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Full Length Research Paper

Evaluation of anti-bacterial activity and bioactive chemical analysis of *Ocimum basilicum* using Fourier transform infrared (FT-IR) and gas chromatography-mass spectrometry (GC-MS) techniques

Mohanad Jawad Kadhim[1], Azhar Abdulameer Sosa[2] and Imad Hadi Hameed[3]*

[1]Department of Genetic Engineering, Al-Qasim Green University, Iraq.
[2]College of Education for Women, Al-Qadisyia University, Iraq.
[3]College of Nursing, Babylon University, Iraq.

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The objective of this research was to determine the chemical composition of aerial parts extract from methanol. The phytochemical compound screened by gas chromatography-mass spectrometry (GC-MS) method. Thirty one bioactive phytochemical compounds were identified in the methanolic extract of *Ocimum basilicum*. The identification of phytochemical compounds is based on the peak area, retention time molecular weight, molecular formula, MS fragment-ions and pharmacological actions. GC-MS and Fourier transform infrared (FT-IR) analyses of *O. basilicum* revealed the existence of Paromomycin, Stevioside, Campesterol and Ascaridole epoxide, aliphatic fluoro compounds, alcohols, ethers, carboxlic acids, esters, nitro compounds, alkanes, H-bonded H-X group, hydrogen bonded alcohols and phenols. Methanolic extract of bioactive compounds of *O. basilicum* was assayed for *in vitro* antibacterial activity against *Pseudomonas aerogenosa, Proteus mirabilis, Escherichia coli*, *Staphylococcus aureus* and *Klebsiella pneumonia* by using the diffusion method in agar. The zone of inhibition was compared with different standard antibiotics. The diameters of inhibition zones ranged from 5.70±0.10 to 0.55±0.29 mm for all treatments.

Key words: GC/MS, Bioactive compounds, Fourier transform infrared (FT-IR), *Ocimum basilicum*.

INTRODUCTION

Plants secondary metabolites have recently been referred to as phytochemicals. Phytochemicals are naturally occurring and biologically active plant compounds that have potential disease inhibiting capabilities (Rukayadi et al., 2006; Yoshikawa et al., 2007; Hameed et al., 2015a; Al-Marzoqi et al., 2016). It is believed that phytochemicals may be effective in combating or preventing disease due to their antioxidant

*Corresponding author. E-mail: imad_dna@yahoo.com. Tel: 009647716150716.

effect (Halliwell and Gutteridge, 1992; Altameme et al., 2015a). Plant materials have played an important role in traditional methods of field crop and stored grain protection against insect pest infestation since time immemorial (Ogendo et al., 2003; Al-Marzoqi et al., 2015). *Ocimum* species contains a wide range of essential oils rich in phenolic compounds and a wide array of other natural products including polyphenols such as flavonoids and anthocyanins. The genus *Ocimum* comprises more than 150 species and is considered as one of the largest genera of the Lamiaceae family (Holm, 1996; Hameed et al., 2015b). *Ocimum basilicum* L. (sweet basil) is an annual herb which grows in several regions all over the world. The plant is widely used in food and oral care products. The essential oil of the plant is also used as perfumery (Bauer et al., 1997; Chiang, 2005). Kéita et al. (2000) reported *O. basilicum* and *O. gratissimum* to be potential insecticides. The leaves and seeds are rich in essential oils, which are repellent, toxic or growth inhibitory to many insects. A high degree of polymorphism in the genus *Ocimum* determines a large number of subspecies, different varieties and forms producing essential oils with varying chemical composition offering variable level of medicinal potential. Essential oils extracted from *Ocimum* plants have been reported to possess interesting biological properties. These volatile oils have been applied in perfumery, to inhibit growth of microorganisms, in food preservation and in aromatherapy. The potential uses of *O. basilicum, Ocimum canum Ocimum gratissimum* and *Ocimum sanctum* essential oils, particularly as antioxidant and antimicrobial agents have also been explored (Politeo et al., 2007; Koba et al., 2009; Zhang et al., 2009; Hameed et al., 2015c; Altameme et al., 2015b; Hussein et al., 2016a). *O. basilicum* has been traditionally used for the treatment of many ailments, such as headaches, coughs and diarrhea and it is generally recognized as safe and is a rich source of phenolic antioxidant compounds and flavonoids (Juliani and Simon, 2002). The aims of this study were to determine the phytochemical composition of aerial parts and evaluation of anti-bacterial activity.

MATERIALS AND METHODS

Collection and preparation of plant

The aerial parts were dried at room temperature for ten days and when properly dried then powdered using clean pestle and mortar, and the powdered plant was size reduced with a sieve (Altameme et al., 2015c; Hameed et al., 2015d; Hussein et al., 2016b). The fine powder was then packed in airtight container to avoid the effect of humidity and then stored at room temperature. About 9 g of the plant sample powdered were soaked in 100 ml methanol individually. It was left for 72 h so that alkaloids, flavonoids and other constituents if present will get dissolved (Jasim et al., 2015; Hadi et al., 2016; Hussein et al., 2016c). The methanol extract was filtered using Whatman No.1 filter paper and the residue was removed.

Gas chromatography–mass spectrum (GC-MS) analysis

The GC-MS analysis of the plant extract (*O. basilicum*) was made in a Agilent 7890 A instrument under computer control at 70 eV. About 1 µl of the methanol extract was injected into the GC-MS using a micro syringe and the scanning was done for 45 min. 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. 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 is referred to as the retention time (RT). 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 1 ml/min. 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 (Yang et al., 2010).

Determination of antibacterial activity of crude bioactive compounds of *O. basilicum*

The test pathogens (*Pseudomonas aeruginosa, Klebsiella pneumoniae, Escherichia coli,* and *Staphylococcus aureus)* were swabbed in Muller Hinton agar plates. 60 µl of plant extract was loaded on the bored wells. The wells were bored in 0.5 cm in diameter. The plates were incubated at 37C° for 24 h and examined. After the incubation the diameter of inhibition zones around the discs was measured.

RESULTS AND DISCUSSION

Medicinal herbs are known as sources of active compounds that are widely sought after worldwide for their natural properties. They have been used since ancient times as sources of flavorings and for their pharmaceutical properties (Bais et al., 2002). Phytochemicals may be effective in combating or preventing disease due to their antioxidant effect (Halliwell and Gutteridge, 1992). A great number of organizations and scientists turn their attention to traditional therapies in order to find and conserve important resources and up to 80% of the population relies on traditional medicines or folk remedies for primary health care needs (Smith et al., 2010). Gas chromatography and mass spectroscopy analysis of compounds was carried out in methanolic aerial parts extract of *O. basilicum*, shown in Table 1. The GC-MS chromatogram of the 31 peaks of the compounds detected was shown in Figure 1. Chromatogram GC-MS analysis of the methanol extract of *O. basilicum* showed the presence of thirty one major peaks and the components corresponding to the peaks were determined

Table 1. Phytochemical compounds identified in methanolic extract of *O. basilicum*.

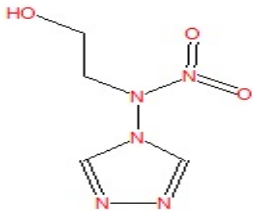
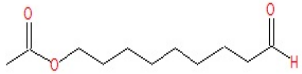
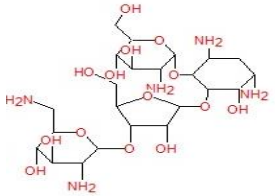
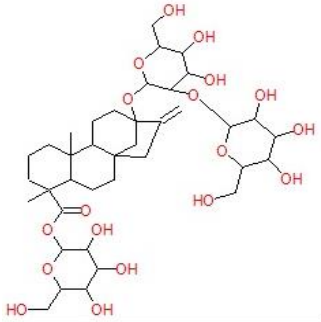
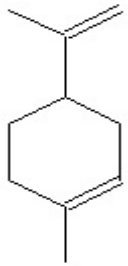
S/N	Phytochemical compound	RT (min)	Formula	Molecular weight	Exact mass	Chemical structure	MS Fragment- ions	Pharmacological actions
1	1,2,4-Triazole , 4-[N-(2-hydroxyethyl)-N-nitro]amino	3.196	$C_4H_7N_5O_3$	173	173.054889		55,70,83,113,127,173	*Biological* activities including *anti*- microbial activity
2	9-Acetoxynonanal	3.459	$C_{11}H_{20}O_3$	200	200.141245		55,81,97,112,157,200	Antimicrobial and *anti* - inflammatory
3	Paromomycin	3.567	$C_{23}H_{45}N_5O_{14}$	615	615.296303		57,67,80,94,109,124,162,191,210,227,244,262,287	*Anti*-bacterial
4	Stevioside	3.773	$C_{38}H_{60}O_{18}$	804	804.377964		60,73,85,98,113,121,144,163,185,214,260,285	Have *anti*-hyperglycemic, *anti*-hypertensive *anti*-inflammatory and *anti*-tumor
5	D-Limonene	3.985	$C_{10}H_{16}$	136	136.1252		53,68,79,93,136	*Anti*-stress *effects*

Table 1. Cont'd

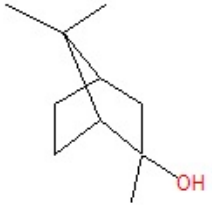
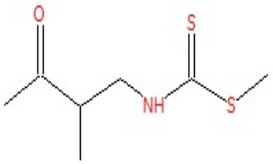
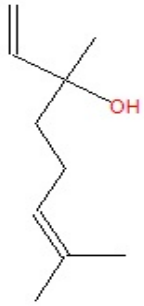
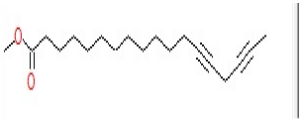
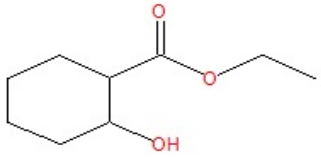
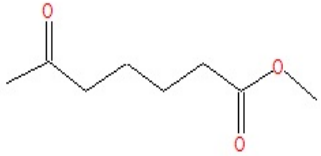
6	Exo-2,7,7-Trimethylbicyclo[2.2.1]heptan-2-ol	4.300	$C_{10}H_{18}O$	154	154.135765		55,71,81,93,107,121,136,154	T*Pharmacological* and *biological* activities including *anti-Candida*, *anti-* inflammatory and anti-diabetic
7	Dithiocarbamate , S-methyl-N-(2-methyl-3-oxobutyl)-	4.775	$C_7H_{13}NOS_2$	191	191.043856		57,72,85,91,117,143,191	*Anti*-inflammatory *effects*
8	1,6-Octadien-3-ol,3,7-dimethyl,	5.067	$C_{10}H_{18}O$	154	154.135765		55,71,80,93,107,121,136,154	Antioxidants
9	13,16-Octadecadiynoic acid , methyl ester	5.301	$C_{19}H_{30}O_2$	290	290.22458		55,74,164,199,242	Antifungal and Antialgal *effect*
10	Cyclohexanecarboxylic acid ,2-hydroxy-, ethyl ester	5.776	$C_9H_{16}O_3$	172	172.109944		57,73,81,101,127,144,154,172	Antipyretic and *anti-* inflammatory
11	Methyl 6-oxoheptanoate	6.011	$C_8H_{14}O_3$	158	158.094295		55,84,111,126,143	Unknown

Table 1. Cont'd

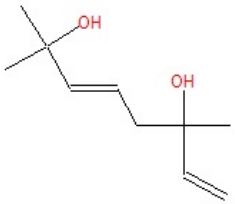
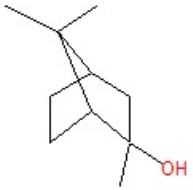
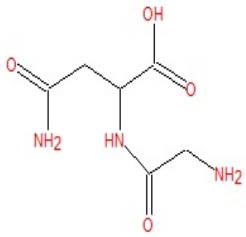
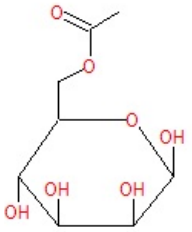
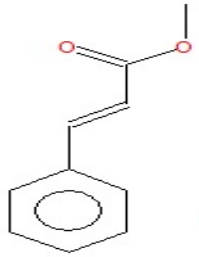
12	3,7-Octadiene-2,6-diol,2,6-dimethyl-	6.245	$C_{10}H_{18}O_2$	170	170.13068		55,59,67,71,82,91,109,125,137	*Anti*-tumour
13	Exo-2,7,7-trimethylbicyclo[2.2.1]heptan-2-ol	6.303	$C_{10}H_{18}O$	154	154.135765		55,81,93,121,136,154	*Anti-Candida*, *anti*-inflammatory and antidiabetic
14	Glycyl-D-asparagine	6.772	$C_6H_{11}N_3O_4$	189	189.074956		55,72,113,154	Acute *anti*-inflammatory effect
15	6-Acetyl-ß-d-mannose	6.932	$C_8H_{14}O_7$	222	222.073953		60,73,81,97,109,126,144,163,175,192	*Anti*-carcinogenic *effects*
16	2-Propenoic acid ,3-phenyl-,methyl ester , (E)-	7.744	$C_{10}H_{10}O_2$	162	162.06808		51,63,77,91,103,117,131,144,162	*Anti*-cancer agents

Table 1. Cont'd

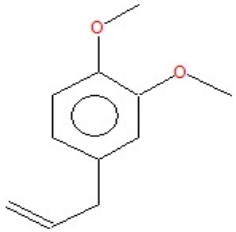
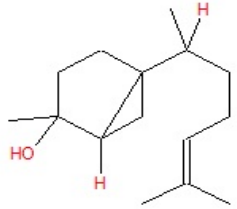
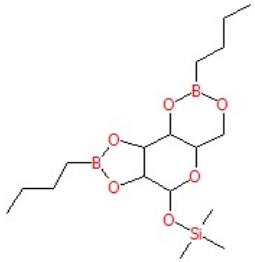
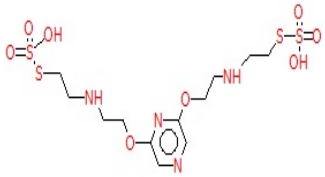
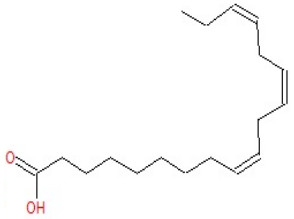
17	Methyleugenol	8.980	$C_{11}H_{14}O_2$	178	178.09938		51,65,77,103,147,163	*Anti*-inflammatory
18	7-epi-cis-sesquisabinene hydrate	9.404	$C_{15}H_{26}O_2$	222	222.198365		55,69,82,93,105,119,133,147,161,175,204,222	Significant *anti*-microbial activities
19	Mannopyranose , 1-O-(triethylsilyl)-, 2,3:4,6-dibutaneboronate	13.163	$C_{17}H_{34}B_2O_6Si$	384	384.231075		55,75,103,139,157,213,228,257,313,341,369	New chemical compound
20	2,6-Bis[2-[2-S-thiosulfuroethylamino]ethoxy]pyrazine	16.133	$C_{12}H_{22}N_4O_8S_4$	478	478.032047		60,88,124,163,195,213,259,317,349	Unknown
21	9,12,15-Octadecatrienoic acid , (Z,Z,Z)-	17.031	$C_{18}H_{30}O_2$	278	278.22458		55,67,79,93,108,121,135,222,249,278	Antioxidant, *anti*-inflammatory, antimicrobial, pesticide and cancer preventive.

Table 1. Cont'd

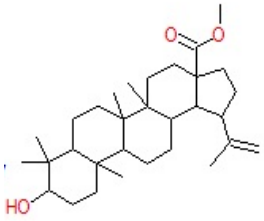
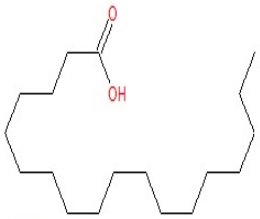
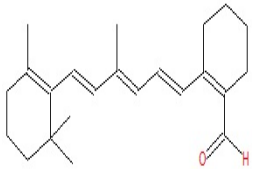
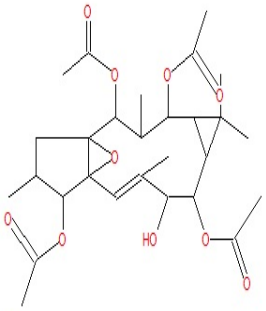
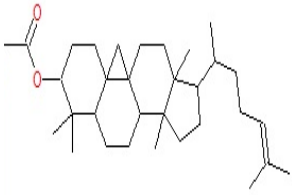
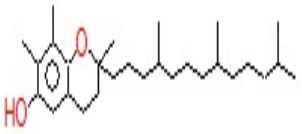
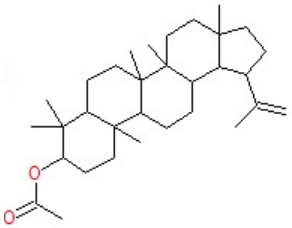
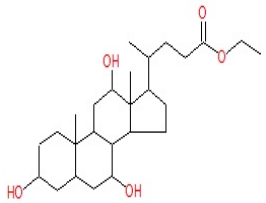
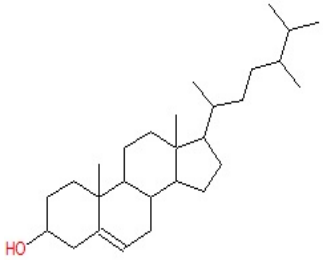
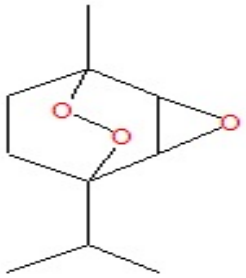
22	Lup-20(29)-en-28-oic acid , 3-hydroxy-, methyl ester , (3ß)-	17.317	$C_{31}H_{50}O_3$	470	470.375996		107,175,189,207,220,262,341,411,452,470	*Anti*-bacterial
23	Octadecanoic acid	17.186	$C_{18}H_{36}O_2$	284	284.27153		60,73,83,97,115,129,143,157,171,185,199,227,241,255,284	Antiviral and *anti*-inflammatory activities
24	2-[4-methyl-6-(2,6,6-trimethylcyclohex-1-enyl)hexa-1,3,5-trienyl]cyclol	17.369	$C_{23}H_{32}O$	324	324.245316		55,69,79,91,105,135,173,187,239,269,324	Unknown
25	9-Desoxo-9-x-acetoxy-3,8,12-tri-acetylingol	21.946	$C_{28}H_{40}O_{10}$	536	536.262146		55,69,122,207,236,297,357,417,477	*Anti*-macrofouling
26	9,12-Cyclolanost-24-en-3-ol, acetate,(3ß)-	23.497	$C_{32}H_{52}O_2$	468	468.39673		55,69,81,95,175,203,231,286,408,468	*Anti*-inflammatory

Table 1. Cont'd

27	y-Tocopherol	25.231	$C_{28}H_{48}O_2$	416	416.36543		57,107,135,151,191,205,232,260,288,316,344,372,416	*Anti*-inflammatory properties
28	Lup-20(29)-en-3-ol,acetate,(3ß)-	26.467	$C_{32}H_{52}O_2$	468	468.39673		55,69,81,95,189,218,249,298,357,408,453,468	*Anti*-inflammatory *effects*
29	Ethyl iso – allocholate	26.890	$C_{26}H_{44}O_5$	436	436.318874		55,69,81,95,253,400,418	Antimicrobial, *anti*-inflammatory, cancer preventive and antifouling agents
30	Campesterol	28.229	$C_{28}H_{48}O$	400	400.370516		55,81,145,161,213,255,289,315,382,400	*Anti*-oxidative, *anti*-inflammatory, immunomodulatory and antiviral properties.
31	Ascaridole epoxide	7.167	$C_{10}H_{16}O_3$	184	184.109944		55,69,79,91,97,107,117,135,150,168	*Anti*-carcinogenic *effects*

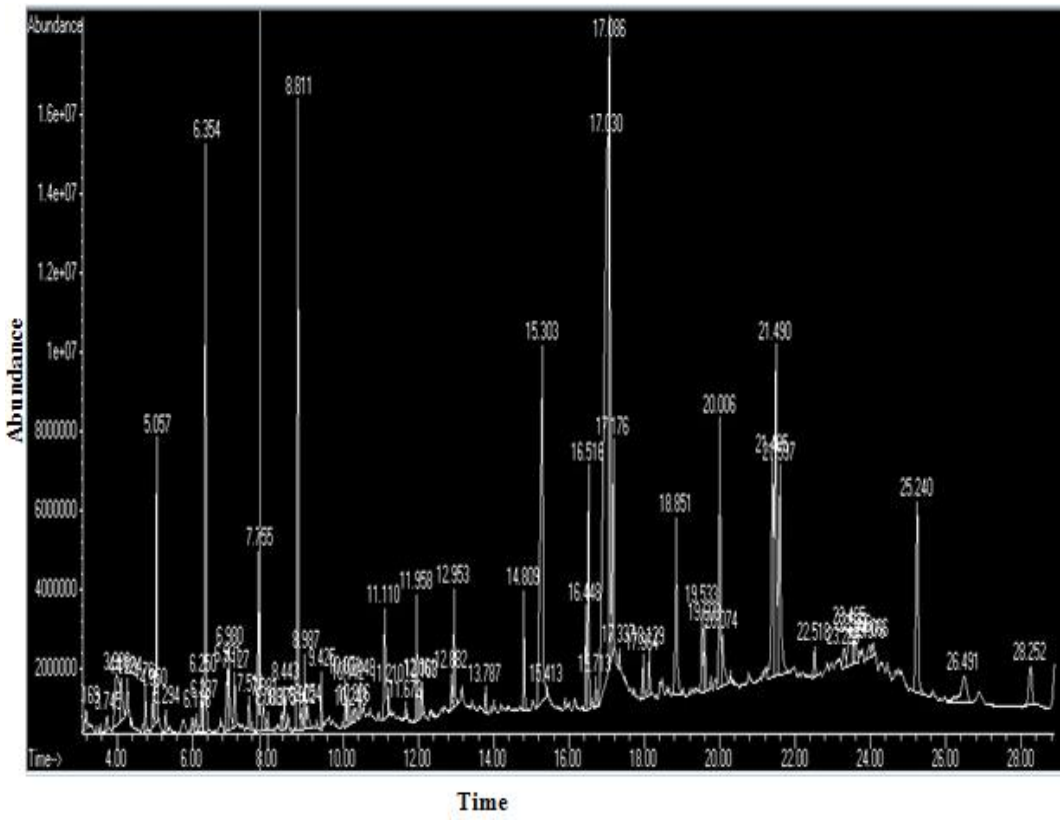


Figure 1. GC-MS chromatogram of methanolic extract of *Ocimum basilicum*.

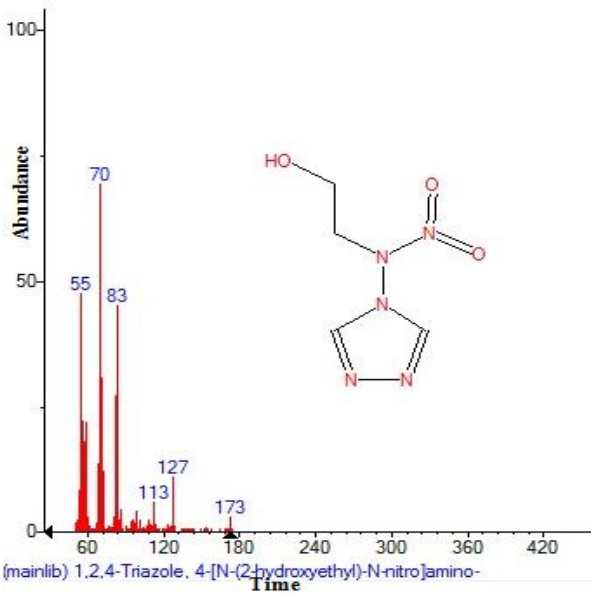


Figure 2. Structure of 1,2,4-Triazole, 4-[N-(2-hydroxyethyl)-N-nitro]amino with 3.196 (RT) present in *Ocimum basilicum*.

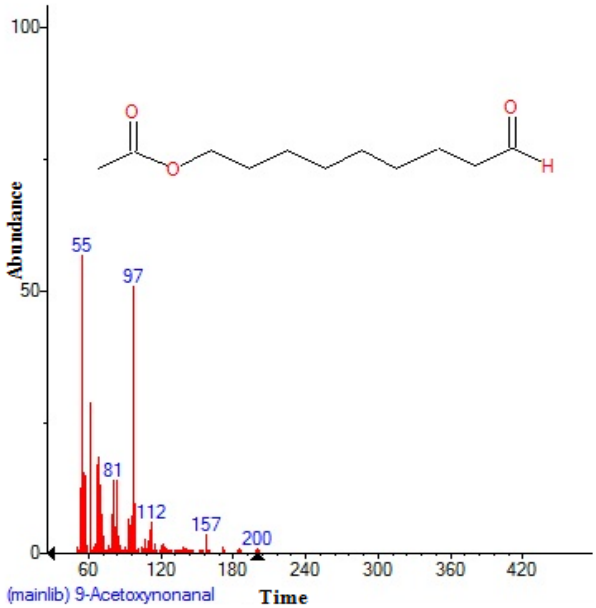


Figure 3. Structure of 9-Acetoxynonanal with 3.459 (RT) present in *Ocimum basilicum*.

as follows. The first set up peak were determined to be 1,2,4-Triazole (Figure 2). The second peak indicated to be 4-[N-(2-hydroxyethyl)-N-nitro]amino (Figure 3). The next peaks were considered to be, 9-Acetoxynonanal,

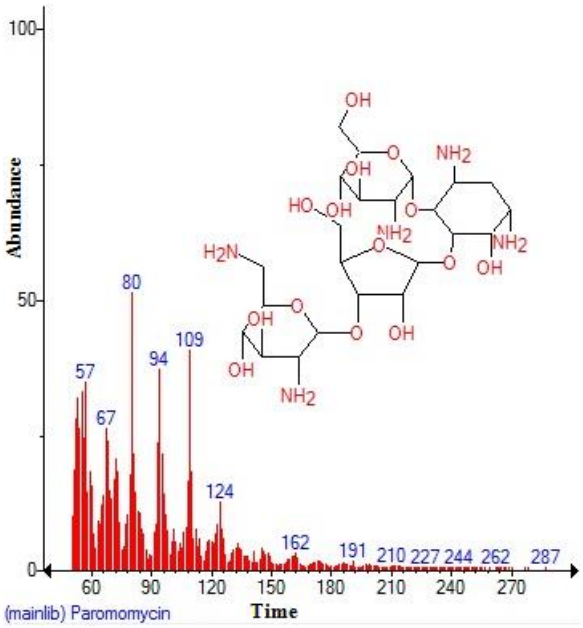


Figure 4. Structure of Paromomycin with 3.567 (RT) present in *Ocimum basilicum*.

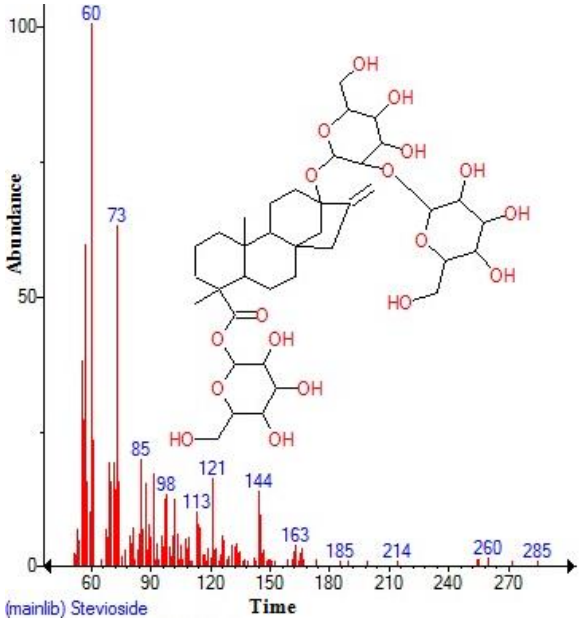


Figure 5. Structure of Stevioside with 3.773 (RT) present in *Ocimum basilicum*.

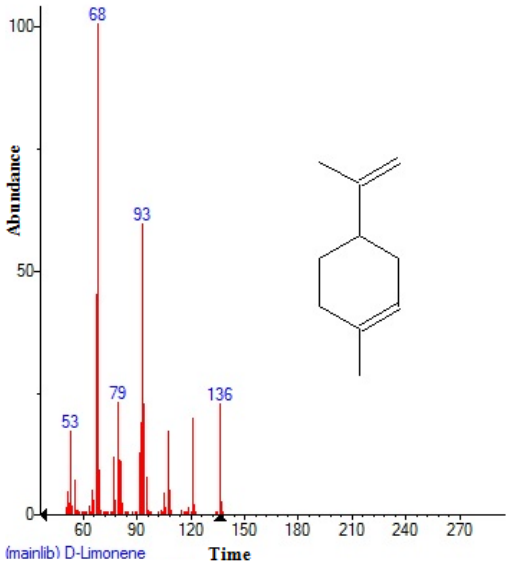


Figure 6. Structure of D-Limonene with 3.985 (RT) present in *Ocimum basilicum*.

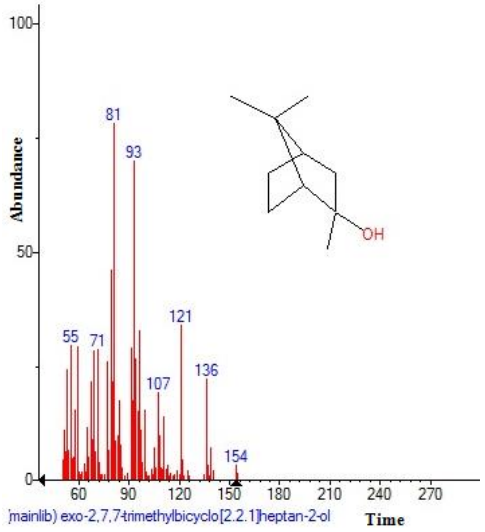


Figure 7. Structure of Exo-2,7,7-Trimethylbicyclo[2.2.1]heptan-2-ol with 4.300 (RT) present in *Ocimum basilicum*.

Paromomycin, Stevioside, D-Limonene, Exo-2,7,7-Trimethylbicyclo[2.2.1]heptan-2-ol, Dithiocarbamate, S-methyl-N-(2-methyl-3-oxobutyl)-, 1,6-Octadien-3-ol,3,7-dimethyl-, 13,16-Octadecadiynoic acid , methyl ester, Cyclohexanecarboxylic acid ,2-hydroxy-, ethyl ester, Methyl 6-oxoheptanoate, 3,7-Octadiene-2,6-diol,2,6-dimethyl-, Exo-2,7,7-trimethylbicyclo [2.2.1] heptan-2-ol, Glycyl-D-asparagine, 6-Acetyl-ß-d-mannose, 2-Propenoic acid, 3-phenyl-,methyl ester, (E)-, Methyleugenol, 7-epi-cis-sesquisabinene hydrate, Mannopyranose, 1-O-(triethylsilyl)-, 2,3:4,6-dibutaneboronate, 2,6-Bis[2-[2-S-thiosulfuroethylamino] ethoxy]pyrazine, 9,12,15-Octadecatrienoic acid , (Z,Z,Z)-, Lup-20(29)-en-28-oic acid, 3-hydroxy-, methyl ester, (3ß)-, Octadecanoic acid, 2-[4-methyl-6-(2,6,6-trimethylcyclohex-1-enyl)hexa-1,3,5-trienyl]cyclol, 9-Desoxo-9-x-acetoxy-3,8,12-tri-acetylingol, 9,12-Cyclolanost-24-en-3-ol, acetate,(3ß)-, y-Tocopherol, Lup-20(29)-en-3-ol,acetate,(3ß)-, Ethyl iso – allocholate, Campesterol and Ascaridole epoxide (Figures 4 to 32).

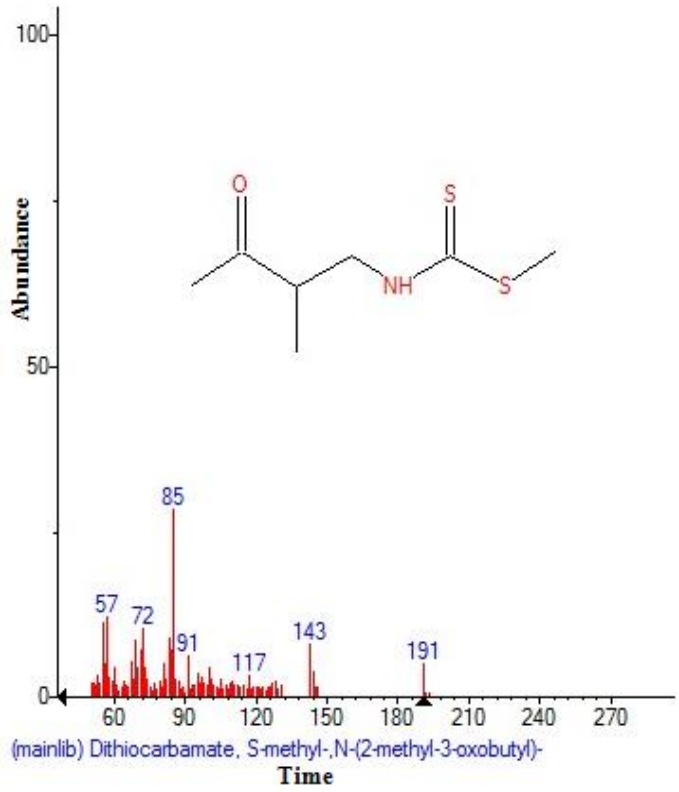


Figure 8. Structure of Dithiocarbamate , S-methyl-N-(2-methyl-3-oxobutyl) with 4.775 (RT) present in *Ocimum basilicum*.

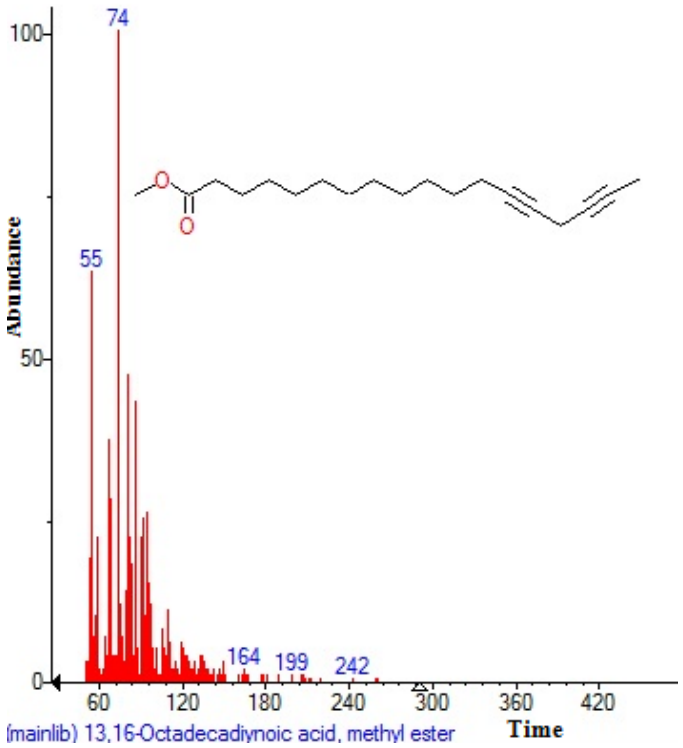


Figure 10. Structure of 13,16-Octadecadiynoic acid , methyl ester with 5.301 (RT) present in *Ocimum basilicum*.

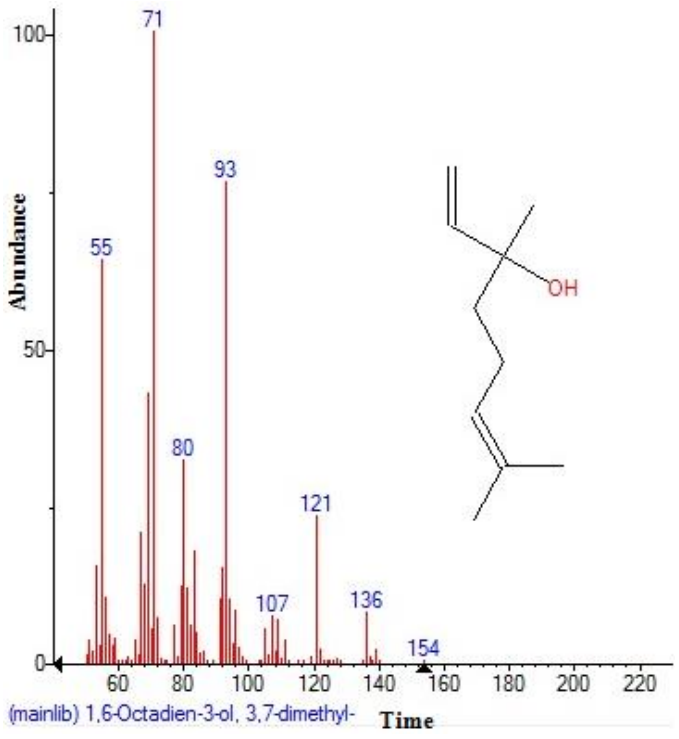


Figure 9. Structure of 1,6-Octadien-3-ol,3,7-dimethyl with 5.067 (RT) present in *Ocimum basilicum*.

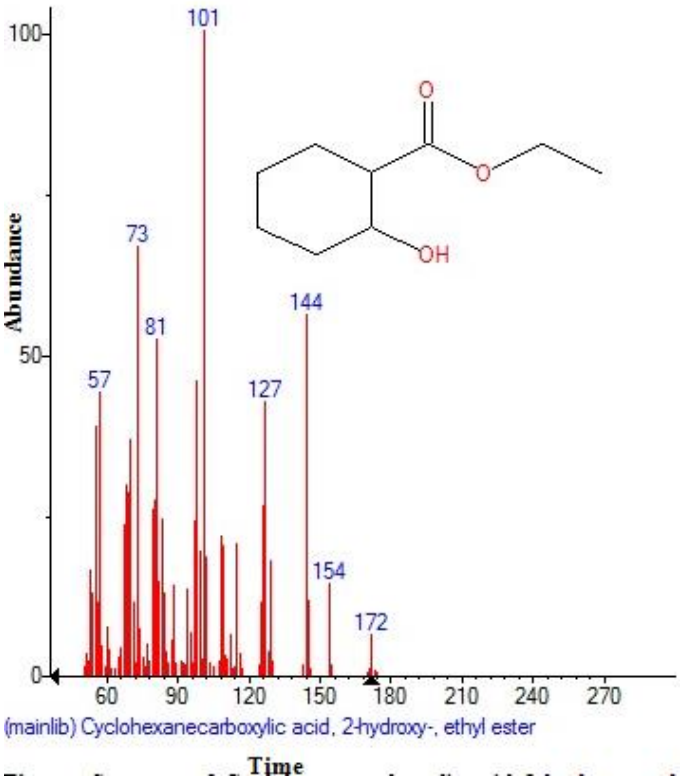


Figure 11. Structure of Cyclohexanecarboxylic acid ,2-hydroxy-, ethyl ester with 5.776 (RT) present in *Ocimum basilicum*.

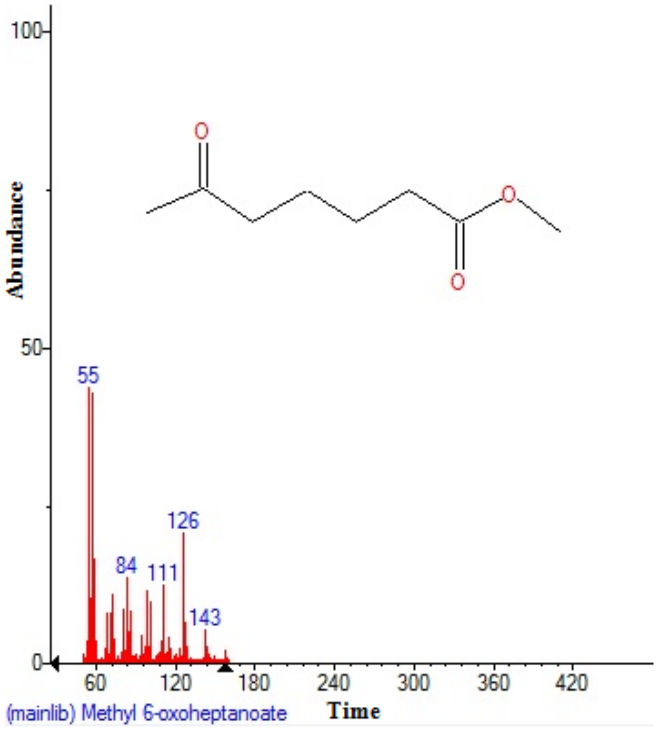


Figure 12. Structure of Methyl 6-oxoheptanoate with 6.011 (RT) present in *Ocimum basilicum*.

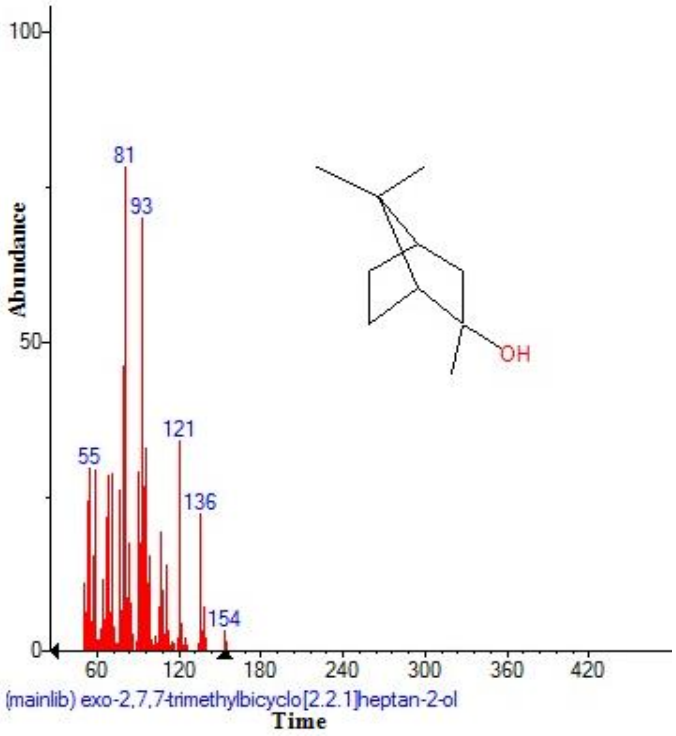


Figure 14. Structure of Exo-2,7,7-trimethylbicyclo[2.2.1]heptan-2-ol with 6.303 (RT) present in *Ocimum basilicum*.

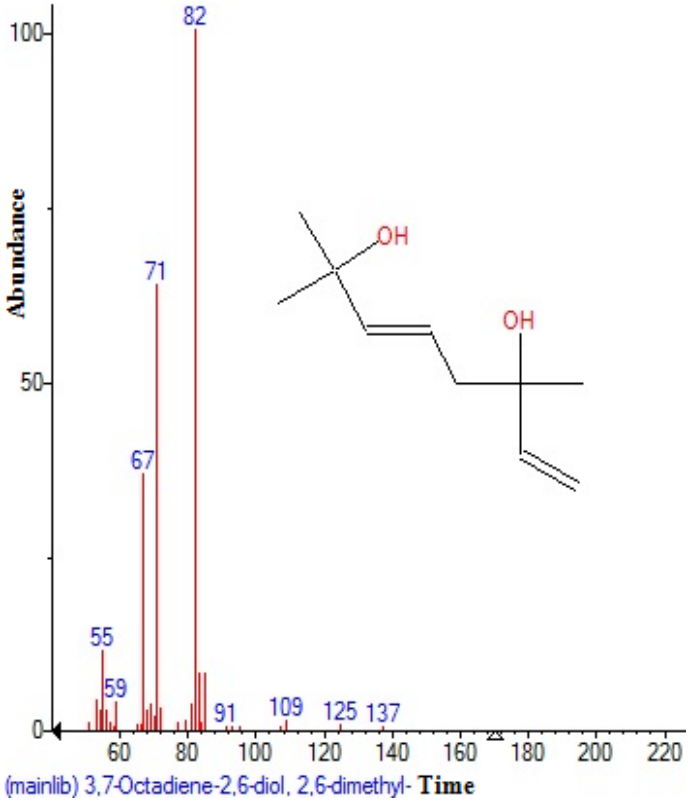


Figure 13. Structure of 3,7-Octadiene-2,6-diol,2,6-dimethyl with 6.245 (RT) present in *Ocimum basilicum*.

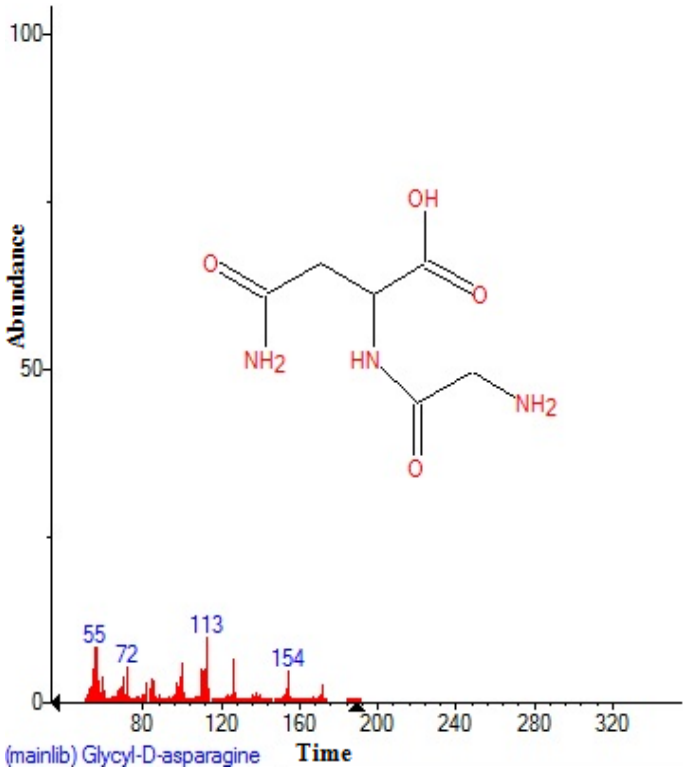


Figure 15. Structure of Glycyl-D-asparagine with 6.772 (RT) present in *Ocimum basilicum*.

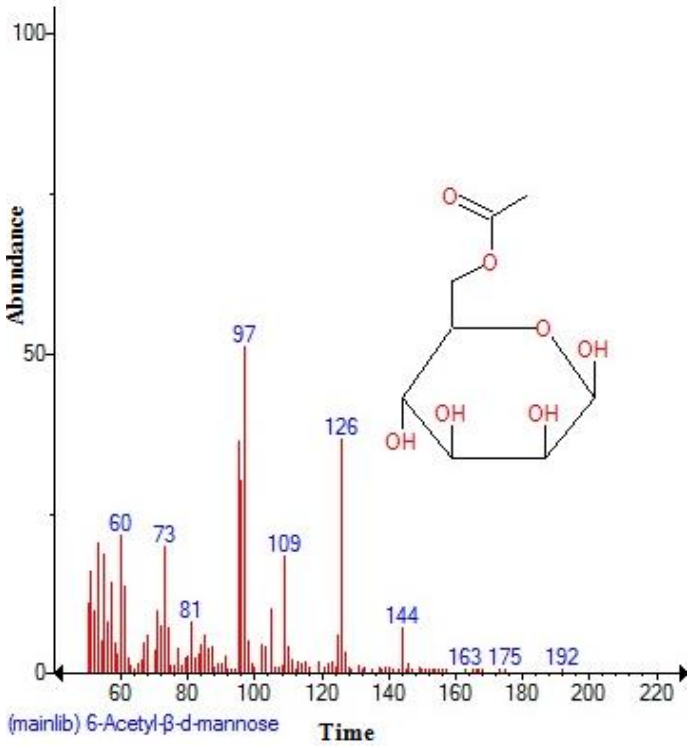


Figure 16. Structure of 6-Acetyl-ß-d-mannose with 6.932 (RT) present in *Ocimum basilicum*.

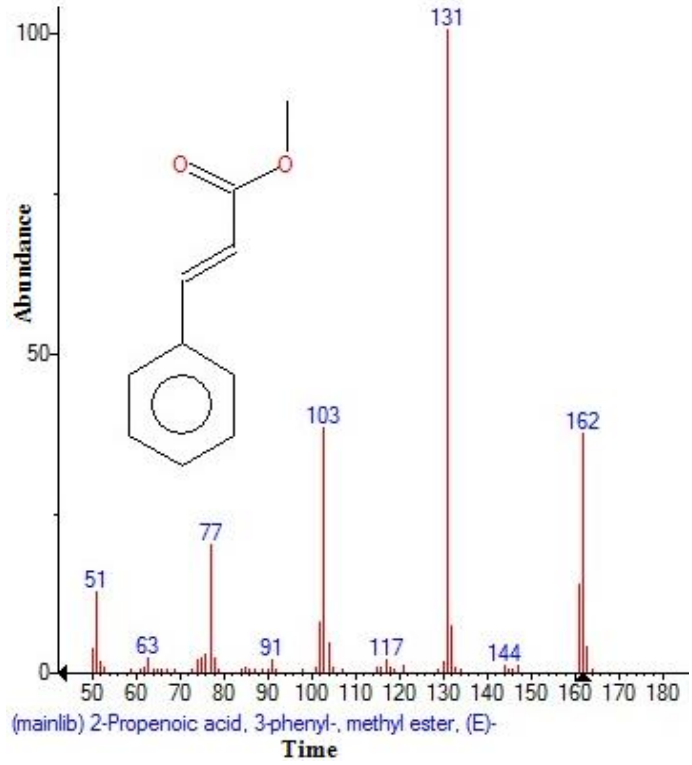


Figure 17. Structure of 2-Propenoic acid ,3-phenyl-,methyl ester , (E) with 7.744 (RT) present in *Ocimum basilicum*.

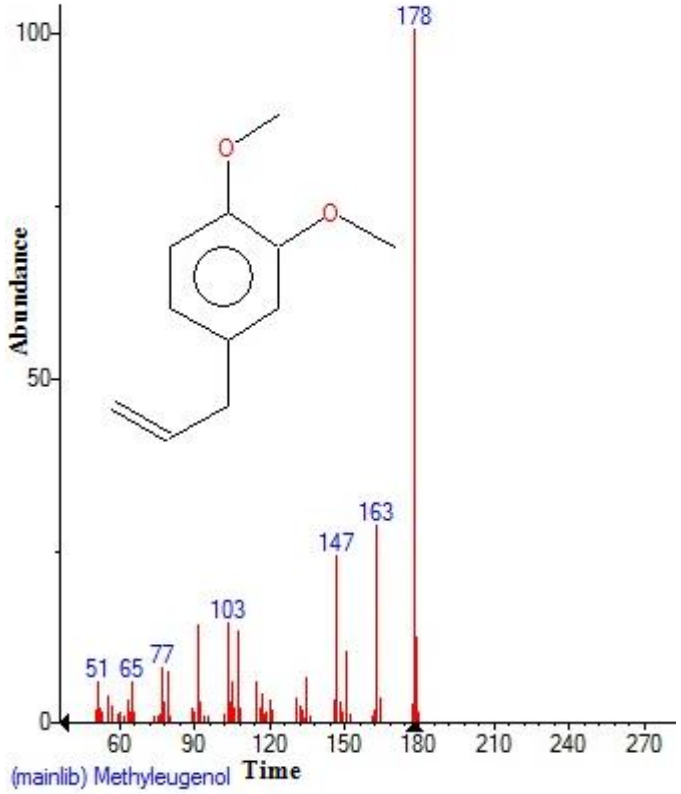


Figure 18. Structure of Methyleugenol with 8.980 (RT) present in *Ocimum basilicum*.

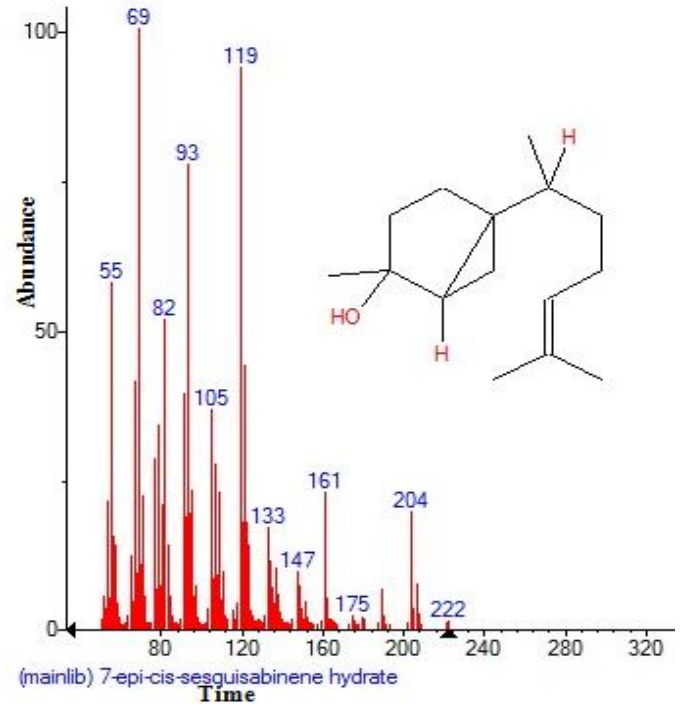


Figure 19. Structure of 7-epi-cis-sesquisabinene hydrate with 9.404 (RT) present in *Ocimum basilicum*.

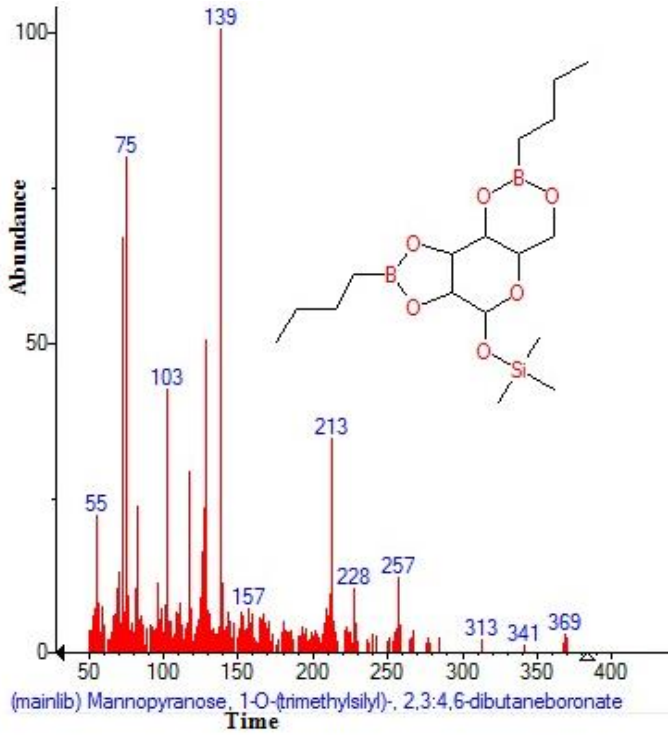


Figure 20. Structure of Mannopyranose , 1-O-(triethylsilyl)-, 2,3:4,6-dibutaneboronate with 13.163 (RT) present in *Ocimum basilicum*.

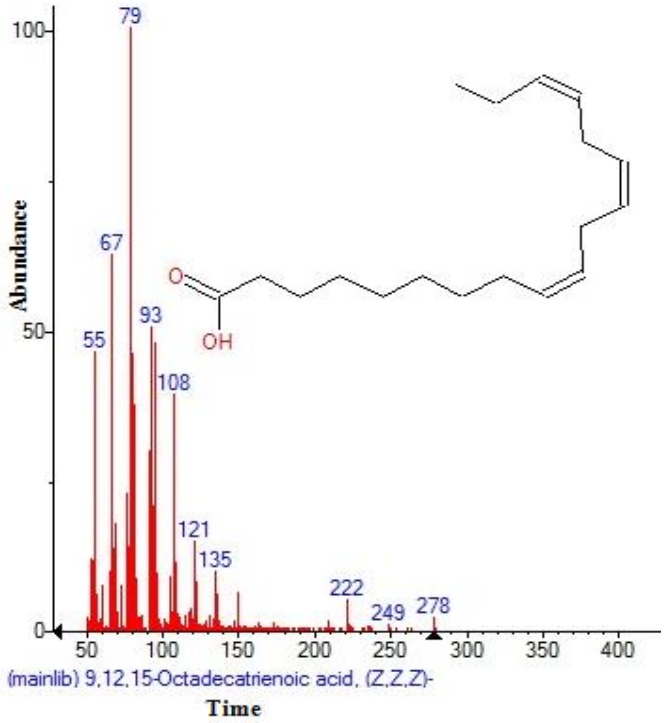


Figure 22. Structure of 9,12,15-Octadecatrienoic acid , (Z,Z,Z) with 17.031 (RT) present in *Ocimum basilicum*.

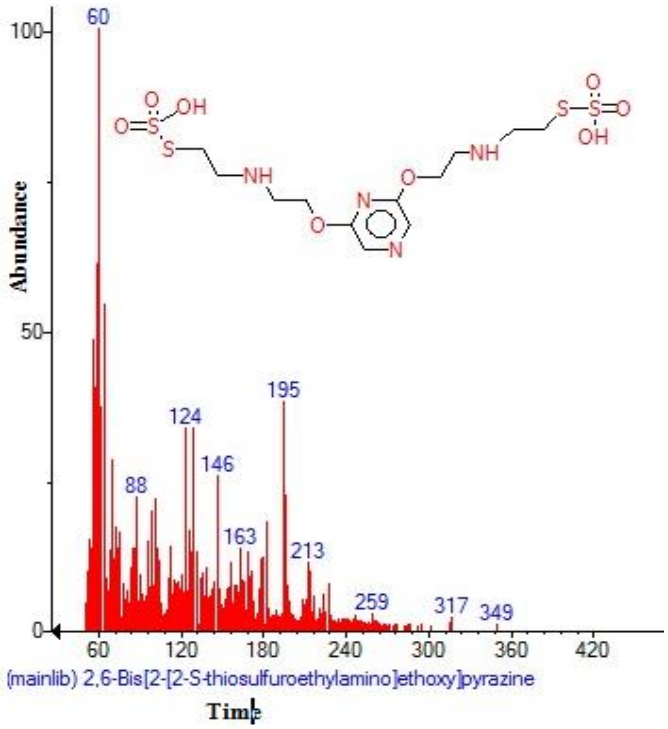


Figure 21. Structure of 2,6-Bis[2-[2-S-thiosulfuroethylamino]ethoxy]pyrazine with 16.133 (RT) present in *Ocimum basilicum*.

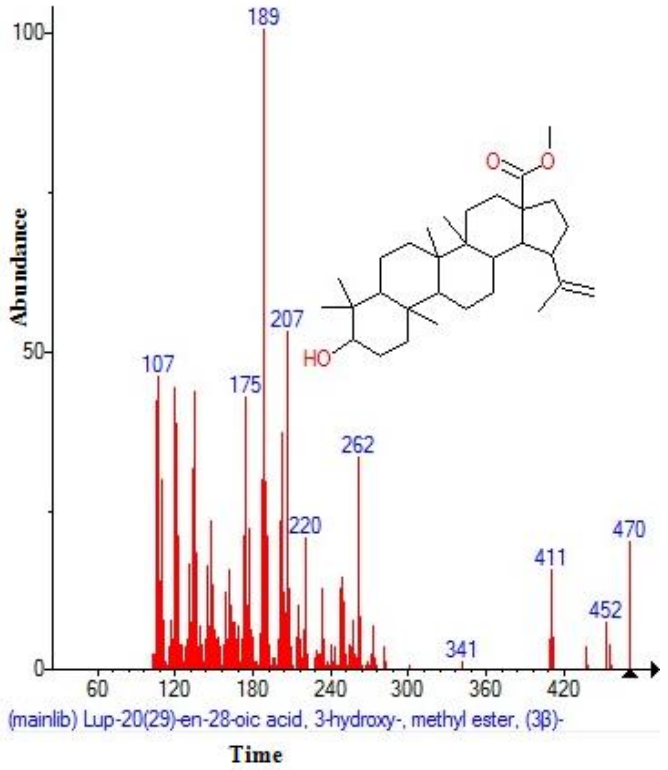


Figure 23. Structure of Lup-20(29)-en-28-oic acid , 3-hydroxy-, methyl ester , (3ß) with 17.317 (RT) present in *Ocimum basilicum*.

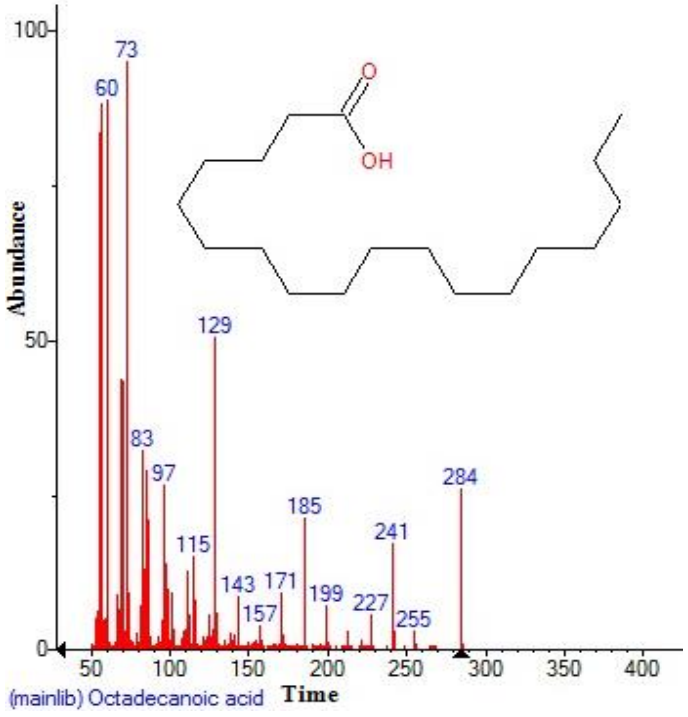


Figure 24. Structure of Octadecanoic acid with 17.186 (RT) present in *Ocimum basilicum*.

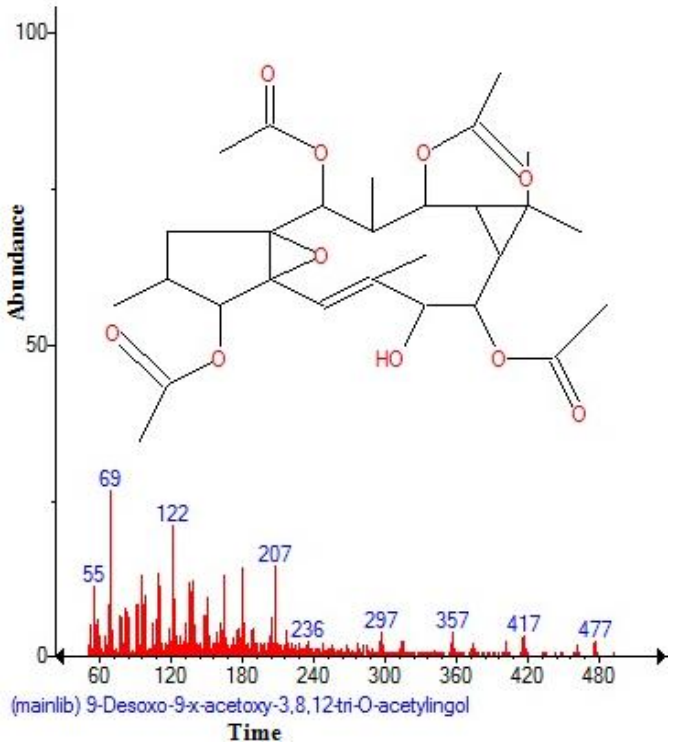


Figure 26. Structure of 9-Desoxo-9-x-acetoxy-3,8,12-tri-acetylingol with 21.946 (RT) present in *Ocimum basilicum*.

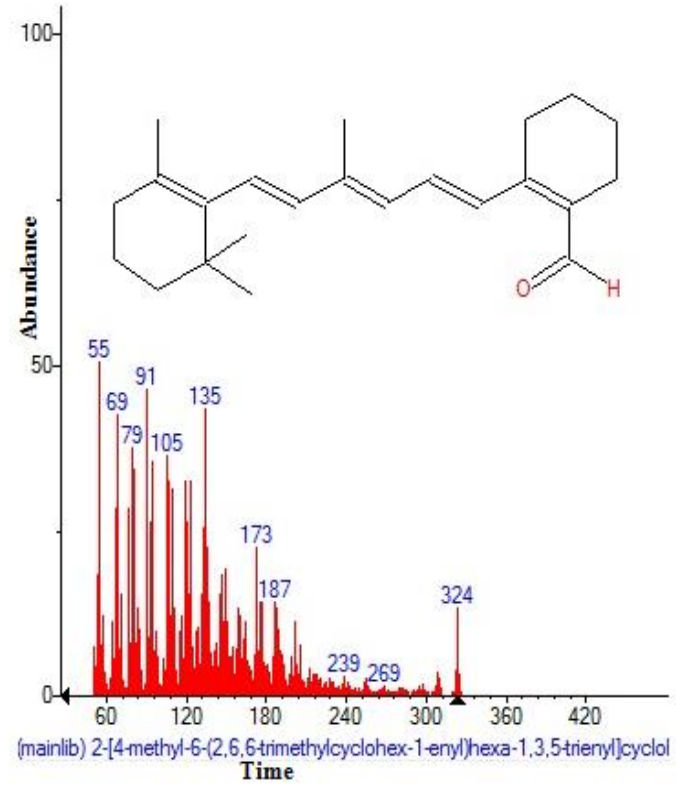


Figure 25. Structure of 2-[4-methyl-6-(2,6,6-trimethylcyclohex-1-enyl)hexa-1,3,5-trienyl]cyclol with 17.369 (RT) present in *Ocimum basilicum*.

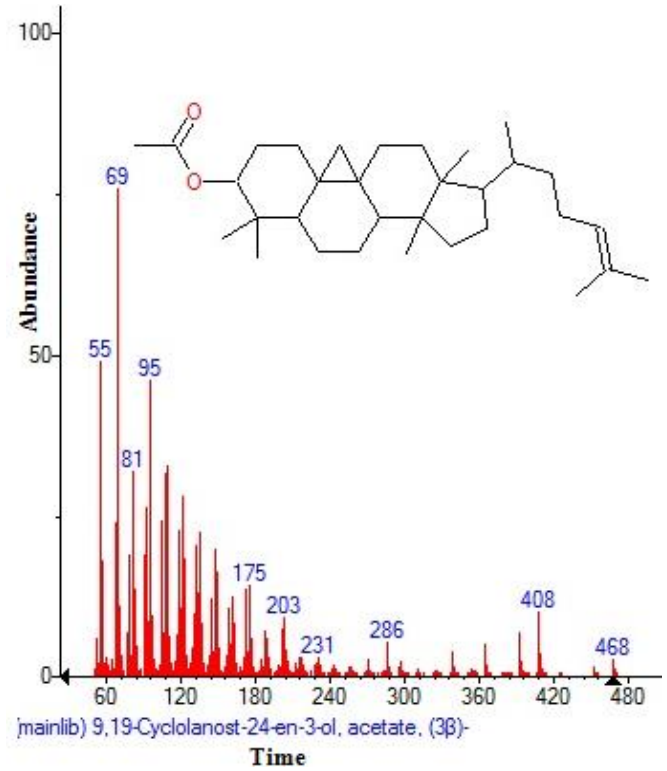


Figure 27. Structure of 9,12-Cyclolanost-24-en-3-ol, acetate,(3ß) with 23.497 (RT) present in *Ocimum basilicum*.

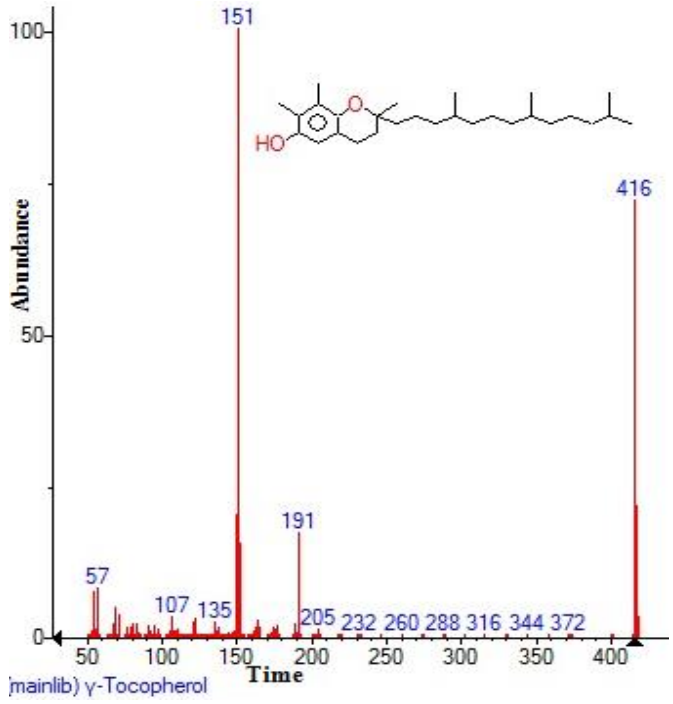


Figure 28. Structure of γ-Tocopherol with 25.231 (RT) present in *Ocimum basilicum*.

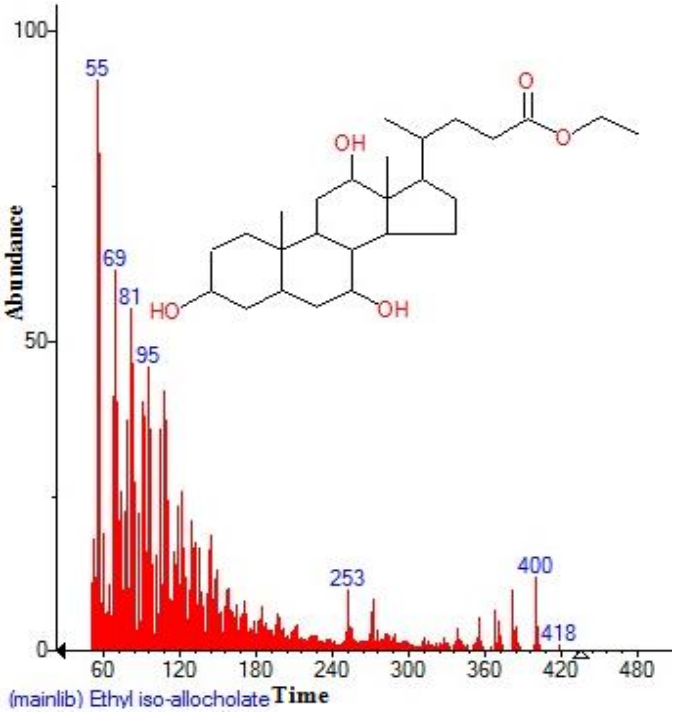


Figure 30. Structure of Ethyl iso – allocholate with 26.890 (RT) present in *Ocimum basilicum*.

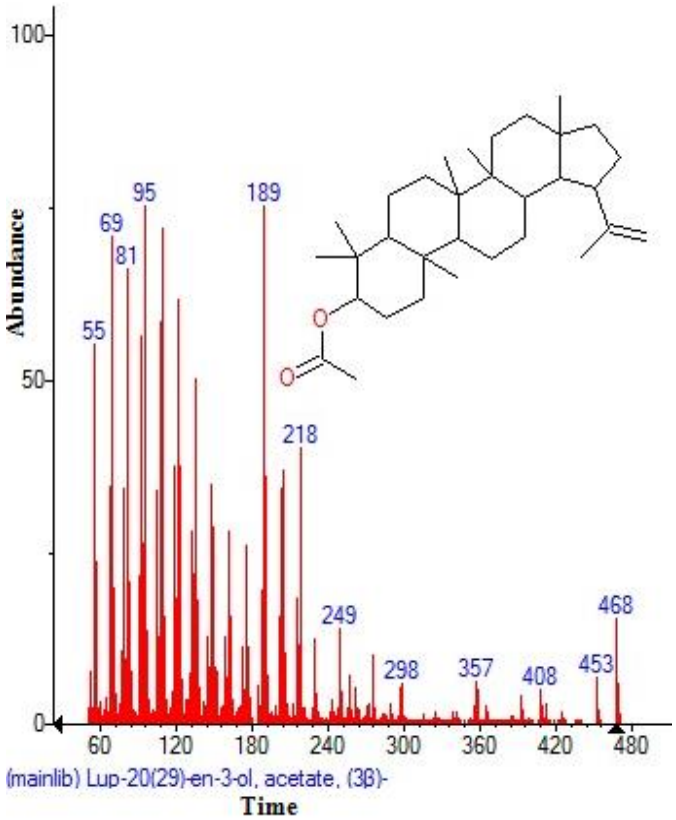


Figure 29. Structure of Lup-20(29)-en-3-ol,acetate,(3ß) with 26.467 (RT) present in *Ocimum basilicum*.

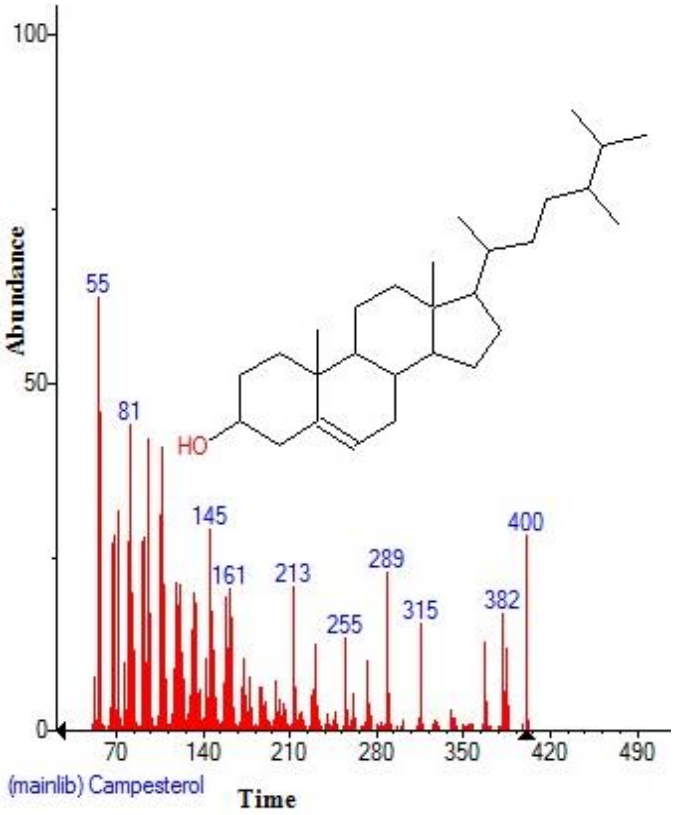


Figure 31. Structure of Campesterol with 28.229 (RT) present in *Ocimum basilicum*.

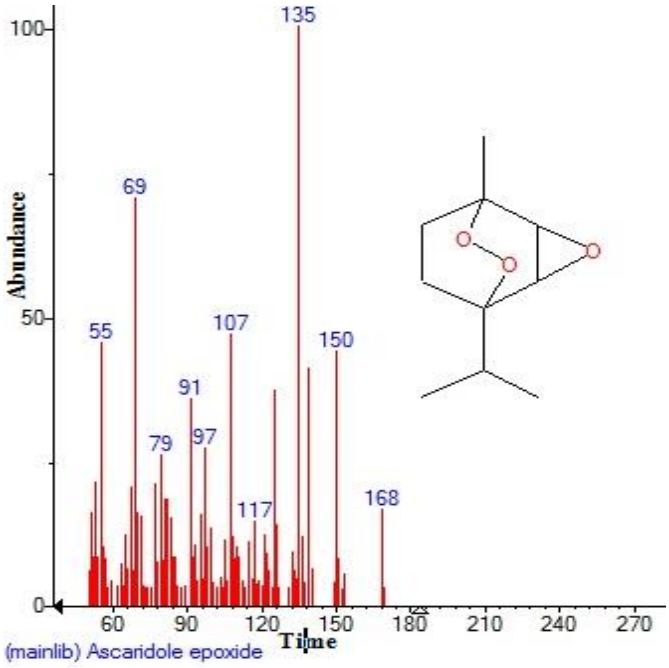


Figure 32. Structure of Ascaridole epoxide with 7.167 (RT) present in *Ocimum basilicum*.

Table 2. FT-IR peak values of *Ocimum basilicum* methanolic aerial parts extract.

No.	Peak (Wave number cm-ˡ)	Intensity	Bond	Functional group assignment	Group frequency
1	665.44	61.240	-	Unknown	-
2	1028.06	60.648	C-F stretch	Aliphatic fluoro compounds	1000-1050
3	1095.57	64.096	C-O	Alcohols, ethers, carboxlic acids, esters	1050-1300
4	1139.93	67.976	C-O	Alcohols, ethers, carboxlic acids, esters	1050-1300
5	1155.36	67.976	C-O	Alcohols, ethers, carboxlic acids, esters	1050-1300
6	1238.30	72.739	C-O	Alcohols, ethers, carboxlic acids, esters	1050-1300
7	1317.38	76.675	NO_2	Nitro compounds	1300-1370
8	1361.74	75.877	NO_2	Nitro compounds	1300-1370
9	1396.46	75.235	C-H	Alkanes	1340-1470
10	1616.35	74.205	-	Unknown	-
11	1734.65	72.915	-	Unknown	-
12	2852.72	79.425	C-H	Alkanes	2850-2970
13	2924.09	73.457	C-H	Alkanes	2850-2970
14	3010.88	84.980	H-O	H-bonded H-X group	2500-3500
15	3196.05	83.617	H-O	H-bonded H-X group	2500-3500
16	3275.13	81.882	O-H	Hydrogen bonded alcohols, phenols	3200-3600

The FTIR analysis of *O. basilicum* aerial parts proved the presence of aliphatic fluoro compounds, alcohols, ethers, carboxlic acids, esters, nitro compounds, alkanes, H-bonded H-X group, hydrogen bonded alcohols and phenols which shows major peaks at 1028.06, 1095.57, 1238.30, 1317.38, 1396.46, 1396.46, 1616.35, 3010.88 and 3275.13 (Table 2 and Figure 33). Baritaux et al. (1992) isolated and analyzed essential oil from basil (*O. basilicum*) by steam distillation, then it were recovered into a pentane/dichlorometane mixture containing known amounts of two internal standards, nonane and octadecane. Laakso et al. (1990) analyzed essential oil from holy basil by two extraction methods steam distillation and water distillation. The essential oil was identified into 20 different compounds by GC-MS and GCFTIR. They contained high amounts of eugenol

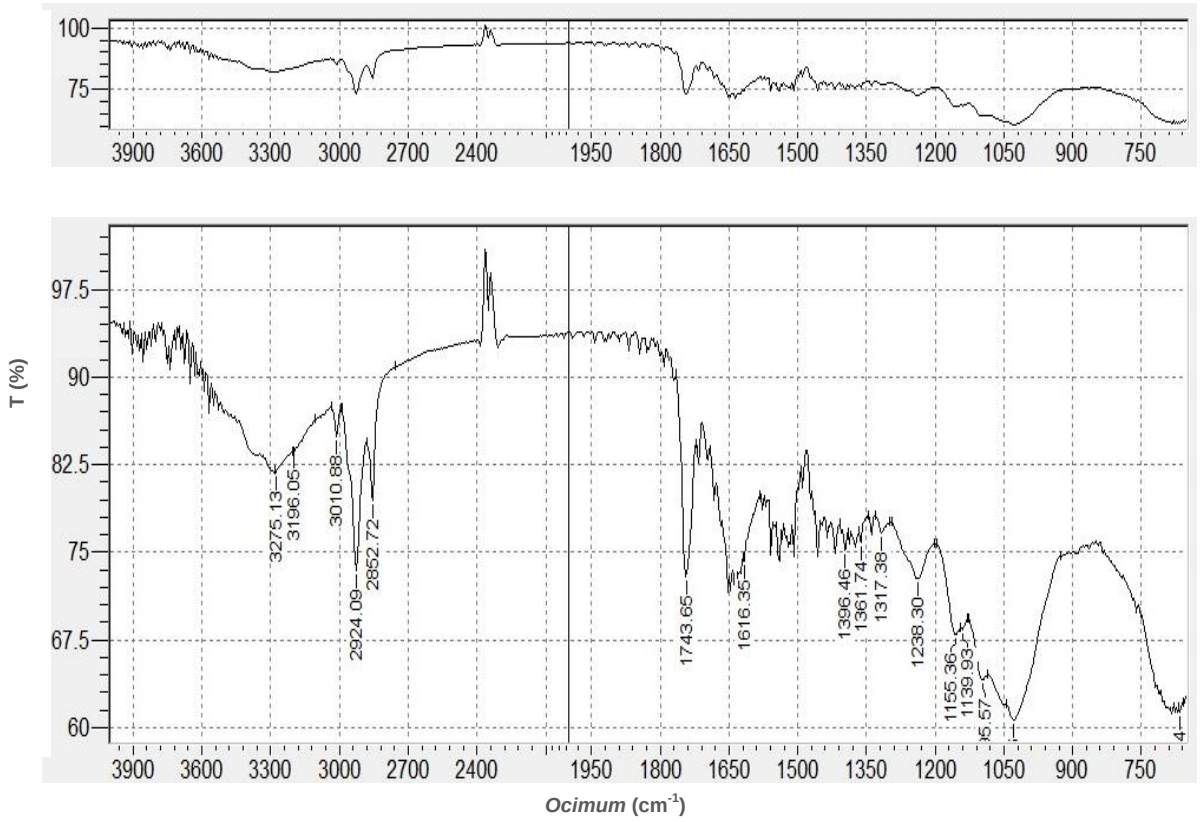


Figure 33. FT-IR peak values of *Ocimum basilicum*.

Table 3. Zone of inhibition (mm) of test bacterial strains to *Ocimum basilicum* bioactive compounds and standard antibiotics.

***Ocimum basilicum* antibiotics**	**Bacteria**				
	Staphylococcus aureus	***Escherichia coli***	***Proteus mirabilis***	***Klebsiella pneumonia***	***Pseudomonas eurogenosa***
Ocimum basilicum	5.00±0.21	5.70±0.10	4.30±0.20	4.22±0.23	4.17±0.44
Rifambin	0.89±0.22	0.86±0.31	1.00±0.35	0.96±0.26	2.00±0.06
Streptomycin	1.09±0.33	1.44±0.29	0.99±0.28	1.00±0.47	1.64±0.30
Kanamycin	0.55±0.29	0.98±0.28	2.01±0.12	0.69±0.23	1.50±0.18
Cefotoxime	1.57±0.27	1.86±0.32	1.03±0.24	1.00±0.23	0.95±0.27

(24.2%), β-bisabolenes (15.4%), α-bisabolenes (10.6%) and methyl chavicol (11.16%), but methyleugenol could not be detected. Raju *et al*. (1999) analyzed bioactive chemical compounds isolated in the leaves of basil from India by GC and GC-MS. Twenty-five components were found from 98.7% total oil area. Eugenol (53.4%), β-caryophyllene (31.7%) and β-elemene were found as the major components. Essential oils are extracted from various aromatic plants generally located in temperate to warm countries, like Brazil, where they represent an important part of the traditional pharmacopoeia due to their important biological activities (Morales and Simon, 1996; Phippen and Simon, 1998). An important approach to discover new medicines is survey of natural products, such as medicinal plants or their secondary metabolites that modulate painful conditions (Baratta et al., 1998; Chiang et al., 2005).

Previous studies (Bakkali et al., 2008; Quintans-Júnior et al., 2008; Oliveira et al., 2009; Li and Vederas, 2009; Venâncio et al., 2011) have demonstrated that several *Ocimum* species are used to treat central nervous system (CNS) disorders in various regions of the world, mainly in developing countries, and their analgesic profile is frequently reported. In this study, five clinical pathogens were selected for antibacterial activity, namely, *S. aureus, K. pneumoniae, P. aeruginosa, E. coli* and *Proteus mirabilis*. Maximum zone formation is against *E. coli* (5.70±0.10) (Table 3). Essential oils derived from several

Ocimum spp. have been reported to be active against several Gram-positive and Gram-negative bacteria as well as against yeasts and fungi due to their terpenic constituents. Recently, essential oils and extracts of certain plants have been shown to have antimicrobial effects as well as imparting flavour to foods (Zhang et al., 2009; Shareef et al., 2016; Kadhim et al., 2016). *Ocimum* spp. contain a wide range of essential oils rich in phenolic compounds and a wide array of other natural products including polyphenols such as flavonoids and anthocyanins. Antiviral and antimicrobial activities of this plant have also been reported (Li and Vederas, 2009; Venâncio et al., 2011).

Conclusion

The results of this study provide data on phytochemical characteristics of *O. basilicum*. *O. basilicum* is native plant of Iraq. It contains chemical constitutions which may be useful for various herbal formulation as anti-inflammatory, analgesic, antipyretic, cardiac tonic and antiasthamatic.

Conflict of interest

The authors have not declared any conflict of interest

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