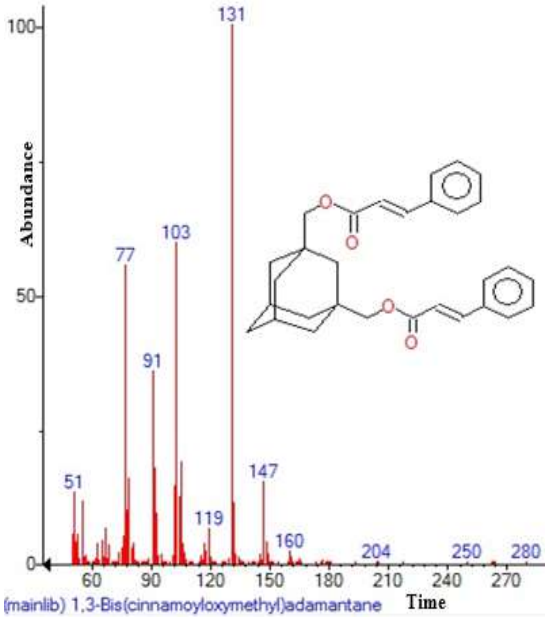

Fig. 13: Structure of 1,3-Bis(cinnamoyloxymethyl)adamantine present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

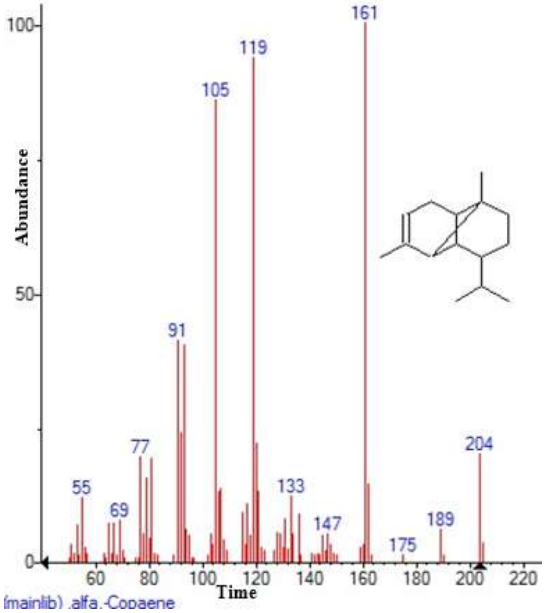

Fig. 14: Structure of Alfa . – Copaene present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

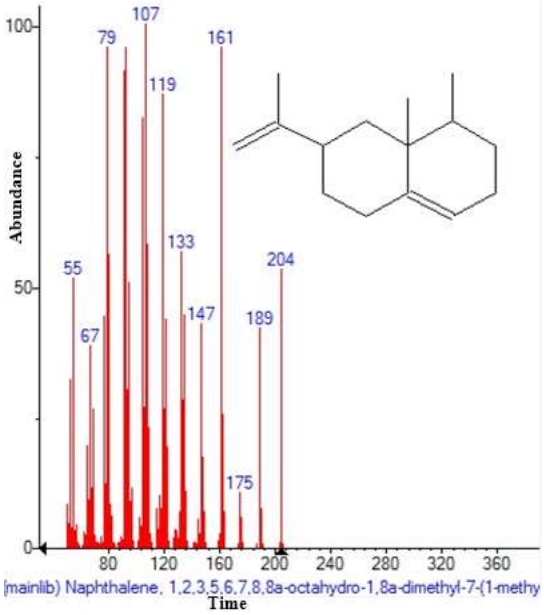

Fig. 15: Structure of Naphthalene , 1,2,3,5,6,7,8,8a-octahydro-1,8a-dimethyl-7-(1-methyl)present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

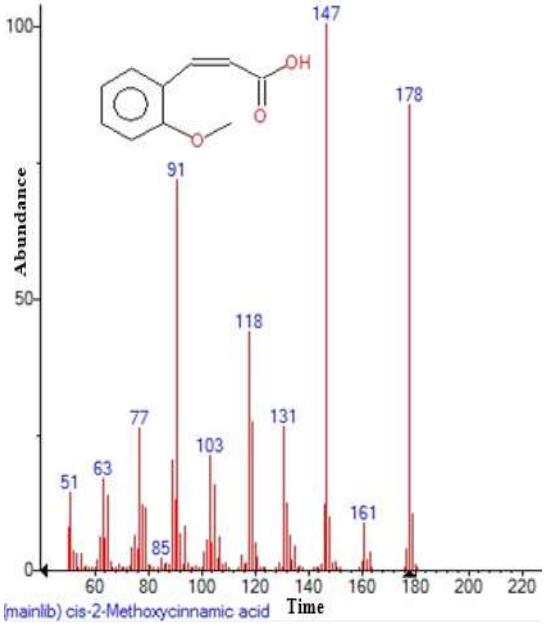

Fig. 16: Structure of Cis – 2-Methoxycinnamic acid present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

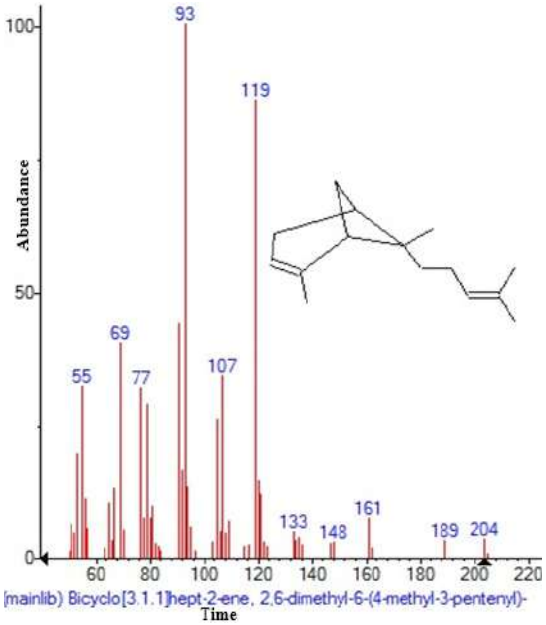

Fig. 17: Structure of Bicyclo[3.1.1]hept-2-ene,2,6- dimethyl-6-(4-methyl-3-pentenyl) present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

RESULTS AND DISCUSION

Analysis of phytochemical compounds of methanolic extract of *Cinnamomum zeylanicum* was carried out by gas chromatography-mass spectroscopy (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

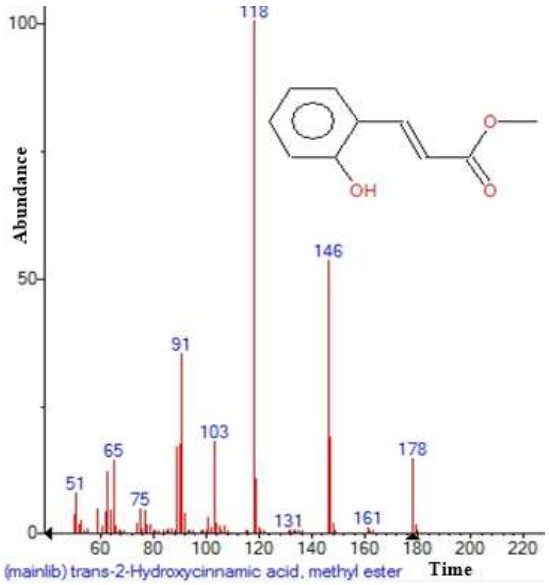

Fig. 18: Structure of Trans-2-Hydroxycinnamic acid , methyl ester present in the methanolic extract of *C. zeylanicum* by using GC-MS analysis

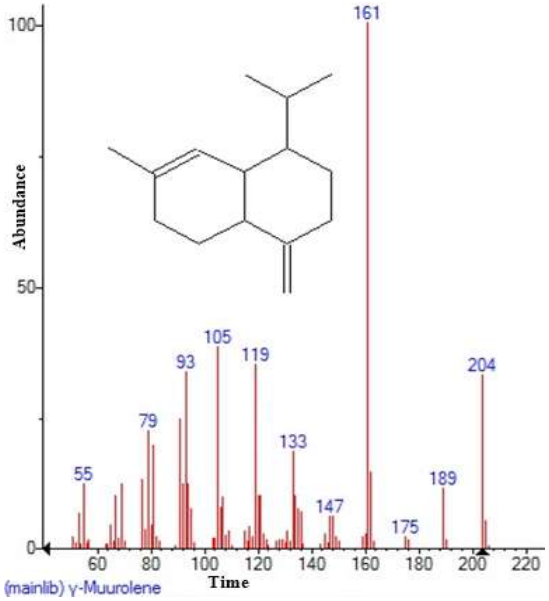

Fig. 19: Structure of y-Muurolene present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

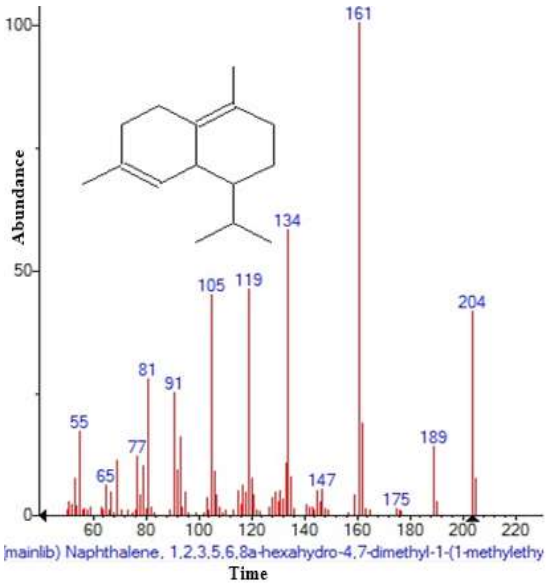

Fig. 20: Structure of Naphthalene present in the methanolic extract of *C. zeylanicum* by using GC-MS analysis

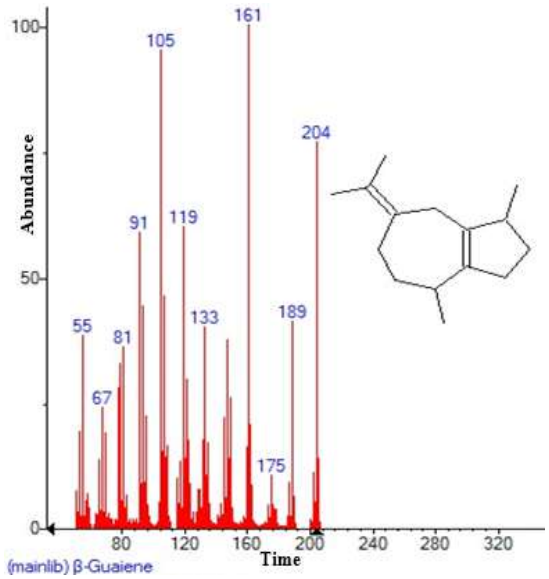

Fig. 21: Structure of ß-Guaiene present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

major peaks and the components corresponding to the peaks were determined as follows. The First set up peak 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, Benzylidenemalonaldehyde, 3-Phenylpropanol,

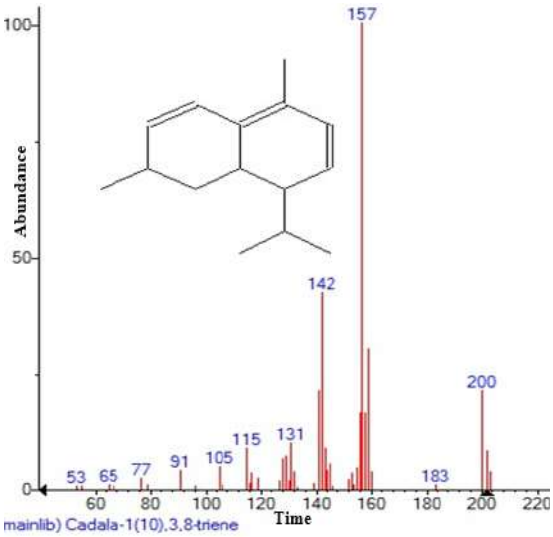

Fig. 22: Structure of Cadala-1(10),3,8-triene present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

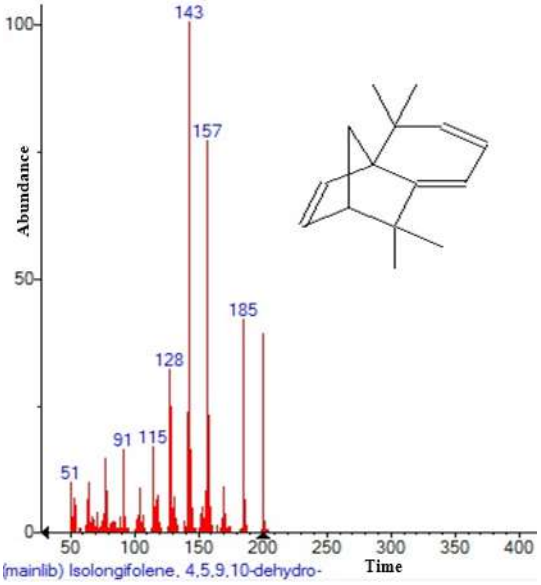

Fig. 23: Structure of Isolongifolene,4,5,9,10-dehydro present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

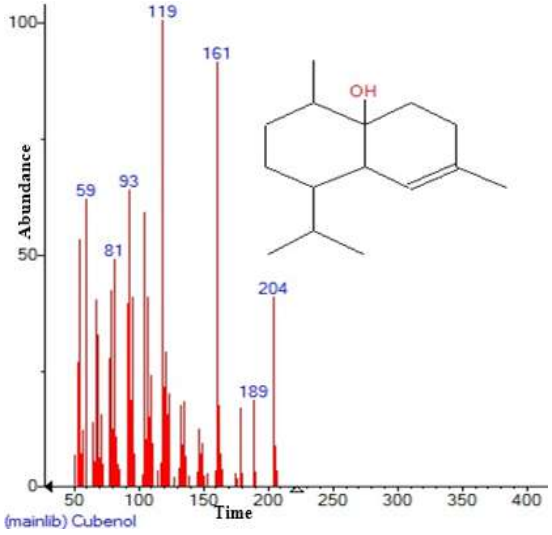

Fig. 24: Structure of Cubenol present in the methanolic extract of *C. zeylanicum* by using GC-MS analysis

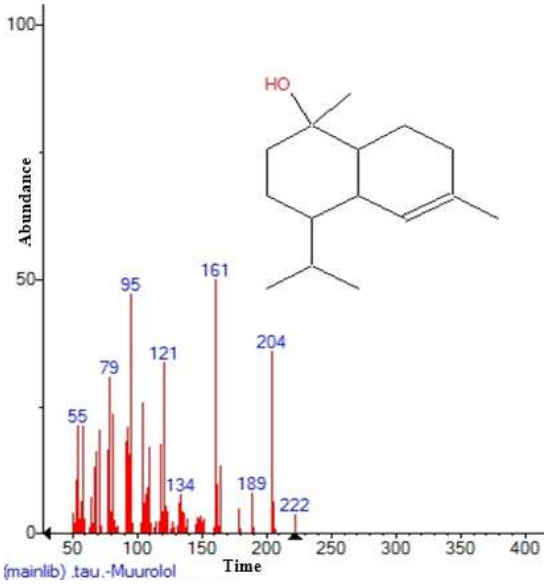

Fig. 25: Structure of Tau-Muurolol present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

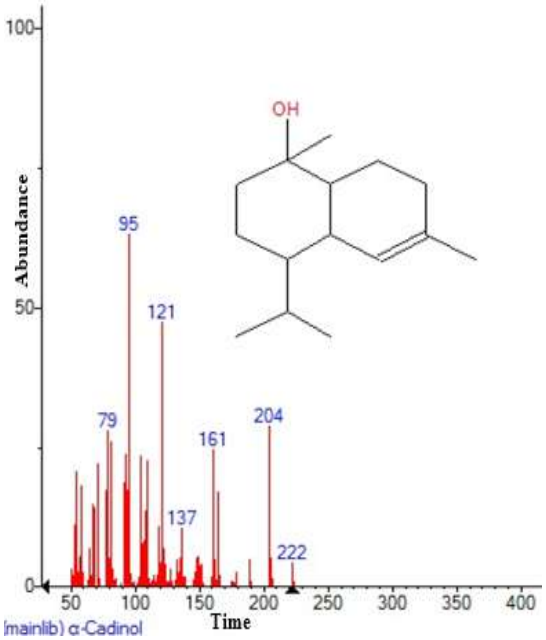

Fig. 26: Structure of Á-Cadinol present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

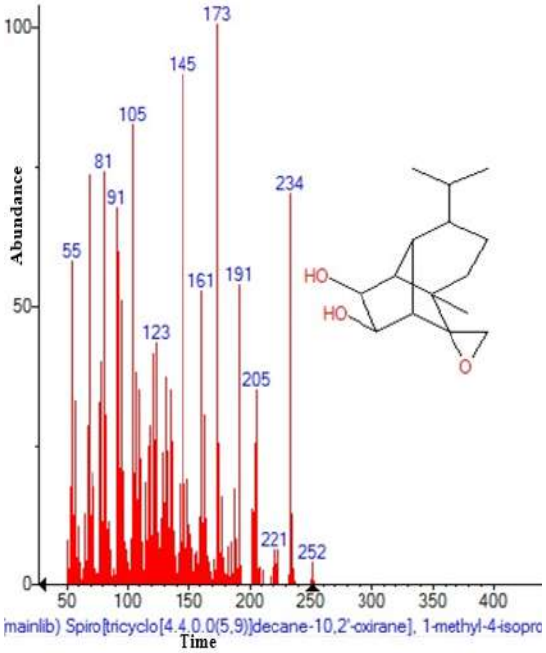

Fig. 27: Structure of Spiro[tricyclo[4.4.0.0(5.9)] decane-10.2oxirane] present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

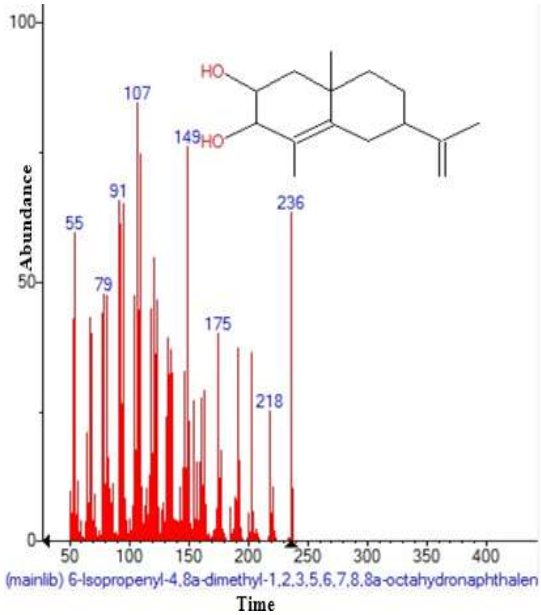

Fig. 28: Structure of 6-Isopropenyl-4,8q-dimethyl-1,2,3,5,6,7,8,8a-octahydronaphthalen present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

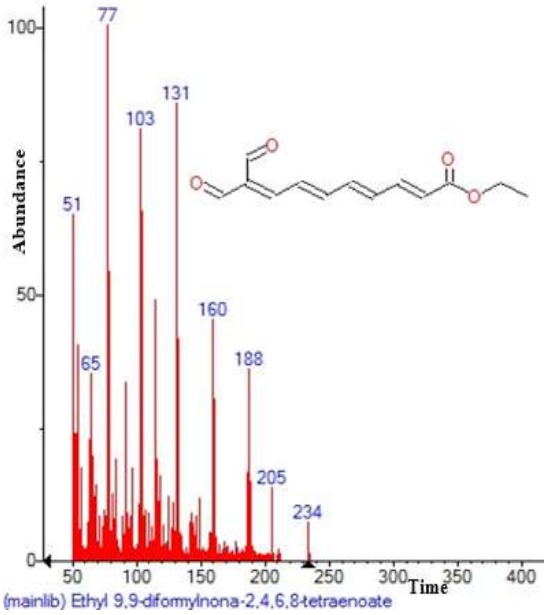

Fig. 29: Structure of Ethyl9,9-difomylnona-2,4,6,8-tetraenoate present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

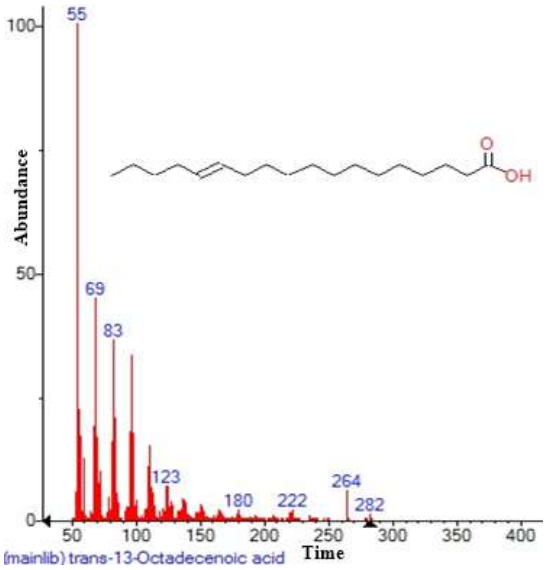

Fig. 30: Structure of Trans-13-Octadecenoic acid present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

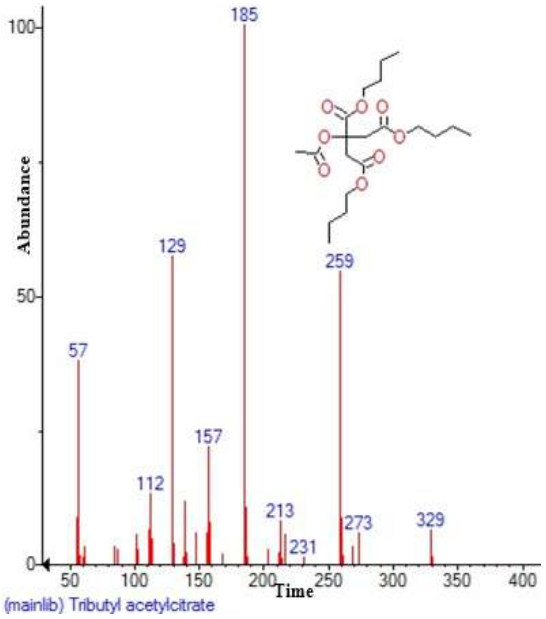

Fig. 31: Structure of Tributyl acetylcitrate present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

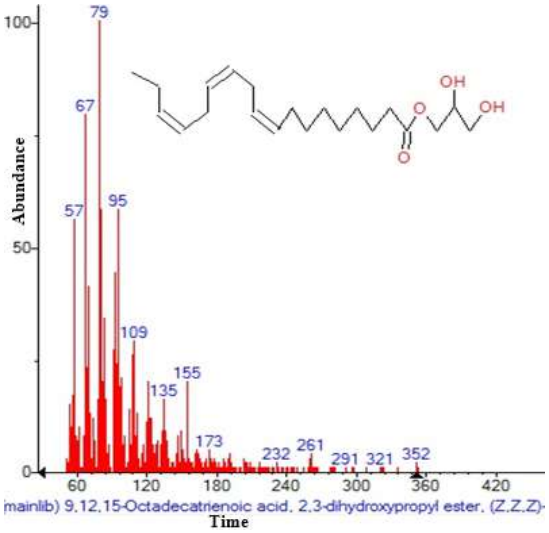

Fig. 32: Structure of 9,12,15-Octadecatrienoic acid ,2,3-dihydroxypropyl ester present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

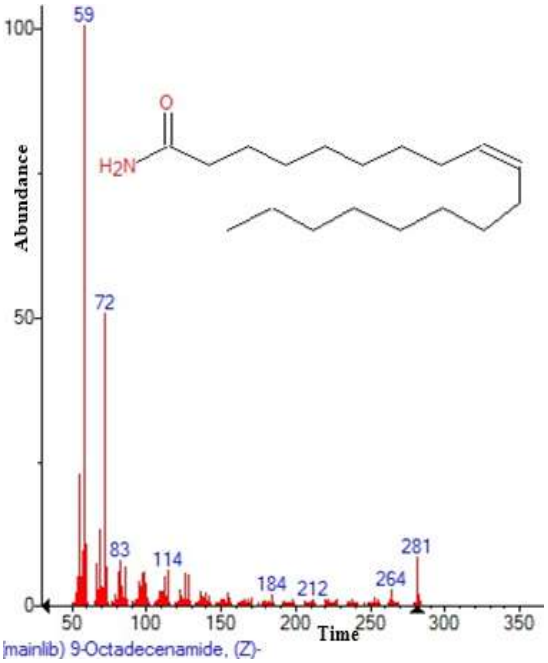

Fig. 33: Structure of 9-Octadecenamide present in the methanolic seeds extract of *C. zeylanicum* using GC-MS analysis

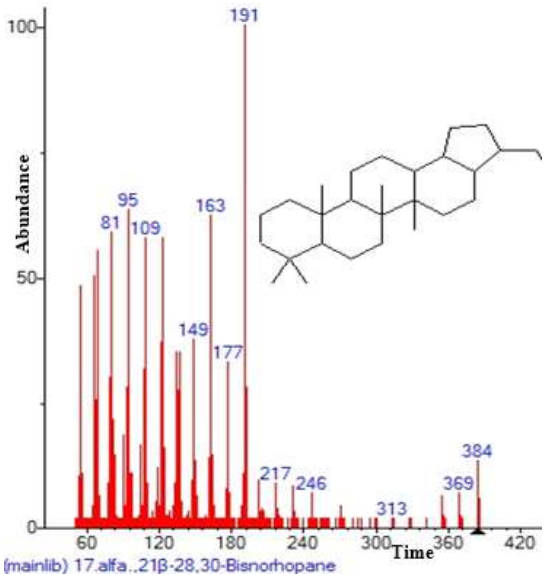

Fig. 34: Structure of 17.alfa.-21ß-28,30-Bisnorhopane present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

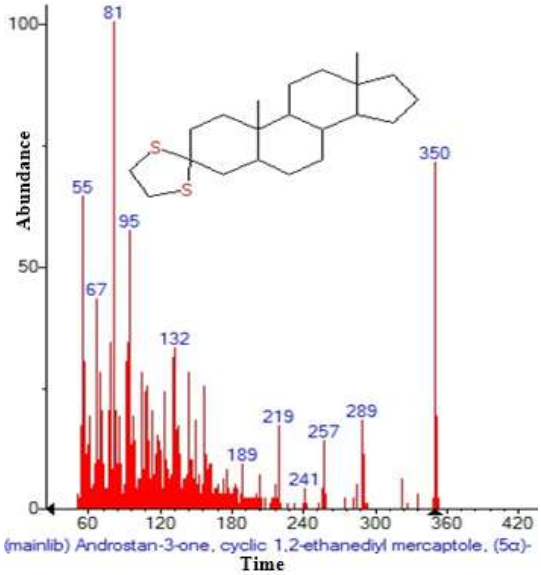

Fig. 35: Structure of Androstan-3-one,cyclic 1,2-ethanediyl mercaptole , (5á) present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

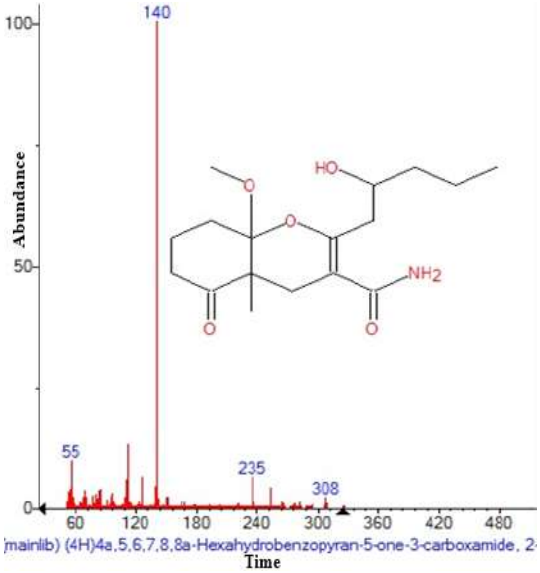

Fig. 36: Structure of (4H)4a,5,6,7,8,8a-Hexahydrobenzopyran-5-one-3-carboxamide,2 present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

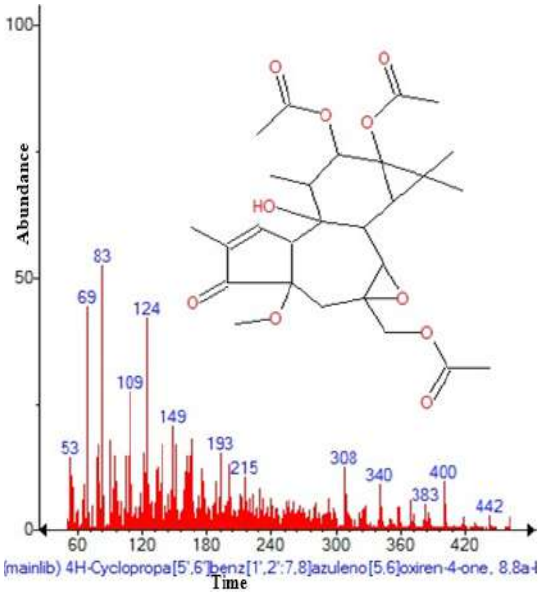

Fig. 37: Structure of 4H-Cyclopropa[5´,6´] benz[1´,2´,7,8]azuleno[5,6]oxiren-4-one,8,8a present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

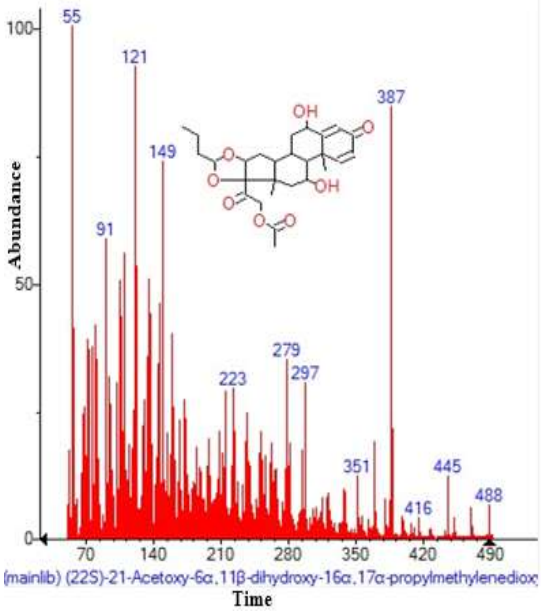

Fig. 38: Structure of (22S)-21-Acetoxy-6á,11ß-dihydroxy-16á,17á-propylmethylenediox present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

Cinnamaldehyde, (E), 2-Propen- 1- ol,3-phenyl, 9-Methoxybicyclo[6.1.0]nona – 2,4,6- triene , 1,3-Bis(cinnamoyloxymethyl) adamantine, Alfa.–Copaene, Naphthalene , 1,2,3,5,6,7,8,8a-octahydro-1,8a-dimethyl-7-(1-methyl), Cis – 2-Methoxycinnamic acid, Bicyclo[3.1.1]hept-2-ene,2,6- dimethyl-6-(4-methyl-3-pentenyl), Trans-2-Hydroxycinnamic acid , methyl ester, y-Muurolene, ß-Guaiene, Cadala-1(10),3,8-triene, Isolongifolene,4,5,9,10-dehydro, Cubenol, Tau-Muurolol, Á-Cadinol , Spiro[tricyclo[4.4.0.0(5.9)]decane-10.2oxirane],1-methyl-4-isoprol, 6-Isopropenyl-4,8q-dimethyl-1,2,3,5,6,7,8,8a-octahydronaphthalen, Ethyl9,9-difomylnona-2,4,6,8-tetraenoate, Trans-13-Octadecenoic acid, Tributyl acetylcitrate, 9,12,15-Octadecatrienoic acid ,2,3-dihydroxypropyl ester , (z,z,z), 9-Octadecenamide, 17.alfa.-21ß-28,30-Bisnorhopane, 17.alfa.-21ß-28,30-Bisnorhopane, Androstan-3-one,cyclic 1,2-ethanediyl mercaptole , (5á), (4H)4a,5,6,7,8,8a-Hexahydrobenzopyran-5-one-3-carboxamide,2, 4H-Cyclopropa[5´,6´] benz [1´,2´,7,8]azuleno[5,6]oxiren-4-one,8,8a, (22S)-21-Acetoxy-6á,11ß-dihydroxy-16á,17á-propylmethylenediox, (+)-ã-Tocopherol,O-methyl

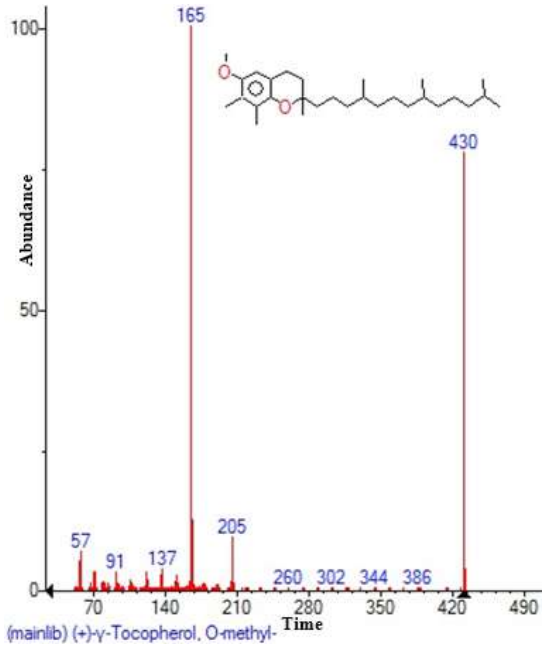

Fig. 39: Structure of (+)-ã-Tocopherol, present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

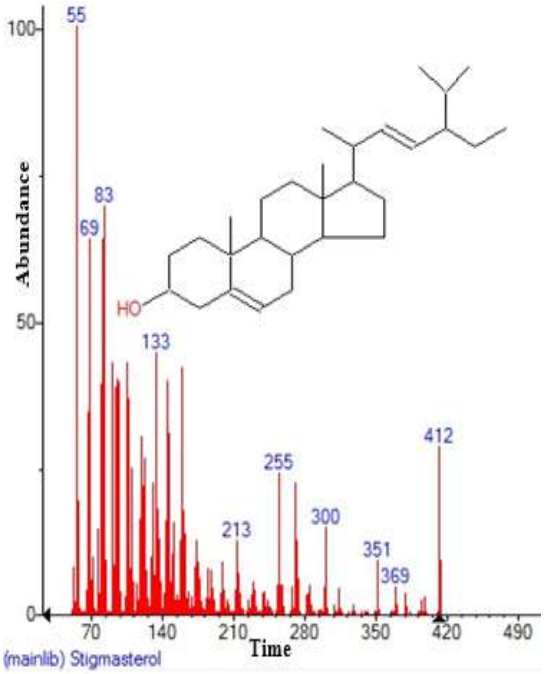

Fig. 40: Structure of Stigmasterol present in the methanolic extract of *C. zeylanicum* using GC-MS analysis

and Stigmasterol Figure 4-40. Five clinical pathogens were selected for antibacterial activity namely, (*Klebsiella pneumoniae, Pseudomonas aeroginosa, E.coli, Staphylococcus aeureus* 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. fumigatu*s 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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