

## Full Length Research Paper

# Analysis of bioactive chemical compounds of *Euphorbia lathyris* using gas chromatography-mass spectrometry and Fourier-transform infrared spectroscopy

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The aim of this study was determination the phytochemical composition of methanolic seeds extract of *Euphorbia lathyris*. Gas chromatography-mass spectrometry (GC-MS) analysis of *E. lathyris* revealed the existence of the Carbonic acid, (ethyl)(1,2,4-triazol-1-ylmethyl) diester, 1H-Pyrrole,2,5-dihydro-1-nitroso, Hexanal dimethyl acetal, Isosorbide dinitrate, DL-Arabinose, Cyclopropane,1-fluoro-1-(2-bromoethenyl)-2,2,3,3-tetramethyl,  $\alpha$ -D-Glucopyranoside, O- $\alpha$ -D-glucopyranosyl-(1.fwdarw.3)- $\beta$ -d-fruc, Desulphosinigrin, D-Glucose, 6-O- $\alpha$ -D-galactopyranosyl, Octanoic acid, Benzofuran,2,3-dihydro, 6-Acetyl- $\beta$ -d-mannose, Estragole, Ascaridole epoxide, 3-Allyl-6-methoxyphenol, 4-Amino-1,5,pentandioic acid, l-Gala-l-ido-octonic lactone,  $\gamma$ -Sitosterol, Tetradecanoic acid, l-(+)-Ascorbic acid 2,6-dihexadecanoate, Estra -1,3,5(10)-trien-17 $\beta$ -ol, Propanoic acid,2-(3-acetoxy-4,4,14-trimethylandrost-8-en-17-yl), Cis-13-Eicosenoic acid, Eicosanoic acid, 3-Pyrinecarboxylic acid, 2,7,10-tris(acetyloxy)-1,1a,2,3,4,6,7,10, Oleic acid, eicosyl ester, Butanoic acid, 4-chloro-,1,1a,1b,4,4a,5,7a,7b,8,9-decahydro-4a, Ethyl iso-allocholate, Ethyl iso -allocholate, Olean-12-ene-3,15,16,21,22,28-hexol, (3 $\beta$ ,15 $\alpha$ ,16 $\alpha$ ,21 $\beta$ ,22 $\alpha$ )- and 2,4,6-Decatrienoic acid,1a,2,5,5a,6,9,10,10a-octahydro-5,5a-dihy. The Fourier-transform infrared spectroscopy (FTIR) analysis of *E. lathyris* seeds proved the presence of alkenes, aliphatic fluoro compounds, alcohols, ethers, carboxlic acids, esters, nitro compounds, alkanes, hydrogen bonded alcohols, and phenols.

**Key words:** Gas chromatography-mass spectrometry (GC/MS), bioactive compounds, Fourier-transform infrared spectroscopy (FT-IR), *Euphorbia lathyris*.

## INTRODUCTION

Medicinal plant parts (roots, leaves, branches/stems, barks, flowers, and fruits) are commonly rich in phenolic

compounds, such as flavonoids, phenolic acids, stilbenes, tannins, coumarins, lignans and lignins (Cai et

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al., 2004; Altameme et al., 2015a; Al-Marzoqi et al., 2015). The seed of *Euphorbia lathyris* is a traditional Chinese medicine which has been used for the treatment of hydropsy, ascites, anuresis and constipation, amenorrhea, and scabies (Liu et al., 2011). Nowadays, traditional medicinal practices form an integral part of complementary or alternative medicine. Although their efficacy and mechanisms of action have not been tested scientifically in most cases, these simple medicinal preparations often mediate beneficial responses due to their active chemical constituents (Park and Pezzutto, 2002; Corro et al., 2014; Hameed et al., 2015a). In recent years, it was reported that the seeds of *Euphorbia* had a significant effect on leukemia, esophageal carcinoma, and skin cancer (Tapiero et al., 2002; Liu et al., 2011; Al-Marzoqi et al., 2016). The seed of *E. lathyris* is a kind of toxic traditional Chinese medicine, which is characterized by pungent, warm and poisonous in drug properties. It shows several side effects, such as irritation and inflammation intense on the skin, mouth and gastrointestinal tract irritation, carcinogenic, etc. (Buenz et al., 2004; Altameme et al., 2015b). The objective of this study was to analyse the chemical composition of seeds extract from methanol. The phytochemical compound was screened by gas chromatography-mass spectrometry (GC-MS) and Fourier-transform infrared spectroscopy (FT-IR) technique.

## MATERIALS AND METHODS

### Plant and preparation of extracts

*E. lathyris* dried seeds were purchased from local market in hilla city, middle of Iraq. After thorough cleaning and removal of foreign materials, the fruits were stored in airtight container to avoid the effect of humidity and then stored at room temperature until further use. About 30 g of the plant sample powdered were soaked in 100 ml methanol for 16 h in a rotatory shaker (Hamza et al., 2015; Hussein et al., 2016a). Whatman No.1 filter paper was used to separate the extract of plant. The filtrates were used for further phytochemical analysis. It was again filtered through sodium sulphate in order to remove the traces of moisture (Altameme et al., 2015c; Hameed et al., 2015b).

### Identification of component by GC-MS analysis

The physicochemical properties of *E. lathyris* are shown in Table 1. Interpretation of mass spectroscopy (GC-MS) was conducted by using data base of National Institute Standard and Technology (NIST) having more than 62000 patterns. The spectrum of the unknown component was compared with the spectrum of the known component stored in the NIST library. 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 (Hadi et al., 2016; Hameed et al., 2015c; Hussein et al., 2016b). The GC-MS analysis of the plant extract was made in an 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. The fragments obtained were actually charged ions with a certain mass

(Hameed et al., 2015d; Hussein et al., 2016c). Helium gas was used as a carrier as well as an eluent. The flow rate of helium was set to 1 ml/min. The electron gun of mass detector liberated electrons having energy of about 70 eV. The column employed here for the separation of components was Elite 1 (100% dimethyl poly siloxane).

### Fourier transform infrared spectrophotometer (FTIR)

The powdered sample of *E. lathyris* specimen was treated for FTIR spectroscopy (Shimadzu, IR Affinity 1, Japan). The sample was run at infrared region between 400 and 4000 nm (Hussein et al., 2016; Jasim et al., 2015).

## RESULTS AND DISCUSSION

Gas chromatography and mass spectroscopy analysis of compounds was carried out in methanolic seed extract of *E. lathyris* shown in Table 1. The GC-MS chromatogram of the 31 peaks of the compounds detected is as shown in Figure 1. Chromatogram GC-MS analysis of the methanol extract of *E. lathyris* showed the presence of thirty one major peaks and the components corresponding to the peaks were determined as follows. The first set up peak was determined to be Carbonic acid, (ethyl)(1,2,4-triazol-1-ylmethyl) diester (Figure 2). The next peaks were considered to be 1H-Pyrrole,2,5-dihydro-1-nitroso, Hexanal dimethyl acetal, Isosorbide dinitrate, DL-Arabinose, Cyclopropane,1-fluoro-1-(2-bromoethenyl)-2,2,3,3-tetramethyl, α-D-Glucopyranoside, O-α-D-glucopyranosyl - (1.fwdarw.3) - β - d-fruc, Desulphosinigrin, D-Glucose, 6-O-α-D-galactopyranosyl, Octanoic acid, Benzofuran,2,3-dihydro, 6-Acetyl-β-d-mannose, Estragole, Ascaridole epoxide, 3-Allyl-6-methoxyphenol, 4-Amino-1,5,pentandioic acid, l-Gala-l-ido-octonic lactone, γ-Sitosterol, Tetradecanoic acid, l-(+)-Ascorbic acid 2,6-dihexadecanoate, Estra-1,3,5(10)-trien-17β-ol, Propanoic acid,2-(3-acetoxy-4,4,14-trimethylandro-8-en-17-yl), Cis-13-Eicosenoic acid, Eicosanoic acid, 3-Pyridinecarboxylic acid, 2,7,10-tris(acetyloxy)-1,1a,2,3,4,6,7,10, Oleic acid, eicosyl ester, Butanoic acid, 4-chloro-,1,1a,1b,4,4a,5,7a,7b,8,9-decahydro-4a, Ethyl iso-allocholate, Ethyl iso - allocholate, Olean-12-ene-3,15,16,21,22,28-hexol, (3β,15α,16α,21β,22α)- and 2,4,6-Decatrienoic acid,1a,2,5,5a,6,9,10,10a-octahydro-5,5a-dihy (Figures 3 to 31). The FTIR analysis of *E. lathyris* seeds proved the presence of alkenes, aliphatic fluoro compounds, alcohols, ethers, carboxylic acids, esters, nitro compounds, alkanes, hydrogen bonded alcohols and phenols which shows major peaks at 837.11, 918.12, 1037.70, 1145.72, 1232.51, 1261.45, 1317.38, 1409.96, 1519.91, 1625.99, 1741.72, 2682.98, 2854.65, 2924.09, 3082.25, and 3275.13 (Table 2 and Figure 32). *E. lathyris* L. active for disinfection is an herbaceous plant of Euphorbiaceae and has been extensively researched in the field of medicine. Phenolic compounds were isolated and identified from *E. lathyris* using RP-HPLC under the

**Table 1.** Major phytochemical compounds identified in methanolic extract of *Euphorbia lathyris*.

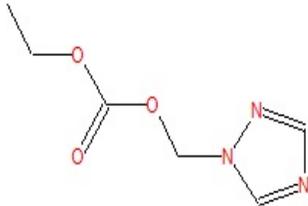
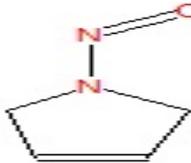
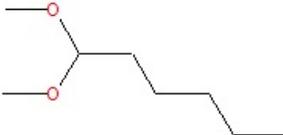
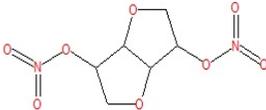
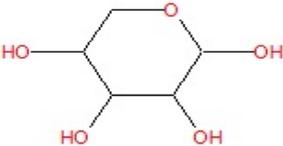
S/N	Phytochemical compound	RT (min)	Molecular Weight	Exact mass	Chemical structure	Pharmacological actions
1	Carbonic acid, (ethyl)(1,2,4-triazol-1-ylmethyl) diester	3.259	171	171.064391		Pharmacological activities such as anti-microbial, anti-inflammatory
2	1H-Pyrrole,2,5-dihydro-1-nitroso-	3.367	98	98.0480127		Antibacterial, antiviral, anticonvulsant and analgesic
3	Hexanal dimethyl acetal	3.533	146	146.13068		Antiviral and anti-inflammatory
4	Isosorbide dinitrate	4.546	236	236.028066		Relaxation
5	DL-Arabinose	4.878	150	150.052823		Anti-tumor activity
6	Cyclopropane,1-fluoro-1-(2-bromoethenyl)-2,2,3,3-tetramethyl-	5.010	220	220.026291		Many medicinal activities, which included anti-cancer and anti-cardiovascular

Table 1. cont'd

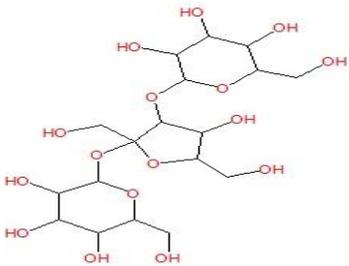
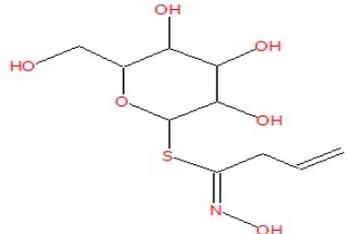
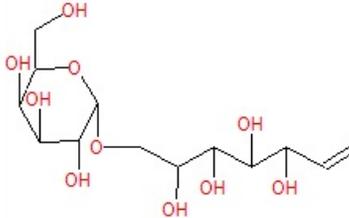
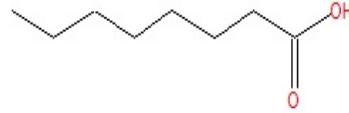
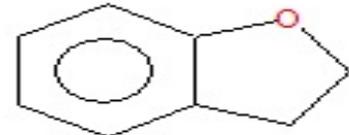
7	$\alpha$ -D-Glucopyranoside, O- $\alpha$ -D-glucopyranosyl-(1.fwdarw.3)- $\beta$ -d-fruc	5.261	504	504.169035		Anti-diabetic activity and anti-tumour
8	Desulphosinigrin	5.313	279	279.077658		Antibacterial activity
9	D-Glucose, 6-O- $\alpha$ -D-galactopyranosyl	5.782	342	342.11621		Anti-trypanosomal activity
10	Octanoic acid	6.137	144	144.115029		Anti-bacterial activity
11	Benzofuran,2,3-dihydro-	6.715	120	120.0575147		Anti-HIV, anticancer, antibacterial, and antifungal activities

Table 1. cont'd

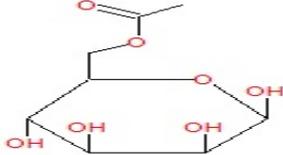
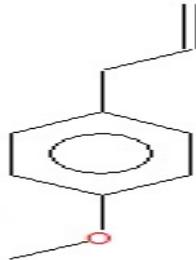
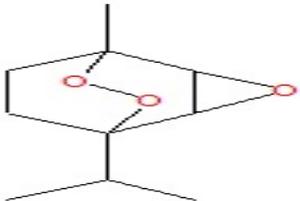
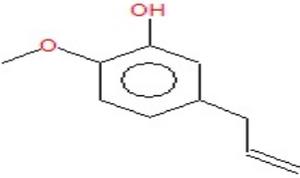
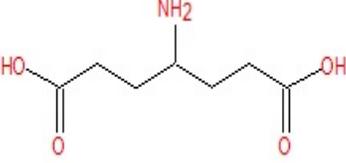
12	6-Acetyl- $\beta$ -d-mannose	6.984	222	222.073953	 <p>The structure shows a six-membered pyranose ring in its chair conformation. The hydroxyl groups at C2, C3, and C4 are in the alpha position (pointing down). The hydroxyl group at C5 is in the beta position (pointing up). An acetyl group (-COCH3) is attached to the C6 carbon via an oxygen atom.</p>	Anti-inflammatory and anti-oxidant
13	Estragole	7.481	148	148.088815	 <p>The structure consists of a benzene ring with a methoxy group (-OCH3) at the para position and an allyl group (-CH2-CH=CH2) at the other para position.</p>	Estragole has been shown to have an anti-inflammatory activity
14	Ascaridole epoxide	7.727	184	184.109944	 <p>The structure is a bicyclic system with a six-membered ring fused to a five-membered ring. It features a methyl group, an isopropyl group, and an epoxide ring (three-membered ring with two oxygen atoms).</p>	Anti-inflammatory
15	3-Allyl-6-methoxyphenol	8.443	164	164.08373	 <p>The structure is a benzene ring with a hydroxyl group (-OH) at the 1 position, a methoxy group (-OCH3) at the 6 position, and an allyl group (-CH2-CH=CH2) at the 3 position.</p>	Anticancer activity
16	4-Amino-1,5-pentandioic acid	9.564	175	175.084458	 <p>The structure is a five-carbon chain with carboxylic acid groups at C1 and C5, and an amino group (-NH2) at C4.</p>	Anti-cancer agent

Table 1. cont'd

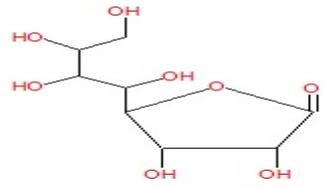
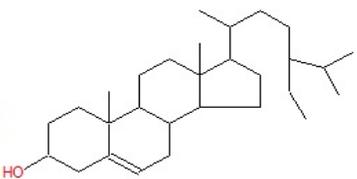
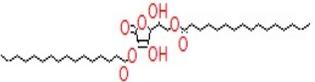
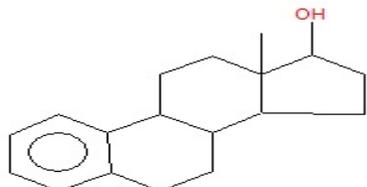
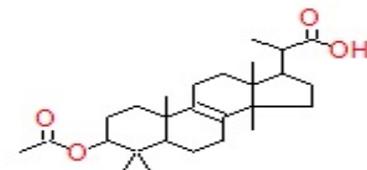
17	l-Gala-l-ido-octonic lactone	10.734	238	238.068868		Antibacterial activity against <i>Pseudomonas aerogenosa</i>
18	$\gamma$ -Sitosterol	15.023	414	414.386166		Anti-inflammatory activity
19	Tetradecanoic acid	13.455	228	228.20893		Antimicrobial, antispasmodic and <i>anti</i> -inflammatory effects
20	l-(+)-Ascorbic acid 2,6-dihexadecanoate	15.486	652	652.49142		antioxidant
21	Estra -1,3,5(10)-trien-17 $\beta$ -ol	16.007	256	256.182714		New chemical compound
22	Propanoic acid ,2-(3-acetoxy-4,4,14-trimethylandro-8-en-17-yl)-	16.745	430	430.30831		Anti-microbial and anti-tumor effects.

Table 1. cont'd

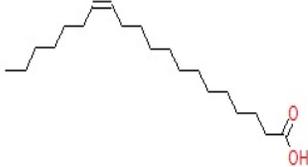
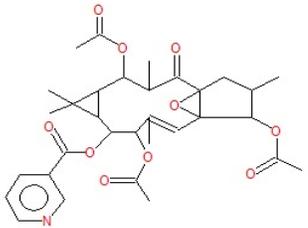
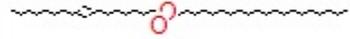
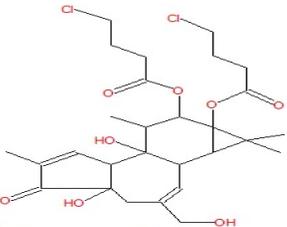
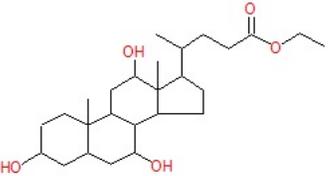
23	Cis-13-Eicosenoic acid	18.914	310	310.28718		Anti-inflammatory activity
24	Eicosanoic acid	19.051	312	312.30283		Anti-inflammatory effects
25	3-Pyrinecarboxylic acid, 2,7,10-tris(acetyloxy)-1,1a,2,3,4,6,7,10-	19.246	597	597.257397		New chemical compound
26	Oleic acid, eicosyl ester	20.339	562	562.568882		Anti-Candida activity
27	Butanoic acid, 4-chloro-, 1,1a,1b,4,4a,5,7a,7b,8,9-decahydro-4a	21.083	572	572.194374		Antiviral, antitumor, anti-HIV and antinociceptive activities
28	Ethyl iso -allocholate	21.134	436	436.318874		Anti-inflammatory activity

Table 1. cont'd

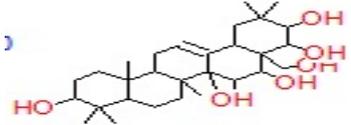
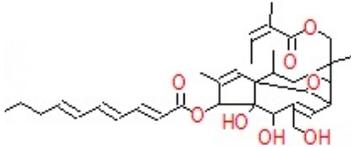
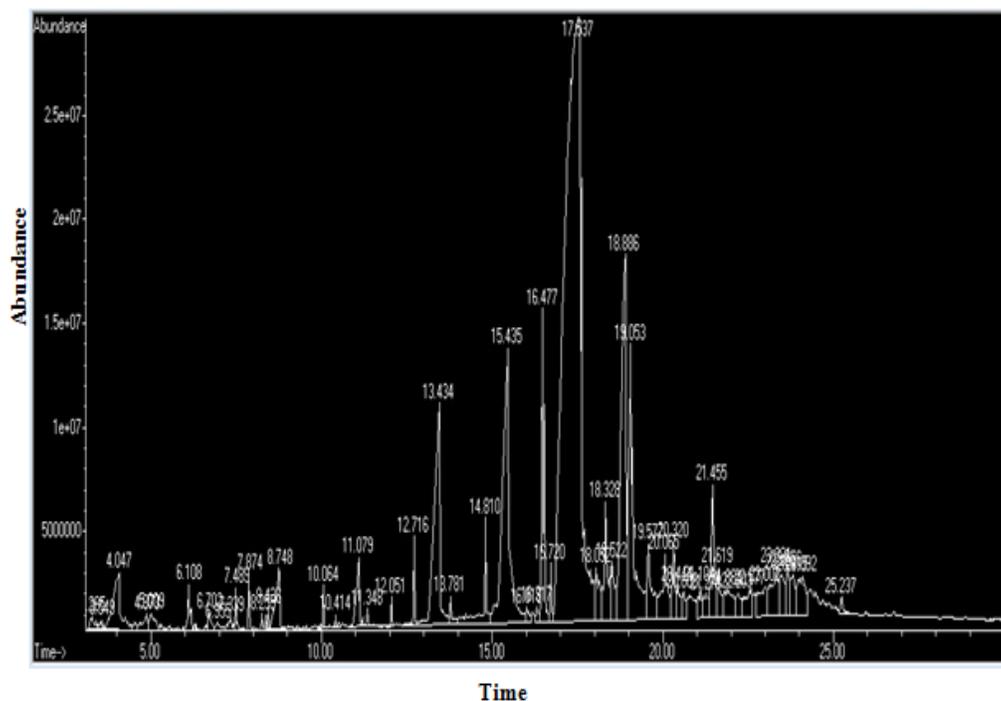
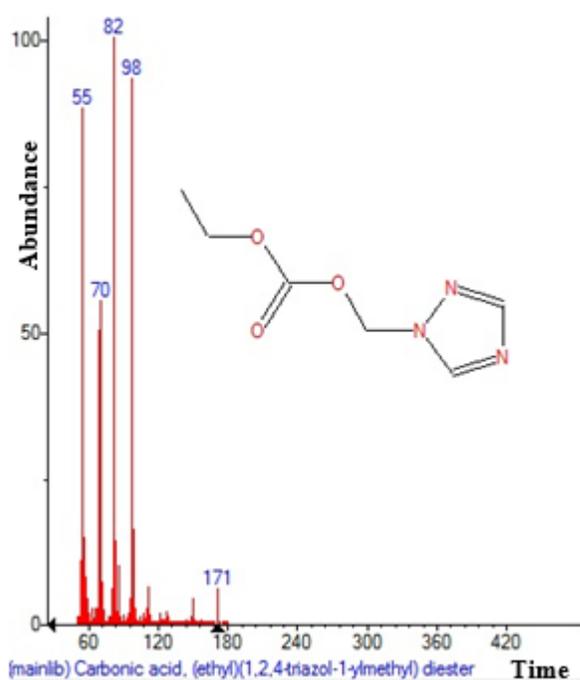
29	Olean-12-ene-3,15,16,21,22,28-hexol, (3 $\beta$ ,15 $\alpha$ ,16 $\alpha$ ,21 $\beta$ ,22 $\alpha$ )-	21.603	506	506.360739		Anti-inflammatory
30	2,4,6-Decatrienoic acid, 1a,2,5,5a,6,9,10,10a-octahydro-5,5a-dihy	21.878	594	594.319267		Anticancer

Table 2. FT-IR peak values of *Euphorbia lathyris*.

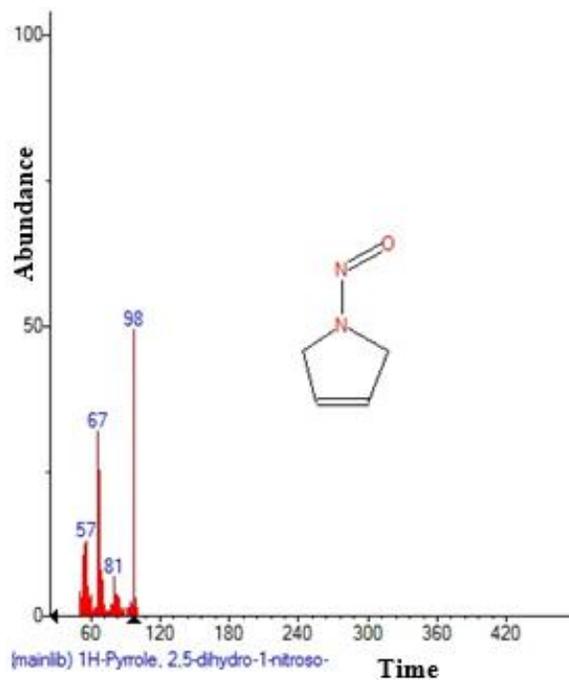
No.	Peak (Wave number $\text{cm}^{-1}$ )	Intensity	Bond	Functional group assignment	Group frequency
1	659.66	59.626	-	Unknown	-
2	837.11	74.522	C-H	Alkenes	675-995
3	898.83	73.438	C-H	Alkenes	675-995
4	918.12	73.336	C-H	Alkenes	675-995
5	1037.7	54.275	C-F stretch	Aliphatic fluoro compounds	1000-1050
6	1145.7	65.485	C-O	Alcohols, Ethers, Carboxylic acids, Esters	1050-1300
7	1232.5	69.798	C-O	Alcohols, Ethers, Carboxylic acids, Esters	1050-1300
8	1261.5	72.924	C-O	Alcohols, Ethers, Carboxylic acids, Esters	1050-1300
9	1317.4	73.54	NO <sub>2</sub>	Nitro Compounds	1300-1370
10	1377.2	73.54	C-H	Alkanes	1340-1470
11	1410	74.741	C-H	Alkanes	1340-1470
12	1456.3	74.929	C-H	Alkanes	1340-1470
13	1519.9	70.721	-	Unknown	-
14	1626	62.255	-	Unknown	-
15	1741.7	79.565	-	Unknown	-
16	2683	92.491	-	Unknown	-
17	2854.7	80.11	C-H	Alkanes	2850-2970
18	2924.1	73.299	C-H	Alkanes	2850-2970
19	3082.3	86.714	H-O	H-bonded H-X group	2500-3500
20	3275.1	79.255	O-H	Hydrogen bonded Alcohols, Phenols	3200-3600



**Figure 1.** GC-MS chromatogram of methanolic extract of *Euphorbia lathyris*.



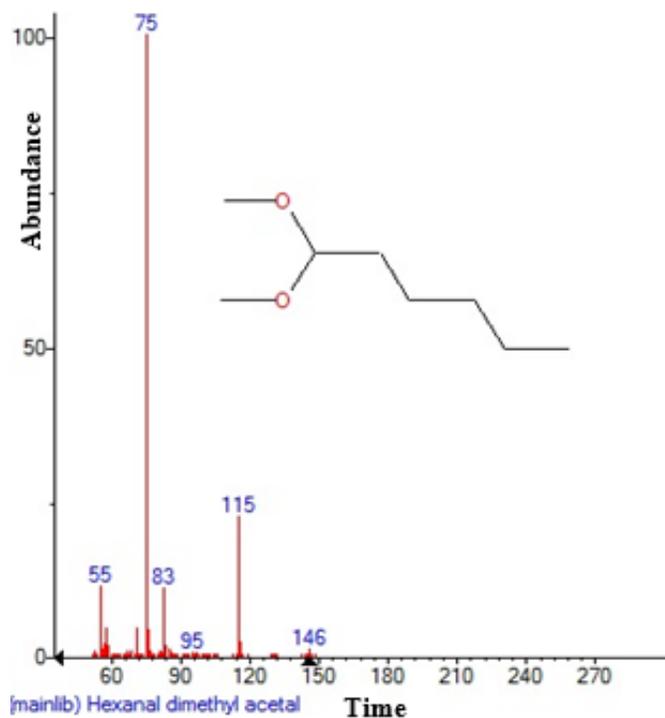
**Figure 2.** Structure of Carbonic acid, (ethyl)(1,2,4-triazol-1-ylmethyl) diester with 3.259 (RT) present in *Euphorbia lathyris*.



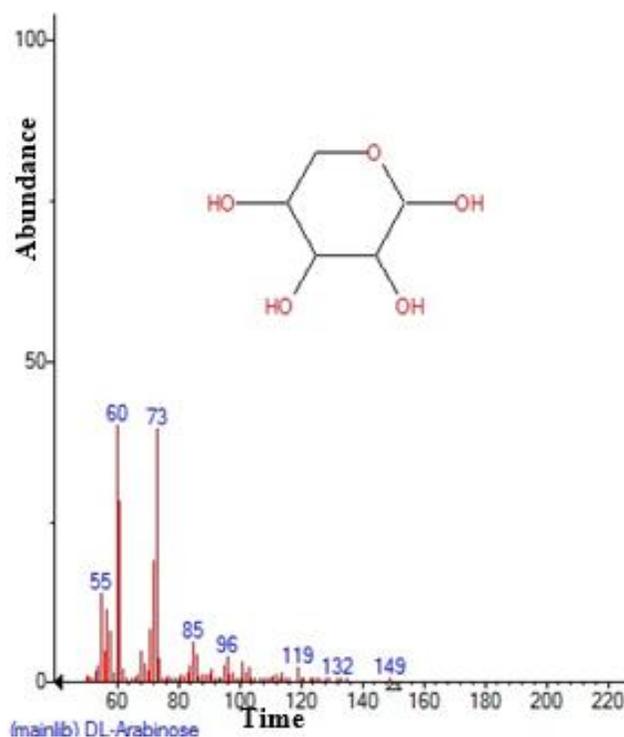
**Figure 3.** Structure of 1H-Pyrrole, 2,5-dihydro-1-nitroso- with 3.367 (RT) present in *Euphorbia lathyris*.

chromatographic conditions (Shahat et al., 2003; Reddy et al., 2003). *E. lathyris* L. oil (ELO) contains large

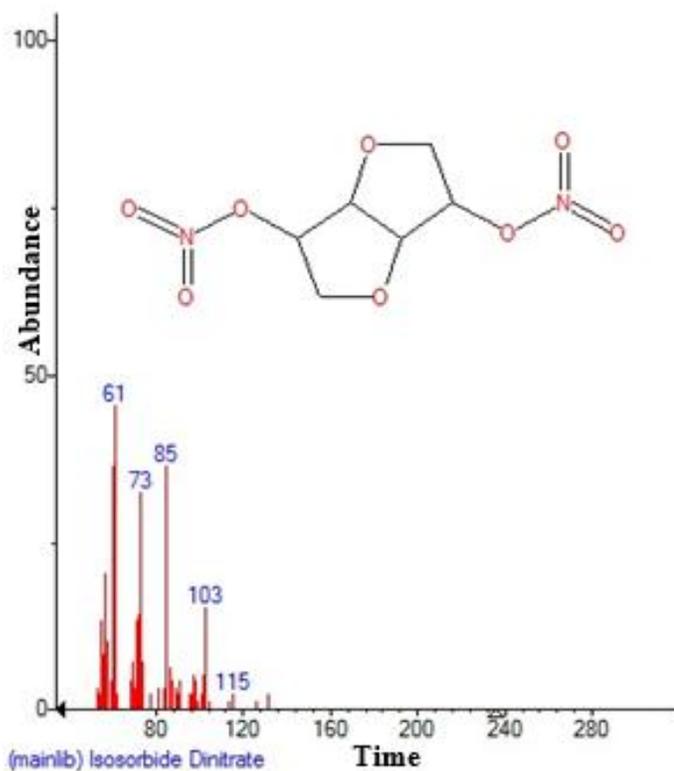
amounts of FFAs and needs to determine acid value (Wei et al., 2007; Liu et al., 2011).



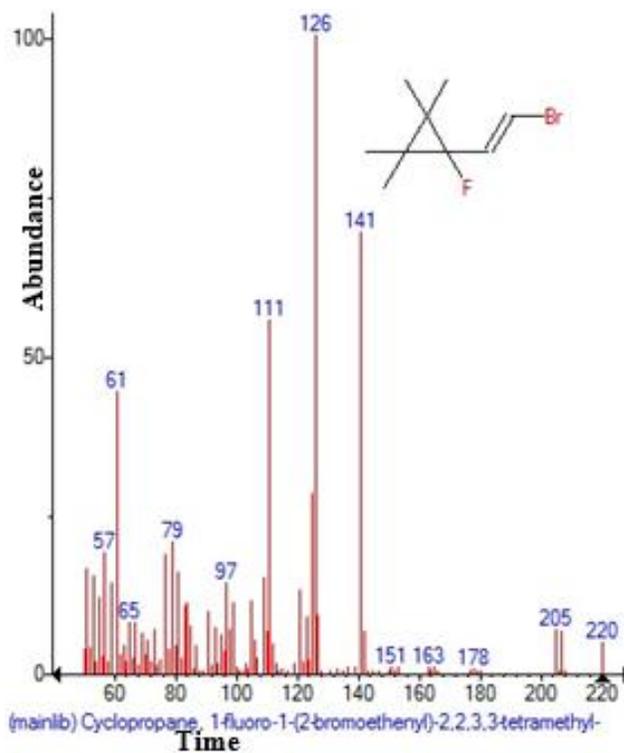
**Figure 4.** Structure of Hexanal dimethyl acetal with 3.533 (RT) present in *Euphorbia lathyris*.



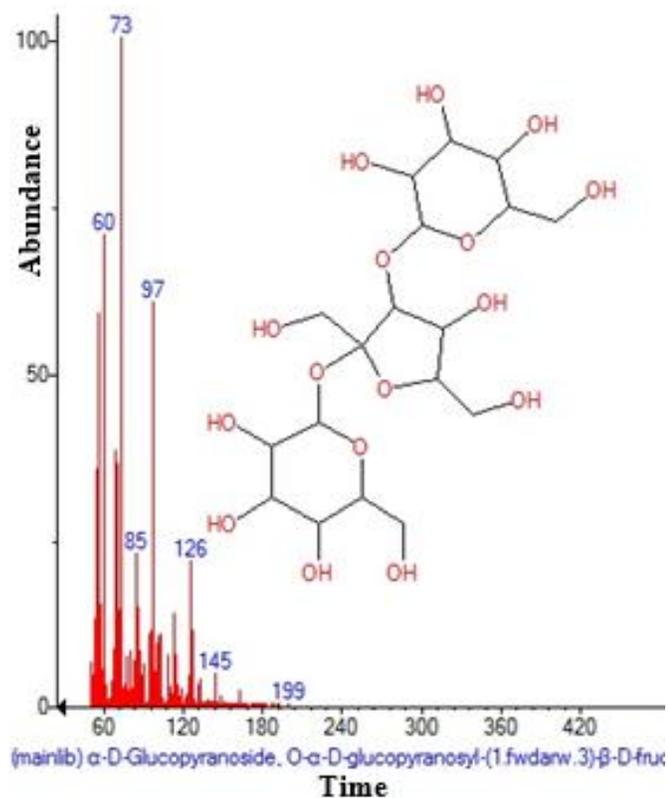
**Figure 6.** Structure of DL-Arabinose with 4.878 (RT) present in *Euphorbia lathyris*



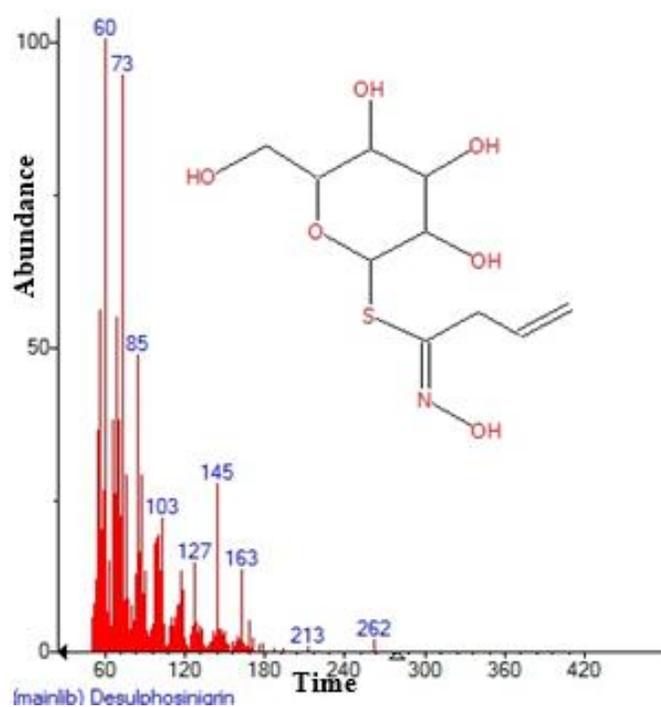
**Figure 5.** Structure of Isosorbide dinitrate with 4.546 (RT) present in *Euphorbia lathyris*.



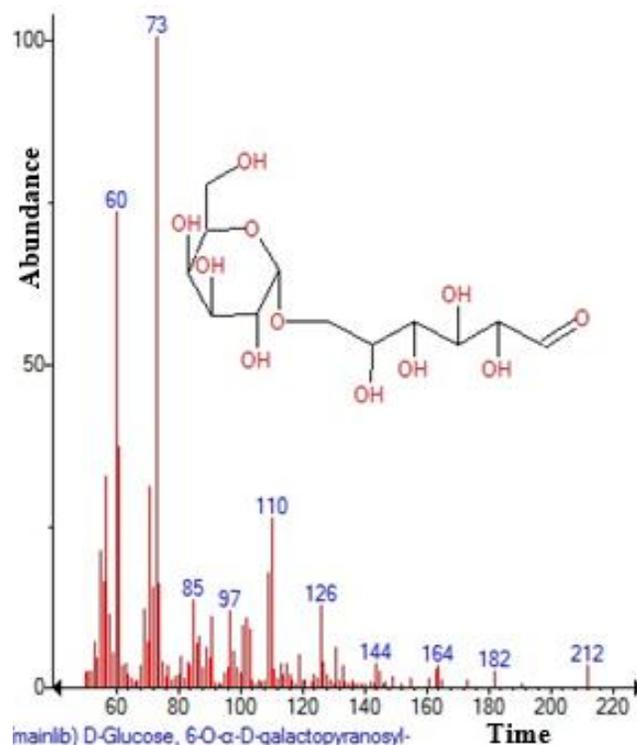
**Figure 7.** Structure of Cyclopropane ,1-fluoro-1-(2-bromoethyl)-2,2,3,3-tetramethyl with 5.010 (RT) present in *Euphorbia lathyris*.



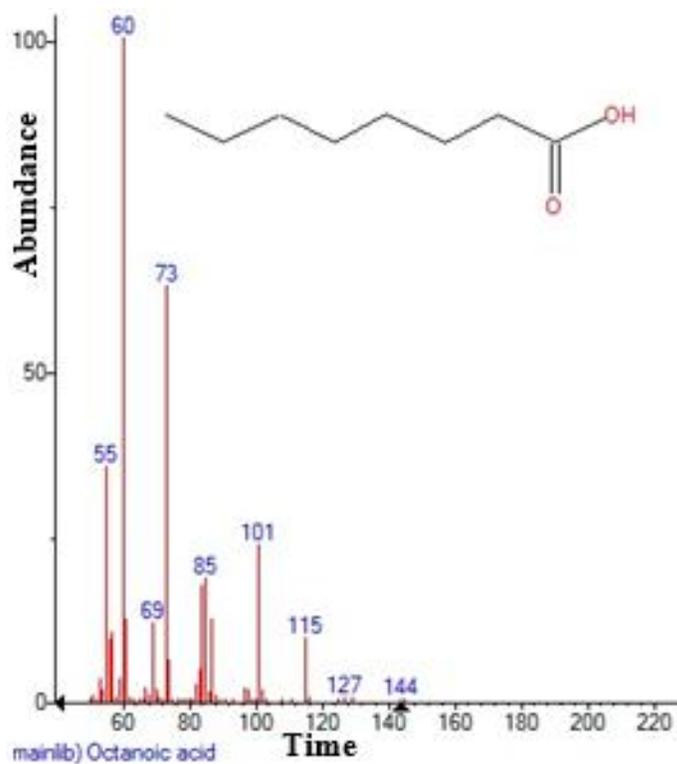
**Figure 8.** Structure of  $\alpha$ -D-Glucopyranoside, O- $\alpha$ -D-glucopyranosyl-(1.fwdarw.3)- $\beta$ -d-fruc with 5.261 (RT) present in *Euphorbia lathyris*.



**Figure 9.** Structure of Desulphosiniarin with 5.313 (RT) present in *Euphorbia lathyris*.



**Figure 10.** Structure of D-Glucose, 6-O- $\alpha$ -D-galactopyranosyl with 5.782 (RT) present in *Euphorbia lathyris*.



**Figure 11.** Structure of Octanoic acid with 6.137 (RT) present in *Euphorbia lathyris*.

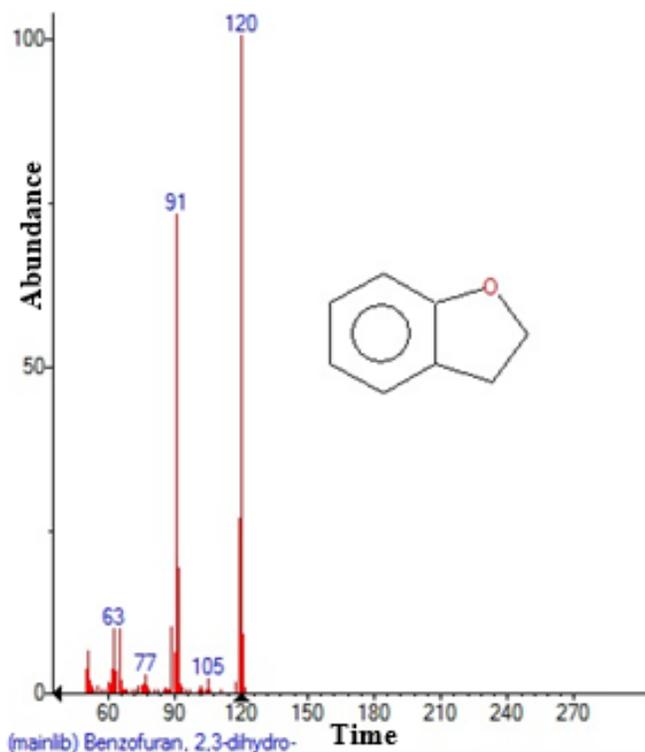


Figure 12. Structure of Benzofuran ,2,3-dihydro with 6.715 (RT) present in *Euphorbia lathyris*.

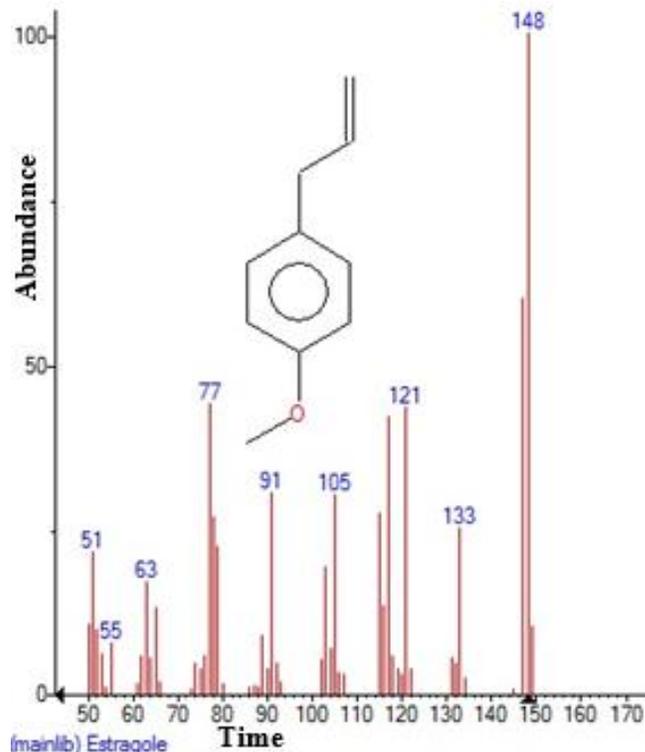


Figure 14. Structure of Estragole with 7.481 (RT) present in *Euphorbia lathyris*.

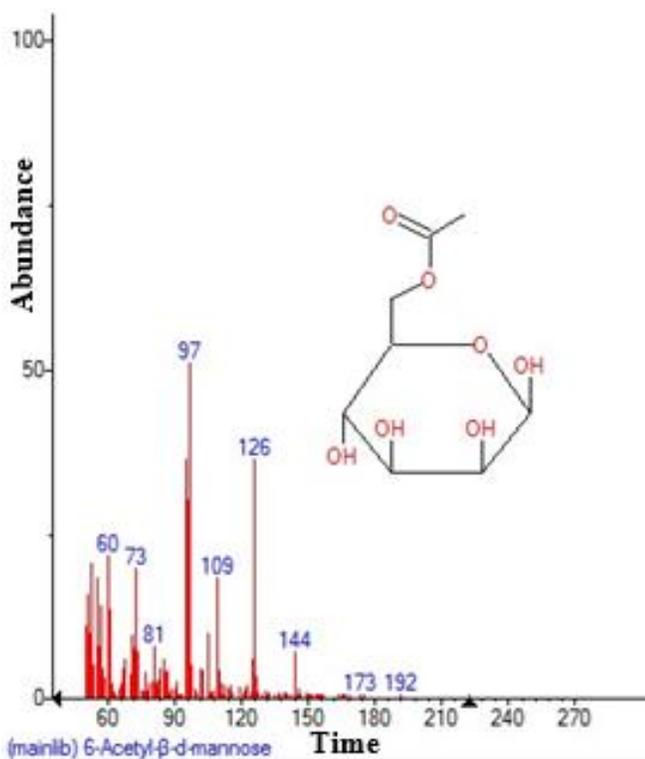


Figure 13. Structure of 6-Acetyl-β-d-mannose with 6.984 (RT) present in *Euphorbia lathyris*.

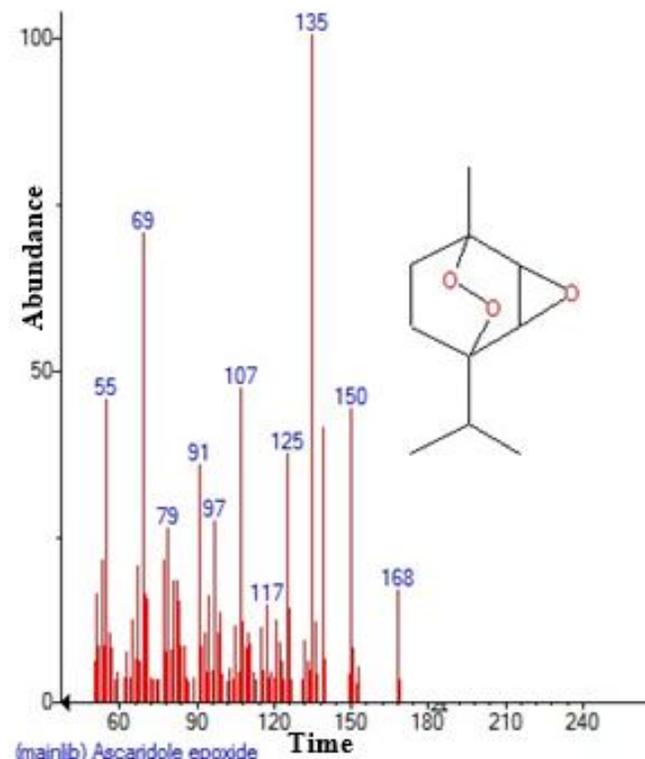
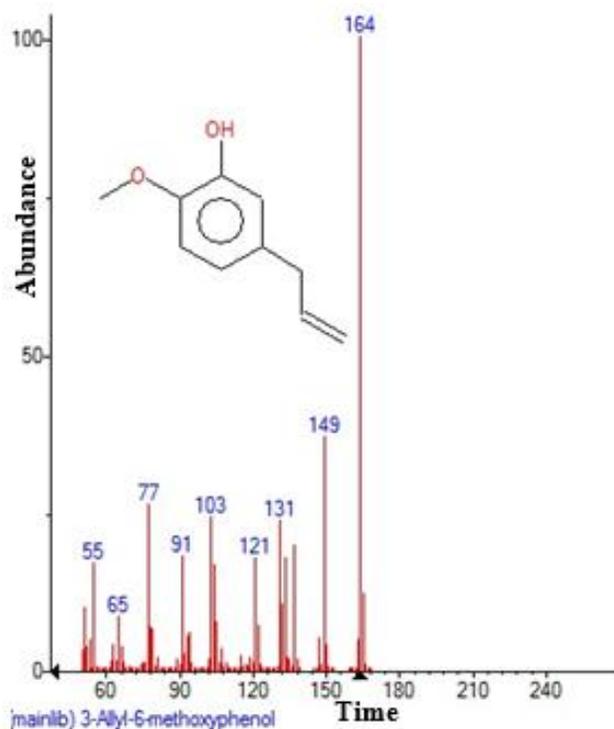
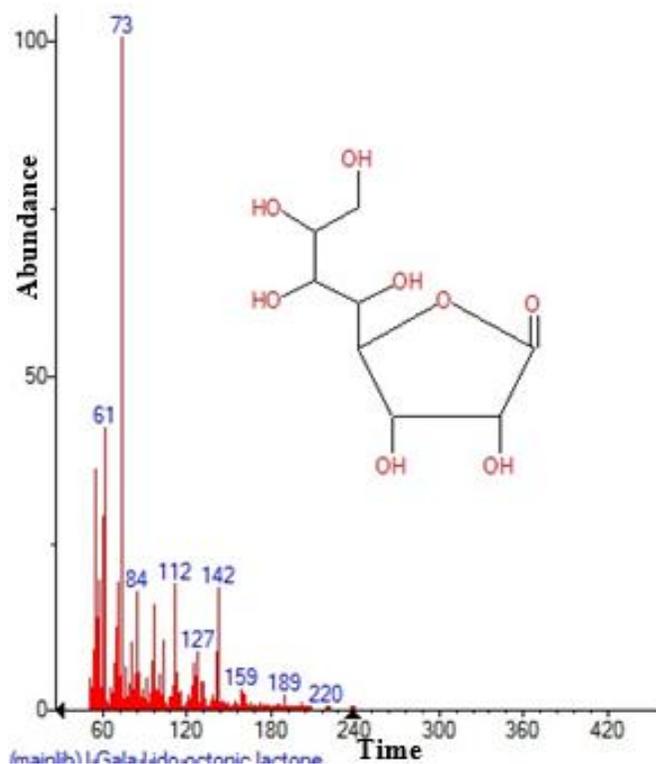


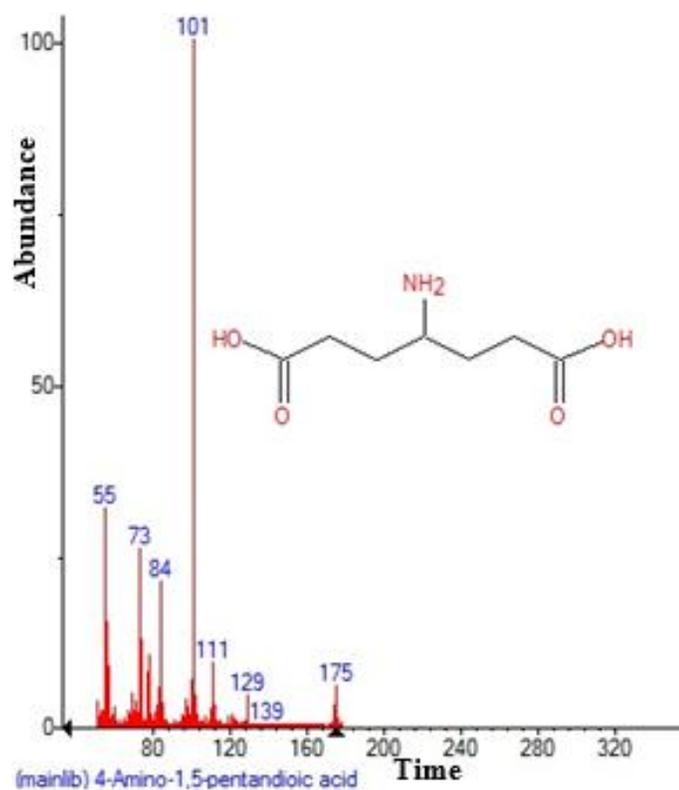
Figure 15. Structure of Ascaridole epoxide with 7.727 (RT) present in *Euphorbia lathyris*.



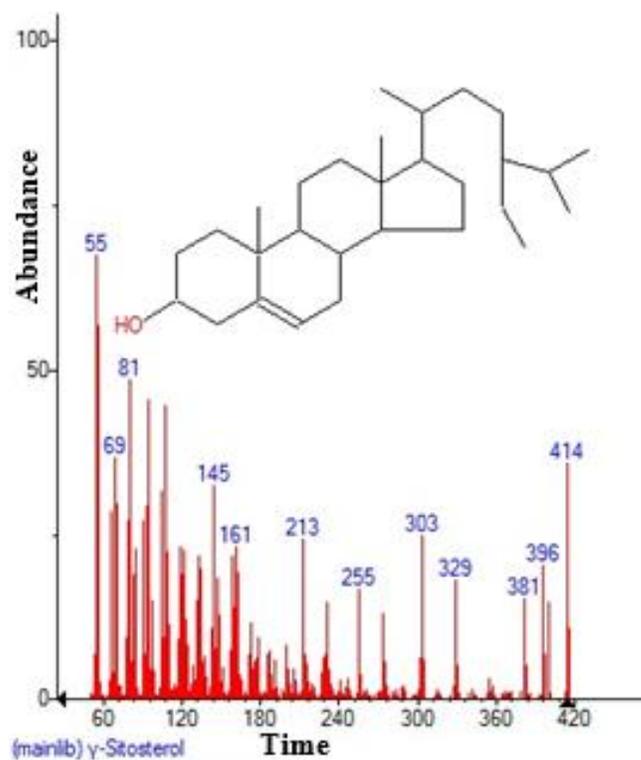
**Figure 16.** Structure of 3-Allyl-6-methoxyphenol with 8.443 (RT) present in *Euphorbia lathyris*.



**Figure 18.** Structure of l-Gala-l-ido-octonic lactone with 10.743 (RT) present in *Euphorbia lathyris*.



**Figure 17.** Structure of 4-Amino-1,5-pentandioic acid with 9.564 (RT) present in *Euphorbia lathyris*.



**Figure 19.** Structure of  $\gamma$ -Sitosterol with 15.023 (RT) present in *Euphorbia lathyris*.

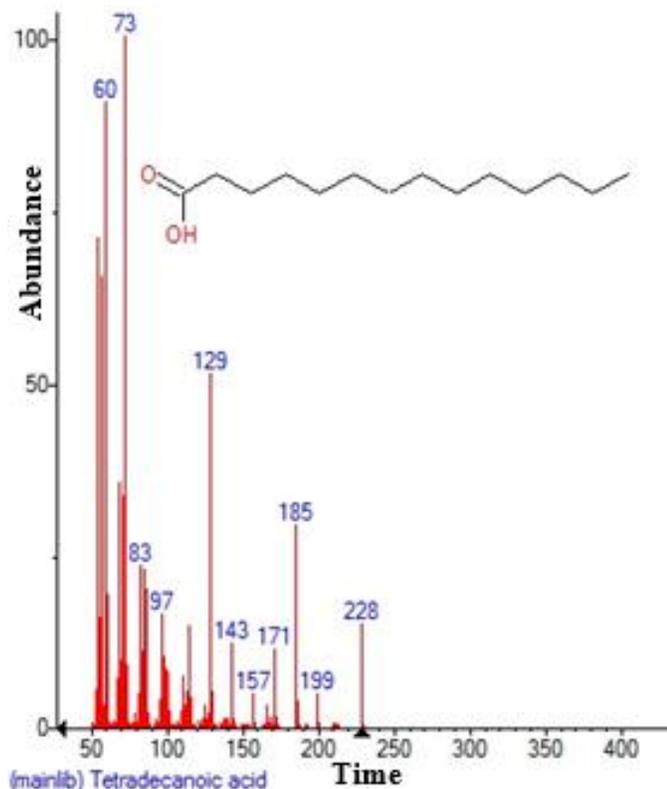


Figure 20. Structure of Tetradeconoic acid with 13.455 (RT) present in *Euphorbia lathyris*.

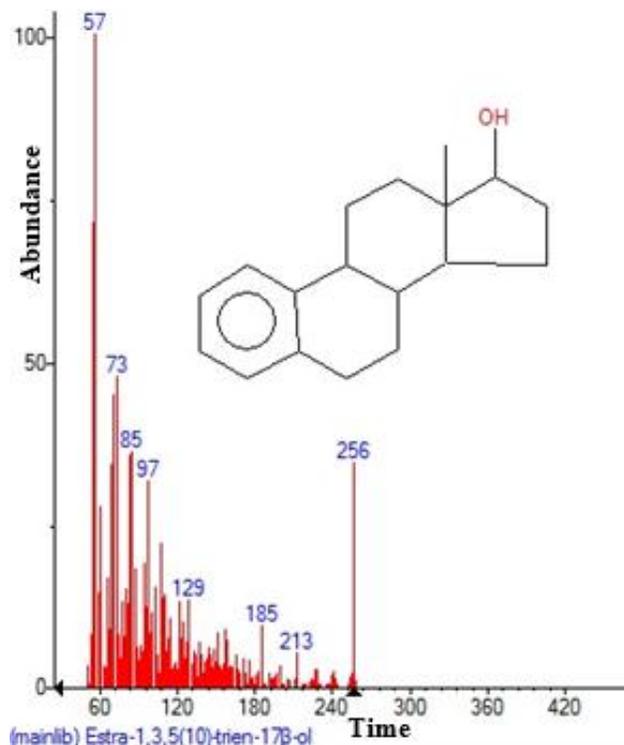


Figure 22. Structure of Estra -1,3,5(10)-trien-17β-ol with 16.007 (RT) present in *Euphorbia lathyris*.

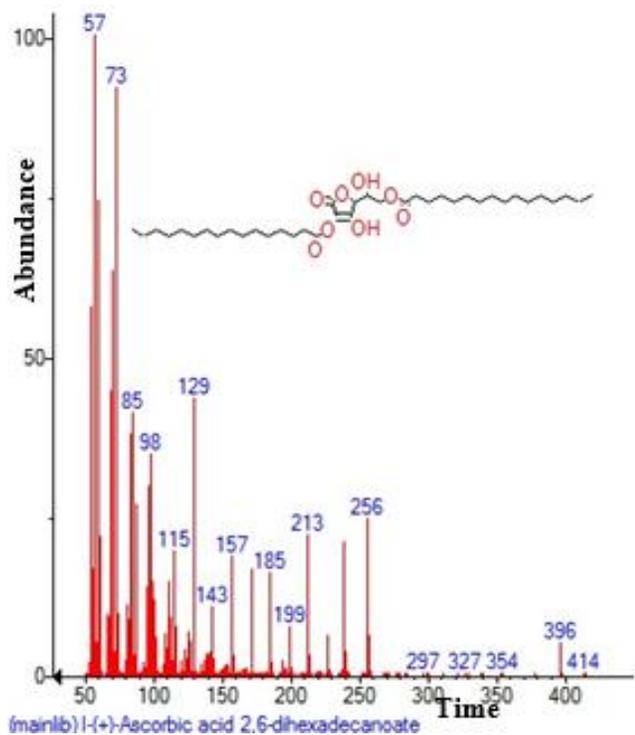


Figure 21. Structure of l-(+)-Ascorbic acid 2,6-dihexadecanoate with 15.486 (RT) present in *Euphorbia lathyris*.

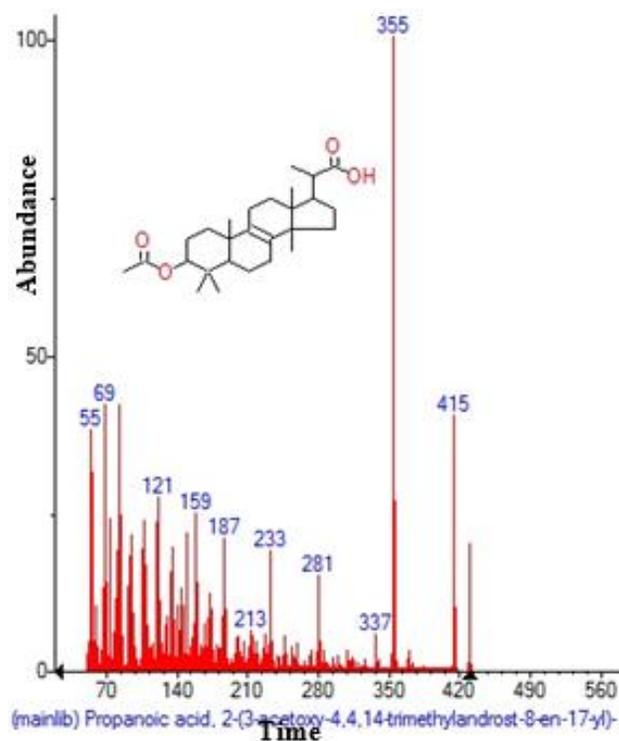
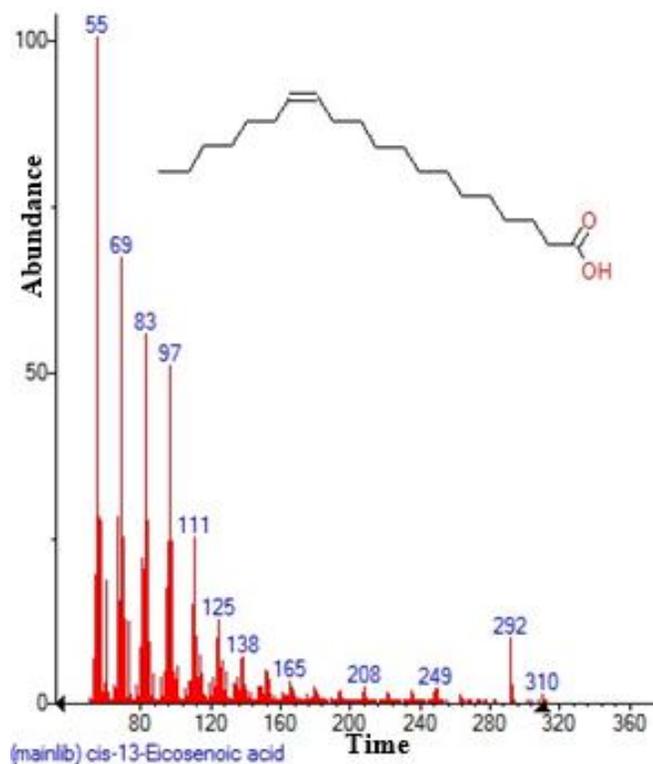
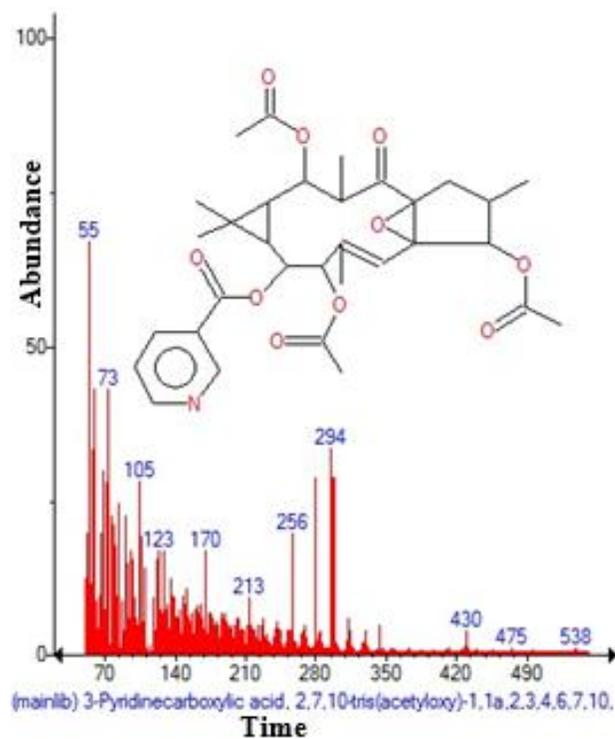


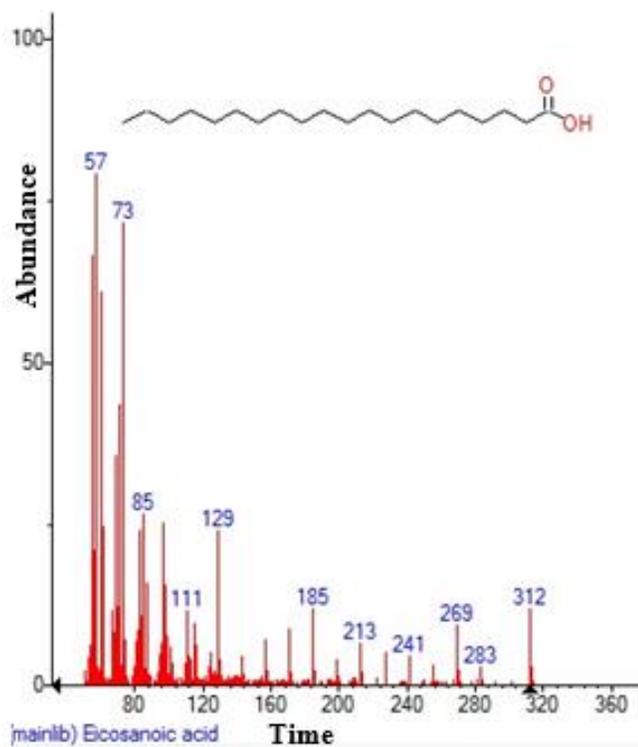
Figure 23. Structure of Propanoic acid ,2-(3-acetoxy-4,4,14-trimethylandro-8-en-17-yl)- with 16.745 (RT) present in *Euphorbia lathyris*.



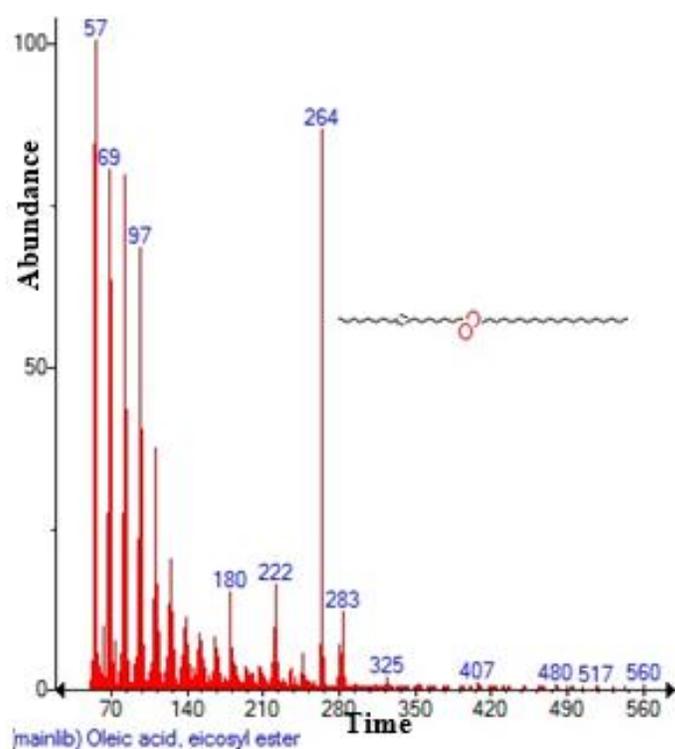
**Figure 24.** Structure of Cis-13-Eicosenoic acid with 18.914 (RT) present in *Euphorbia lathyris*.



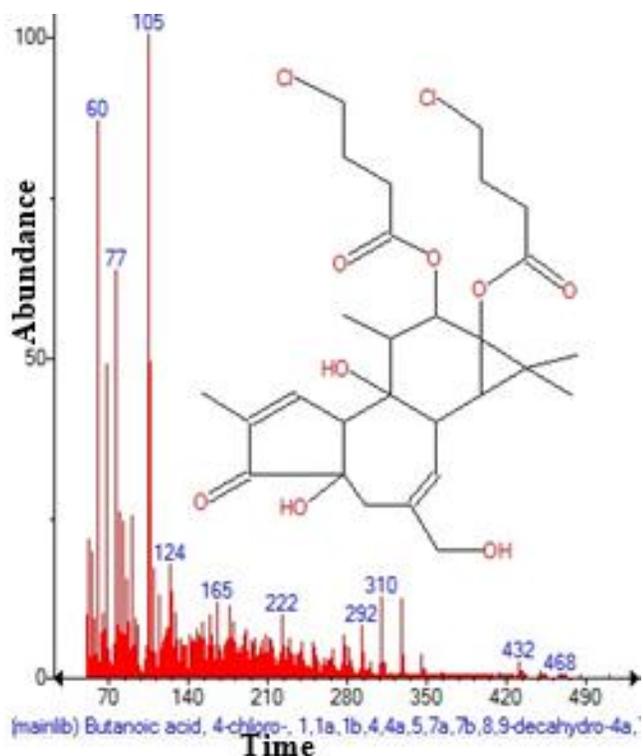
**Figure 26.** Structure of 3-Pyridinecarboxylic acid , 2,7,10-tris(acetyloxy)-1,1a,2,3,4,6,7,10 with 19.246 (RT) present in *Euphorbia lathyris*.



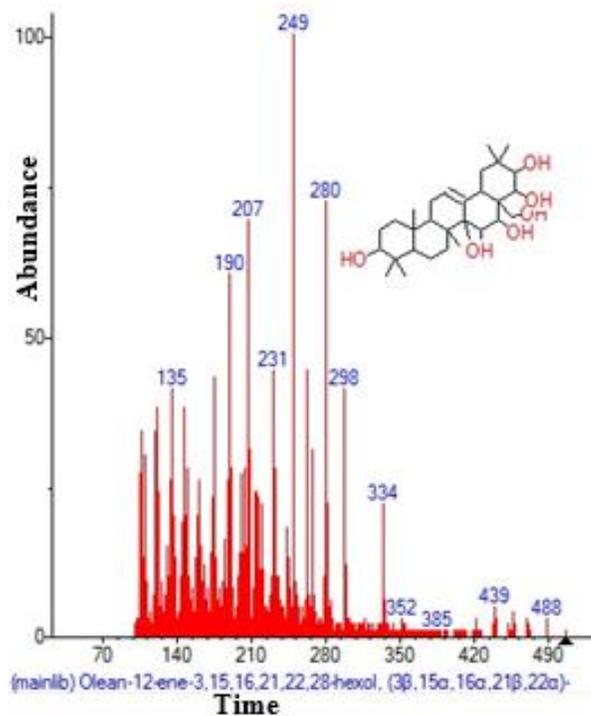
**Figure 25.** Structure of Eicosanoic acid with 19.051 (RT) present in *Euphorbia lathyris*.



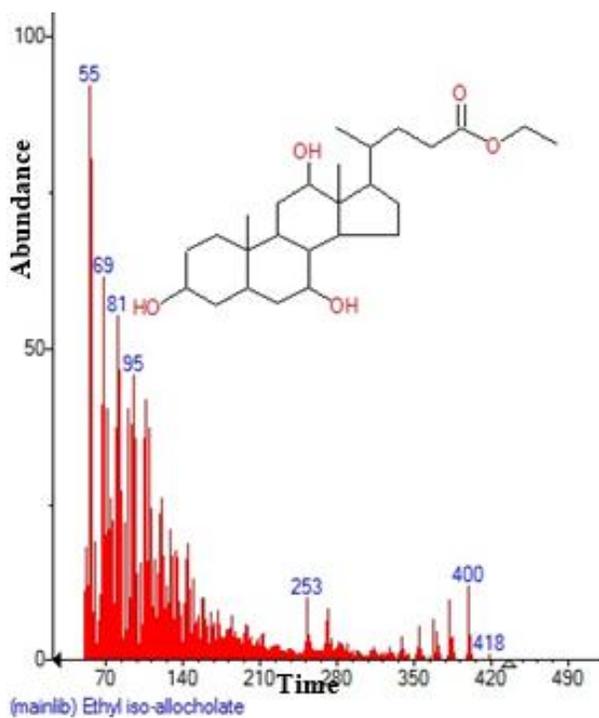
**Figure 27.** Structure of Oleic acid , eicosyl ester with 20.339 (RT) present in *Euphorbia lathyris*.



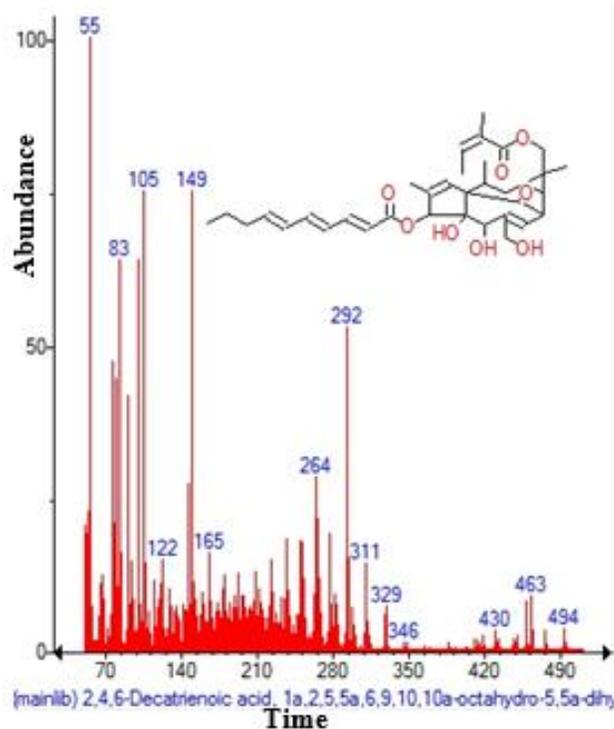
**Figure 28.** Structure of Butanoic acid , 4-chloro- ,1,1a,1b,4,4a,5,7a,7b,8,9-decahydro-4a with 21.083 (RT) present in *Euphorbia lathyris*.



**Figure 30.** Structure of Olean -12-ene-3,15,16,21,22,28-hexol, ( 3β,15α,16α,21β,22α) with 21.603 (RT) present in *Euphorbia lathyris*.



**Figure 29.** Structure of Ethyl iso -allocholate with 21.134 (RT) present in *Euphorbia lathyris*.



**Figure 31.** Structure of 2,4,6-Decatrienoic acid ,1a,2,5,5a,6,9,10,10a-octahydro-5,5a-dihy with 21.878 (RT) present in *Euphorbia lathyris*.

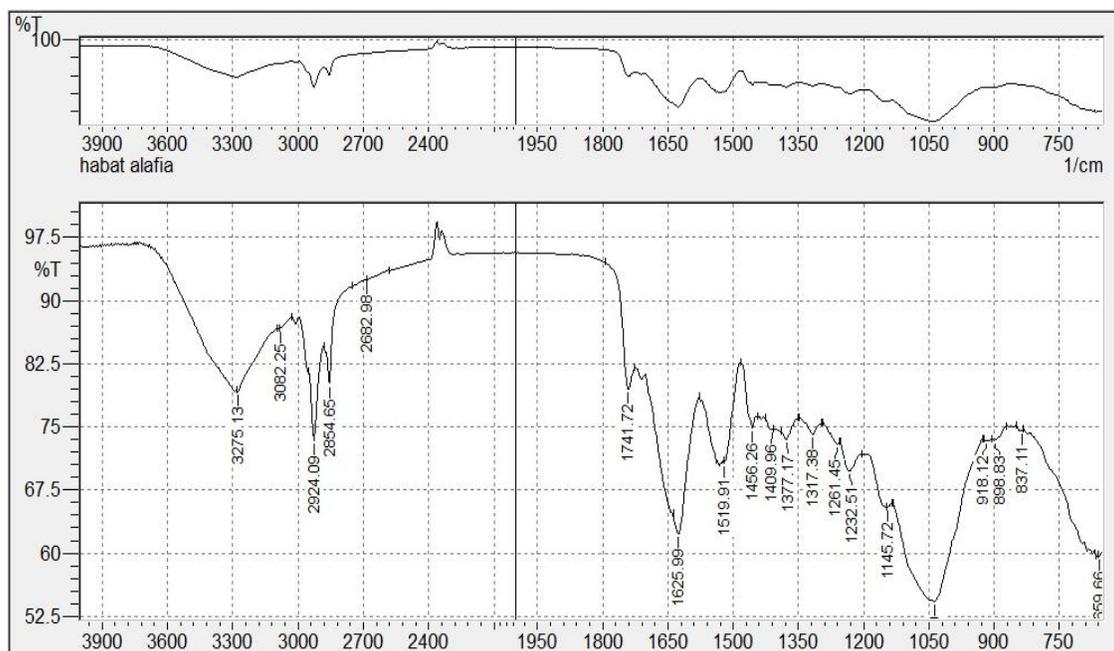


Figure 32. FT-IR profile of *Euphorbia lathyris*.

## Conclusion

*E. lathyris* 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 antiasthmatic.

## Conflict of interest

The authors have not declared any conflict of interest

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## REFERENCES

- Al-Marzoqi AH, Hadi MY, Hameed IH (2016). Determination of metabolites products by *Cassia angustifolia* and evaluate antimicrobial activity. *J. Pharmacogn. Phytother.* 8(2):25-48.
- Al-Marzoqi AH, Hameed IH, Idan SA (2015). Analysis of bioactive chemical components of two medicinal plants (*Coriandrum sativum* and *Melia azedarach*) leaves using gas chromatography-mass spectrometry (GC-MS). *Afr. J. Biotechnol.* 14(40):2812-2830.
- Altameme H J, Hadi MY, Hameed IH (2015a). Phytochemical analysis of *Urtica dioica* leaves by fourier-transform infrared spectroscopy and gas chromatography-mass spectrometry. *J. Pharmacogn. Phytother.* 7(10):238-252.
- Altameme HJ, Hameed IH, Abu-Serag NA (2015b). analysis of bioactive phytochemical compounds of two medicinal plants, *Equisetum arvense* and *Alchemilla vulgaris* seed using gas chromatography-mass spectrometry and fourier-transform infrared spectroscopy. *Malays. Appl. Biol.* 44(4):47-58.
- Altameme HJ, Hameed IH, Idan SA, Hadi MY (2015c). Biochemical analysis of *Origanum vulgare* seeds by fourier-transform infrared (FT-IR) spectroscopy and gas chromatography-mass spectrometry (GC-MS). *J. Pharmacogn. Phytother.* 7(9):221-237.
- Buenz EJ, Schnepfle DJ, Bauer BA, Elkin PL, Riddle JM, Motley TJ (2004). Techniques: bioprospecting historical herbal texts by hunting for new leads in old tomes. *Trends Pharmacol. Sci.* 25:494-498.
- Cai YZ, Luo Q, Sun M, Corke H (2004). Antioxidant activity and phenolic compounds of 112 Chinese medicinal plants associated with anticancer. *Life Sci.* 74:2157-2184.
- Corro G, Bañuelos F, Vidal E, Cebada S (2014). Measurements of Surface Acidity of Solid Catalysts for Free Fatty Acids Esterification in *Jatropha curcas* crude oil for biodiesel production. *Fuel.* 115:625-628.
- Hadi MY, Mohammed GJ, Hameed IH (2016). Analysis of bioactive chemical compounds of *Nigella sativa* using gas chromatography-mass spectrometry. *J. Pharmacogn. Phytother.* 8(2):8-24.
- Hameed IH, Abdulzahra AI, Jebor MA, Kqueen CY, Ommer AJ (2015a). Haplotypes and variable position detection in the mitochondrial DNA coding region encompassing nucleotide positions. *Mitochondrial DNA.* 26(4):544-9.
- Hameed IH, Hamza LF, Kamal SA (2015b). Analysis of bioactive chemical compounds of *Aspergillus niger* by using gas chromatography-mass spectrometry and fourier-transform infrared spectroscopy. *J. Pharmacogn. Phytother.* 7(8):132-163.
- Hameed IH, Hussein HJ, Kareem MA, Hamad NS (2015c). Identification of five newly described bioactive chemical compounds in methanolic extract of *Mentha viridis* by using gas chromatography-mass spectrometry (GC-MS). *J. Pharmacogn. Phytother.* 7(7):107-125.
- Hameed IH, Ibraheem IA, Kadhim HJ (2015d). Gas chromatography mass spectrum and fourier-transform infrared spectroscopy analysis of methanolic extract of *Rosmarinus officinalis* leaves. *J. Pharmacogn. Phytother.* 7(6):90-106.
- Hamza LF, Kamal SA, Hameed IH (2015). Determination of metabolites products by *Penicillium expansum* and evaluating antimicrobial activity. *J. Pharmacogn. Phytother.* 7(9):194-220.

- Hussein AO, Mohammed GJ, Hadi MY, Hameed IH (2016a). Phytochemical screening of methanolic dried galls extract of *Quercus infectoria* using gas chromatography-mass spectrometry (GC-MS) and Fourier transform-infrared (FT-IR). J. Pharmacogn. Phytother. 8(3):49-59.
- Hussein HJ, Hadi MY, Hameed IH (2016b). Study of chemical composition of *Foeniculum vulgare* using Fourier transform infrared spectrophotometer and gas chromatography - mass spectrometry. J. Pharmacogn. Phytother. 8(3):60-89.
- Hussein HM, Hameed IH, Ibraheem OA (2016c). Antimicrobial activity and spectral chemical analysis of methanolic leaves extract of *Adiantum capillus-veneris* using GC-MS and FT-IR spectroscopy. Int. J. Pharmacogn. Phytochem. Res. 8(3).
- Jasim H, Hussein AO, Hameed IH, Kareem MA (2015). Characterization of alkaloid constitution and evaluation of antimicrobial activity of *Solanum nigrum* using gas chromatography mass spectrometry (GC-MS). J. Pharmacogn. Phytother. 7(4):56-72.
- Liu H, Hong LZ, Wang MW (2011). Progress of Study on Energy Plant *Euphorbia lathyris* L. Anhui Agric. Sci. Bull. 17:119-120.
- Park EJ, Pezzutto JM (2002). Botanicals in cancer chemoprevention. Cancer Metastasis Rev. 21:231-255.
- Reddy VBM, Reddy K, Gunasekar D, Murthy M, Caux C, Bodo B (2003). A new sesquiterpene lactone from *Bombax malabaricum*. Chem. Pharm. Bull. 51:458-459.
- Shahat AA, Hassan RA, Nazif NM, Van MS, Pieters L, Hammuda FM (2003). Isolation of mangiferin from *Bombax malabaricum* and structure revision of shamimin. Planta Med. 69:1068-1070.
- Tapiero H, Tew KD, Ba N, Mathe G (2002). Polyphenols: do they play a role in the prevention of human pathologies? Biomed. Pharmacother. 56:200-207.
- Wei WL, Jin MY, Ma C (2007) Fatty Acid Composition Analysis of *Euphorbia lathyris* L. Seed Oil. China Oils Fats 32:70-71.