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GC-MS Analysis of Phytoconstituents in Fractions of *Corydalis adiantifolia*

Iftikhar Ali[1]*, Saleha S. Khan[2], Ajmal Khan[3], Zulfiqar Ali[1], Huma A. Bhatti[4], Jean J.K. Bankeu[5], Viqar U. Ahmad[4]

[1]*Department of Chemistry, Karakoram International University, 15100-Gilgit, Gilgit-Baltistan, Pakistan.*
[2]*Department of Chemistry, Sardar Bahadur Khan Women University, Quetta, Balochistan, Pakistan.*
[3]*UoN Chair of Oman's Medicinal Plants and Marine Natural Products, University of Nizwa, Nizwa, Sultanate of Oman.*
[4]*HEJ Research Institute of Chemistry, University of Karachi, Karachi-75270, Pakistan.*
[5]*Department of Chemistry, Faculty of Science, The University of Bamenda, P.O. Box 39, Bambili, Cameroon.*

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ABSTRACT

Corydalis adiantifolia Hook.f. & Thomson (Fumariaceae) is a herb known as shampoo (*Balti*) in Shigar valley, Baltistan. In addition, other Corydalis species have been reported as antidiabetic, anticancer, anti-inflammatory, and analgesic. Phytochemical study has exhibited the presence of mostly alkaloids in various Corydalis species. *C. adiantifolia*, to the best of our knowledge, has not been investigated so far for any kind of phytochemical analysis.
In our present study, the n-hexane, dichloromethane and ethyl acetate fractions of the methanol extract of *Corydalis adiantifolia* Hook.f. & Thomson (Fumariaceae) were studied through gas chromatography-mass spectrometry (GC-MS) analysis. A number of phytoconstituents are found in these fractions. The phytoconstituents reported in our present study include different esters, long chain alcohols, ketones, aldehydes and carboxylic acids, phenols, etc. More interestingly, different alkaloids are being reported in this study. Protopine, hydrastine, hydrastinine, oxyhydrostinine, (RS)-stylopine, oxoberberine, D-bicuculline and norsanguinarine are the main alkaloids reported through GC-MS in different fractions of *C. adiantifolia*.

Keywords: *Corydalis adiantifolia*, GC-MS Analysis, Fractions, Baltistan.

Introduction

Corydalis adiantifolia Hook.f. & Thomson (Fumariaceae) is a wild herb and its roots are reported for topical use as hair tonic.[1] In literature, *Corydalis* species and/or its active principles have been reported for a number of activities such as antithrombotic, anticoagulant,[2] hepatoprotective,[3-4] neuroprotective,[5] antitumor,[6] antiinflammatory,[7] antinoceptive,[8] analgesic,[9] and antimalarial[10] etc. Various compounds like phenylpropanoid amides,[11] lignanamides,[6] flavonoid glycosides,[12] triterpenoids,[13] have been isolated from different *Corydalis* species. However, alkaloids[14-15] are the mostly reported compounds from a number of *Corydalis* species. Keeping in view the medicinal use of *C. adiantifolia* by the local community, it is our aim to investigate the plant species of *C. adiantifolia* for phytoconstituents. For this purpose, the fractions of the plant sample were studied through gas chromatography-mass spectrometry (GC-MS) method. Gas chromatography-mass spectrometry (GC-MS) technique has been utilized for the identification of phytoconstituents in certain plant species,[16-18] and it is an important technique for this purpose.
In our present study, the phytoconstituents found in n-hexane, dichloromethane and ethyl acetate fractions of *C. adiantifolia* have been sorted out.

*Corresponding author. E mail: iftikhar.ali@kiu.edu.pk
Tel: +92-3339665739

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Materials and Methods

Plant material
The plant material of *C. adiantifolia* (Fumariaceae) was collected from Shigar valley in August 2015 and was identified by Dr. Sher Wali Khan, Department of Biological Sciences, Karakoram International University (KIU), Gilgit. The voucher specimen (SKN-01) was deposited in the Department of Biological Sciences, KIU. The plant material was washed with tap water to remove the dust and other pollutants. Whole plant material was collected, dried in shade and crushed to powder using a grinder.

Extraction and fractionation
The crushed form of *C. adiantifolia* (1 kg) was soaked and extracted with 100% MeOH (3 L) for a week at room temperature. The methanol extract was evaporated to dryness using rotary evaporator at 40°C under reduced pressure.
The methanol extract (25 g) was further fractionated with *n*-hexane (CAH), dichloromethane (CAD), and ethyl acetate (CAE) and water residue was left behind. CAH, CAD and CAE were further analyzed through GC-MS for active principles.

Gas chromatography-mass spectrometry (GC-MS) analysis
The *n*-hexane (CAH), dichloromethane (CAD), and ethyl acetate (CAE) fractions were subjected to GC analysis and the GC-MS was done by means of 'Agilent GC-MS triple quad 7000 GC 7890A'. Helium was utilized as a carrier gas with a flow rate of 1.2 mL/min for all samples. The initial pressure was kept 9.1473 psi and run time 65 min for CAH and CAD and ZebronZB-5MS column was used for both samples at 40°C. For CAE the initial pressure was kept 9.7852 psi, the run time was kept 78 min at 40 °C and Agilent 19091J-433: 1825.64217 column was used. Analysis was performed in split mode in front SS inlet He. A split flow of 12 mL/min was kept for CAH and CAD while 36 mL/min split flow was maintained for CAE. The injection volume for CAH and CAD was kept 2 µL each while it was 1.5 µL for CAE. The oven program for CAH and CAD was kept on at 40°C for 10 min, then

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10ºC/min to 190ºC for 15 min and then 10ºC/min to 290ºC for 20 min. While the oven program for CAE was kept on at 50ºC for 10 min, then 10ºC/min to 180ºC for 20 min and then 10ºC/min to 280ºC for 25 min. Electron impact (EI) was the ion source and triple quadruple detector was used.

The identification of compounds of each fraction was based on the computer evaluation of mass spectra through NIST based AMDIS V 2.69 (Automated mass spectral deconvolution and identification software), direct comparison of peaks and retention time with those for standard compounds, with eight peak index.[19] A mass spectral survey was performed using NIST library for spectral comparison and identification.

Results and Discussion

The results of GC-MS analysis of n-hexane (CAH), dichloromethane (CAD) and ethyl acetate (CAE) fractions of *C. adiantifolia* are presented in Table 1, Table 2 and Table 3, respectively. Each table contains the data on retention time (min), name of compound, molecular formula, molecular weight and concentration i.e. peak area (%) for every individual compound identified through the technique. The GC-MS analysis of CAH, CAD and CAE revealed the presence of 24, 10 and 31 compounds, respectively.

The major compounds found in CAH include phthalic acid, mono(2-ethylhexyl) ester; 10-nonadecanol; hexadecanoic acid, methyl ester; *β*-Sitosterol and 9,12-Octadecadienoic acid (Z,Z)-methyl ester, etc.

The mentionable phytoconstituents found in CAD were protopine; benzo[f]quinolin-3(2H)-one, 1,4-dihydro-1-(2,5-dimethoxyphenyl)-; isobenzofuran-1,3-dione, 4,5-dimethoxy-; hydrastine; oxyhydrostinine and (RS)-stylopine, etc. However, the ethyl acetate fraction (CAE) was found to contain more of the compounds. Among those compounds benzo[f]quinolin-3(2H)-one, 1,4-dihydro-1-(2,5-dimethoxyphenyl)-; protopine; n-hexadecanoic acid; 3,4-methylenedioxypropiophenone; 1(3H)-isobenzofuranone, 6,7-dimethoxy; norsanguinarine; *γ*-sitosterol; D-bicuculline; hydrastine; hydrastinine and oxoberberine.

The literature survey of some of the chemical principles found in the fractions of *C. adiantifolia* mentioned above reveals the medicinal value of the plant species. Protopine; an alkaloid, has been reported for its anticonvulsant activity,[20] microtubule-stabilizing effects,[21] anti-inflammatory activity reducing effects,[22] neuroprotective effects,[23-24] anticholinesterase effects,[25] etc. Sanguinarine compounds have been reported for anticancer,[26-27] anti-osteoporosis,[28-29] and norsanguinarine has been reported for antifungal activity.[30] Hydrastine has been reported for the effects on dopamine biosynthesis,[31] PAK4 kinase inhibition[32] etc. Oxoberberine has exhibited effects on sodium current in human atrial myocytes.[33]

The GC-MS chromatograms of CAH, CAD and CAE are given in Figure 1, Figure 2 and Figure 3, respectively.

The mass spectra of the identified compounds reported in CAH, CAD and CAE fractions of *C. adiantifolia* through GC-MS analysis along with their structures are provided as Figure 4, Figure 5 and Figure 6, respectively.

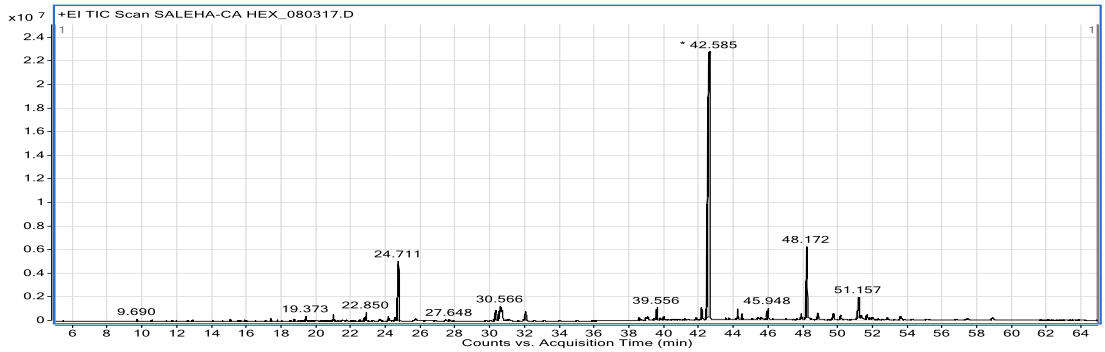

Figure 1: GC-MS chromatogram for n-hexane fraction of *C. adiantifolia*

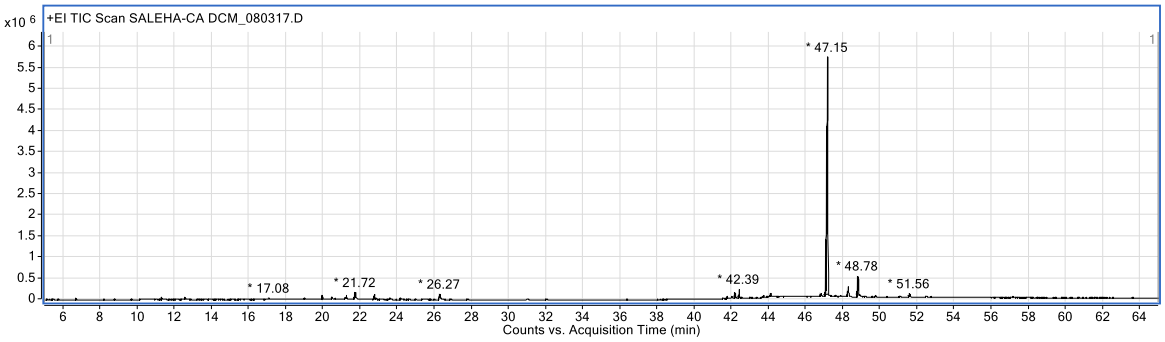

Figure 2: GC-MS chromatogram for dichloromethane fraction of *C. adiantifolia*

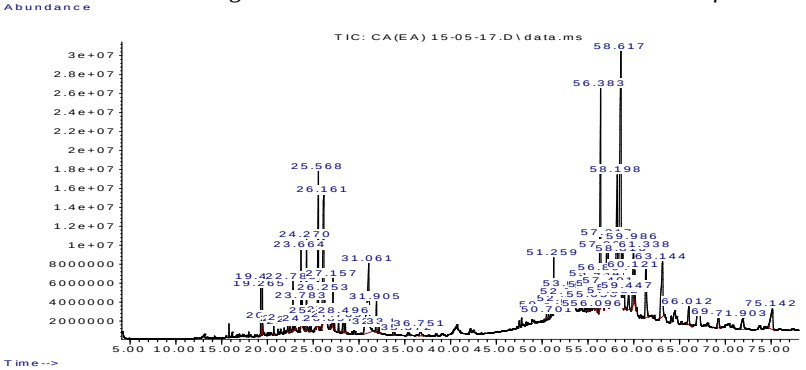

Figure 3: GC-MS chromatogram for ethyl acetate fraction of *C. adiantifolia*

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Table 1: GC-MS spectral analysis of n-hexane fraction of *C. adiantifolia*.

Peak No.	RT (min)	Name of compound	Molecular formula	Molecular weight	Peak area (%)
1	9.70	2-Heptenal, (Z)-	$C_7H_{12}O$	112	0.10
2	17.38	Nonanoic acid, 9-oxo-, methyl ester	$C_{10}H_{18}O_3$	186	0.12
3	19.38	Methyl 10-oxo-8-decenoate	$C_{11}H_{18}O_3$	198	0.19
4	20.96	Methyl tetradecanoate	$C_{15}H_{30}O_2$	242	0.30
5	22.85	2-Pentadecanone, 6,10,14-trimethyl-	$C_{18}H_{36}O$	268	0.17
6	23.64	1-Hexadecanol	$C_{16}H_{34}O$	242	0.19
7	24.13	7-Hexadecenoic acid, methyl ester, (Z)-	$C_{17}H_{32}O_2$	268	0.36
8	24.53	7-Hexadecenoic acid, methyl ester, (Z)-	$C_{17}H_{32}O_2$	268	0.35
9	24.68	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270	6.60
10	27.65	Heptadecanoic acid, methyl ester	$C_{18}H_{36}O_2$	284	0.12
11	30.31	9,12-Octadecadienoic acid (Z,Z)-, methyl ester	$C_{19}H_{34}O_2$	294	1.84
12	30.55	9,12,15-Octadecatrienoic acid, methyl ester, (Z,Z,Z)-	$C_{19}H_{32}O_2$	292	1.23
13	31.99	Octadecanoic acid, methyl ester	$C_{19}H_{38}O_2$	298	1.64
14	38.55	1,2-15,16-Diepoxyhexadecane	$C_{16}H_{30}O_2$	254	0.23
15	39.56	Eicosanoic acid, methyl ester	$C_{21}H_{42}O_2$	326	0.78
16	39.96	Z-(13,14-Epoxy)tetradec-11-en-1-ol acetate	$C_{16}H_{28}O_3$	268	0.23
17	42.13	Heneicosane	$C_{21}H_{44}$	296	0.64
18	42.58	Phthalic acid, mono(2-ethylhexyl) ester	$C_{16}H_{22}O_4$	278	72.68
19	44.19	Heptacosane	$C_{27}H_{56}$	380	0.55
20	44.44	Tetracosanoic acid, methyl ester	$C_{25}H_{50}O_2$	382	0.24
21	47.85	10-Nonadecanone	$C_{19}H_{38}O$	282	0.16
22	48.16	10-Nonadecanol	$C_{19}H_{40}O$	284	8.12
23	48.81	Benzo[f]quinolin-3(2H)-one, 1,4-dihydro-1-(2,5-dimethoxyphenyl)-	$C_{21}H_{19}NO_3$	333	0.34
24	51.14	β-Sitosterol	$C_{29}H_{50}O$	414	2.82

Table 2: GC-MS spectral analysis of dichloromethane fraction of *C. adiantifolia*

Peak No.	RT (min)	Name of compound	Molecular formula	Molecular weight	Peak area (%)
1	19.95	1,3-Dioxolo[4,5-g]isoquinolin-5-ol, 5,6,7,8-tetrahydro-6-methyl-	$C_{11}H_{13}NO_3$	207	0.42
2	21.73	Isobenzofuran-1,3-dione, 4,5-dimethoxy-	$C_{10}H_8O_5$	208	2.15
3	26.27	Oxyhydrostinine	$C_{11}H_{11}NO_3$	205	1.30
4	42.17	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{19}H_{38}O_4$	330	0.80
5	42.38	Phthalic acid, diisooctyl ester	$C_{24}H_{38}O_4$	390	1.28
6	46.79	(RS)-Stylopine	$C_{19}H_{17}NO_4$	323	0.48
7	47.15	Protopine	$C_{20}H_{19}NO_5$	353	85.63
8	48.25	Hydrastine	$C_{21}H_{21}NO_6$	383	2.14
9	48.77	Benzo[f]quinolin-3(2H)-one, 1,4-dihydro-1-(2,5-dimethoxyphenyl)-	$C_{21}H_{19}NO_3$	333	4.69
10	51.57	Spiro[androstane-3,2'-thiazolidine], (5α)-	$C_{21}H_{35}NS$	333	0.93

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Table 3: GC-MS spectral analysis of ethyl acetate fraction of *C. adiantifolia.*

Peak No.	RT (min)	Name of compound	Molecular formula	Molecular weight	Peak area (%)
1	19.26	4-Methoxymethylphenol	$C_8H_{10}O_2$	138	0.73
2	19.45	2-Methoxy-4-vinylphenol	$C_9H_{10}O_2$	150	0.74
3	20.69	Vanillin lactoside	$C_{20}H_{28}O_{13}$	476	0.29
4	22.22	Cinnamic acid, 4-hydroxy-3-methoxy-, [5-hydroxy-2-hydroxymethyl-6-[2-(4-hydroxy-3-methoxyphenyl)ethoxy]-4-(6-methyl-3,4,5-trihydroxytetrahydropyran-2-yloxy)tetrahydropyran-3-yl] ester	$C_{31}H_{40}O_{15}$	652	0.18
5	22.45	Octahydrobenzo[b]pyran, 4a-acetoxy-5,5,8a-trimethyl-	$C_{14}H_{24}O_3$	240	0.11
6	22.79	3',5'-Dimethoxyacetophenone	$C_{10}H_{12}O_3$	180	0.79
7	23.06	9-Hexadecenoic acid	$C_{16}H_{30}O_2$	254	0.09
8	23.66	Hydrastinine	$C_{11}H_{13}NO_3$	207	1.59
9	24.04	1b,4a-Epoxy-2H-cyclopenta[3,4]cyclopropa[8,9]cycloundec[1,2-b]oxiren-5(6H)-one, 7-(acetyloxy)decahydro-2,9,10-trihydroxy-3,6,8,8,10a-pentamethyl-	$C_{22}H_{32}O_8$	424	0.16
10	24.26	Ethenylcyanide, 3-[3,4-methylenedioxyphenyl]-	$C_{10}H_7NO_2$	173	2.92
11	25.52	1(3H)-Isobenzofuranone, 6,7-dimethoxy-	$C_{10}H_{10}O_4$	194	7.66
12	26.06	3,4-Methylenedioxypropiophenone	$C_{10}H_{10}O_3$	178	9.33
13	26.89	3,3a-Epoxydicyclopenta[a,d]cyclooctan-4β-ol, 9,10a-dimethyl-6-methylene-3β-isopropyl-	$C_{20}H_{32}O_2$	304	0.17
14	27.16	3,7,11,15-Tetramethyl-2-hexadecen-1-ol	$C_{20}H_{40}O$	296	1.33
15	27.31	2-Propenoic acid, 3-(4-hydroxy-3-methoxyphenyl)-, methyl ester	$C_{11}H_{12}O_4$	208	0.42
16	27.76	Ethanol, 2-(9-octadecenyloxy)-, (Z)-	$C_{20}H_{40}O_2$	312	0.38
17	28.49	2-Isobenzazol, 1,3-dioxo-2-methyl-4,5-methylenedioxy-	$C_{10}H_7NO_4$	205	0.54
18	31.04	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	256	10.27
19	51.25	3',8,8'-Trimethoxy-3-piperidyl-2,2'-binaphthalene-1,1',4,4'-tetrone	$C_{28}H_{25}NO_7$	487	1.02
20	52.39	Ethyl iso-allocholate	$C_{26}H_{44}O_5$	436	0.16
21	56.38	Protopine	$C_{20}H_{19}NO_5$	353	12.15
22	56.89	2-[4-methyl-6-(2,6,6-trimethylcyclohex-1-enyl)hexa-1,3,5-trienyl]cyclohex-1-en-1-carboxaldehyde	$C_{23}H_{32}O$	324	0.59
23	57.03	Hydrastine	$C_{21}H_{21}NO_6$	383	1.66
24	57.22	Stigmastan-3,5-diene	$C_{29}H_{48}$	396	2.21
25	57.39	9,12-Octadecadienoic acid, 2-phenyl-1,3-dioxan-5-yl ester, cis-	$C_{28}H_{42}O_4$	442	0.67
26	58.61	Benzo[f]quinolin-3(2H)-one, 1,4-dihydro-1-(2,5-dimethoxyphenyl)-	$C_{21}H_{19}NO_3$	333	23.69
27	59.92	D-Bicuculline	$C_{20}H_{17}NO_6$	367	4.12
28	61.36	γ-Sitosterol	$C_{29}H_{50}O$	414	4.99
29	63.16	Norsanguinarine	$C_{19}H_{11}NO_4$	317	6.39
30	66.02	Oxoberberine	$C_{21}H_{21}NO_4$	351	1.47
31	75.05	7-Azadibenz[a,e]azulen-12-one, 5,6,7,7a,12,12a-hexahydro-7-methyl-8,9-bis(methoxy)-2,3-methylenedioxy-12a-acetyloxy-	$C_{23}H_{23}NO_7$	425	3.16

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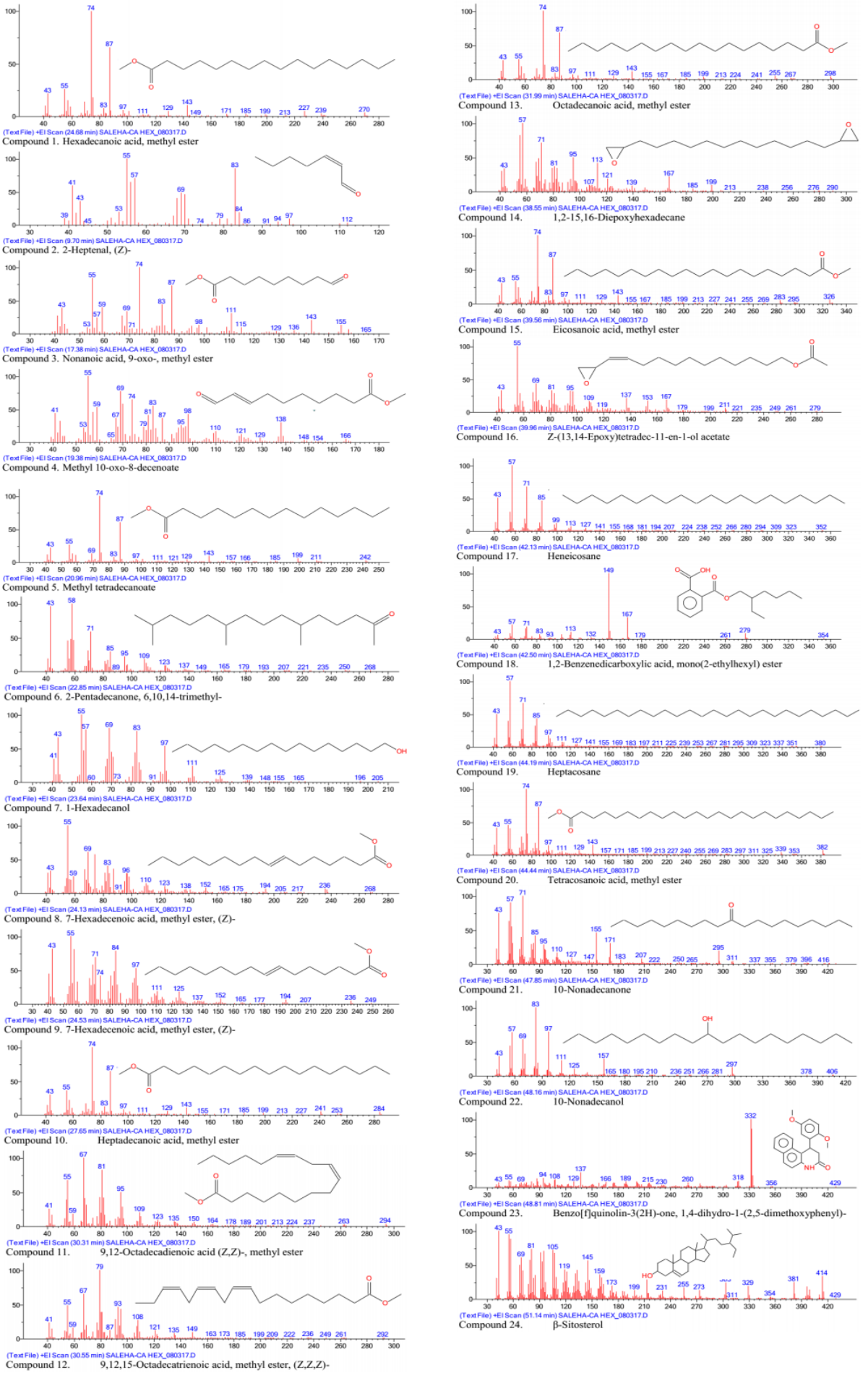

Figure 4: Mass spectra of identified compounds from n-hexane fraction of *C. adiantifolia*.

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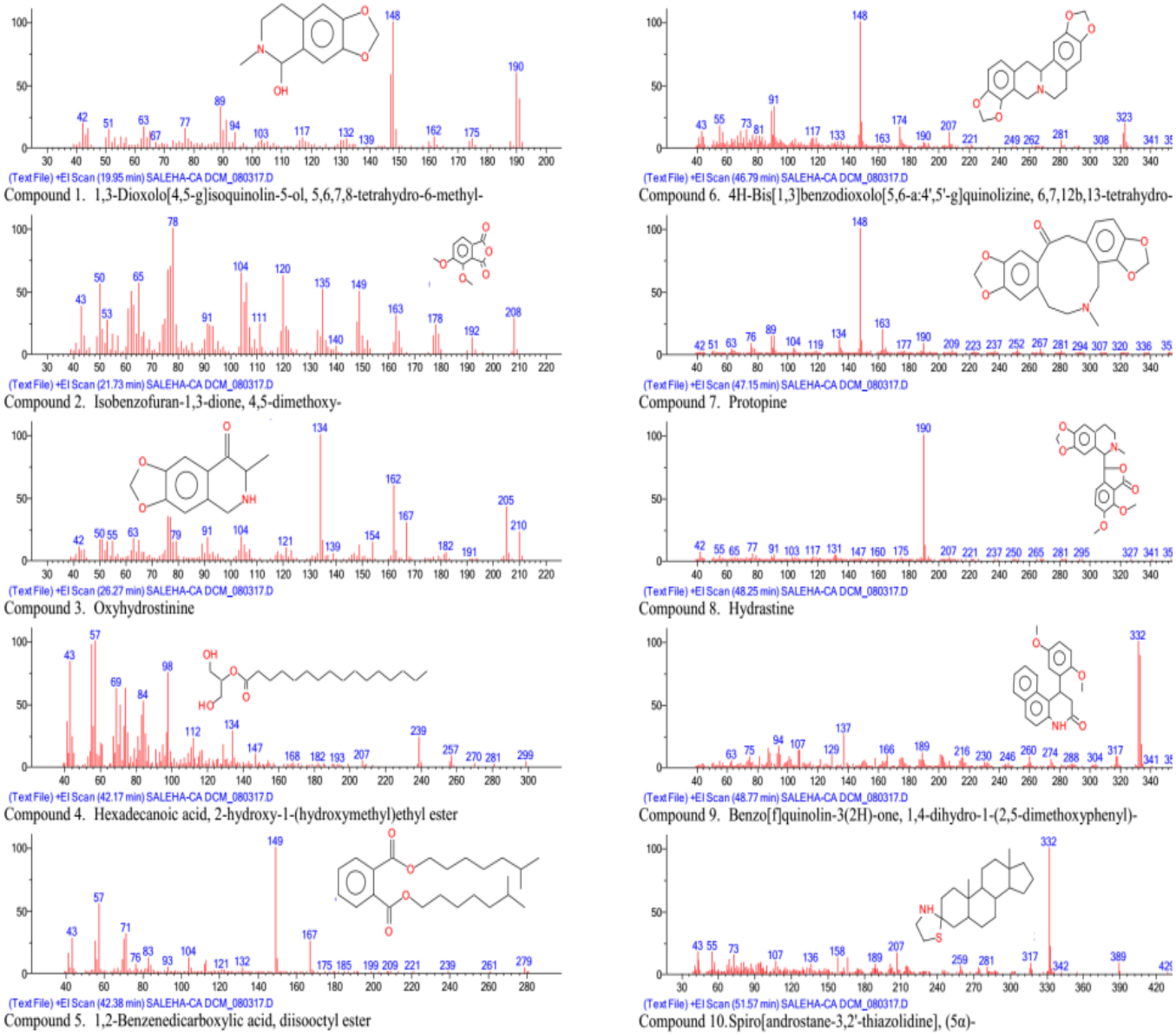

Figure 5: Mass spectra of identified compounds from DCM fraction of *C. adiantifolia*

Conclusion

The n-hexane (CAH), dichloromethane (CAD) and ethyl acetate (CAE) fractions of *Corydalis adiantifolia* extracted in methanol were separately analyzed using gas chromatography-mass spectrometry (GC-MS) technique. Total number of compounds found in CAH, CAD and CAE were 24, 10 and 31, respectively. Mostly esters were reported in CAH fraction of the sample and certain important alkaloids such as protopine, hydrastine, oxyhydrostinine, (RS)-stylopine were found in CAD fraction of *C. adiantifolia*. While, the protopine, hydrastine, hydrastinine, oxoberberine, D-bicuculline and norsanguinarine were reported in ethyl acetate fraction of the plant.

Conflict of interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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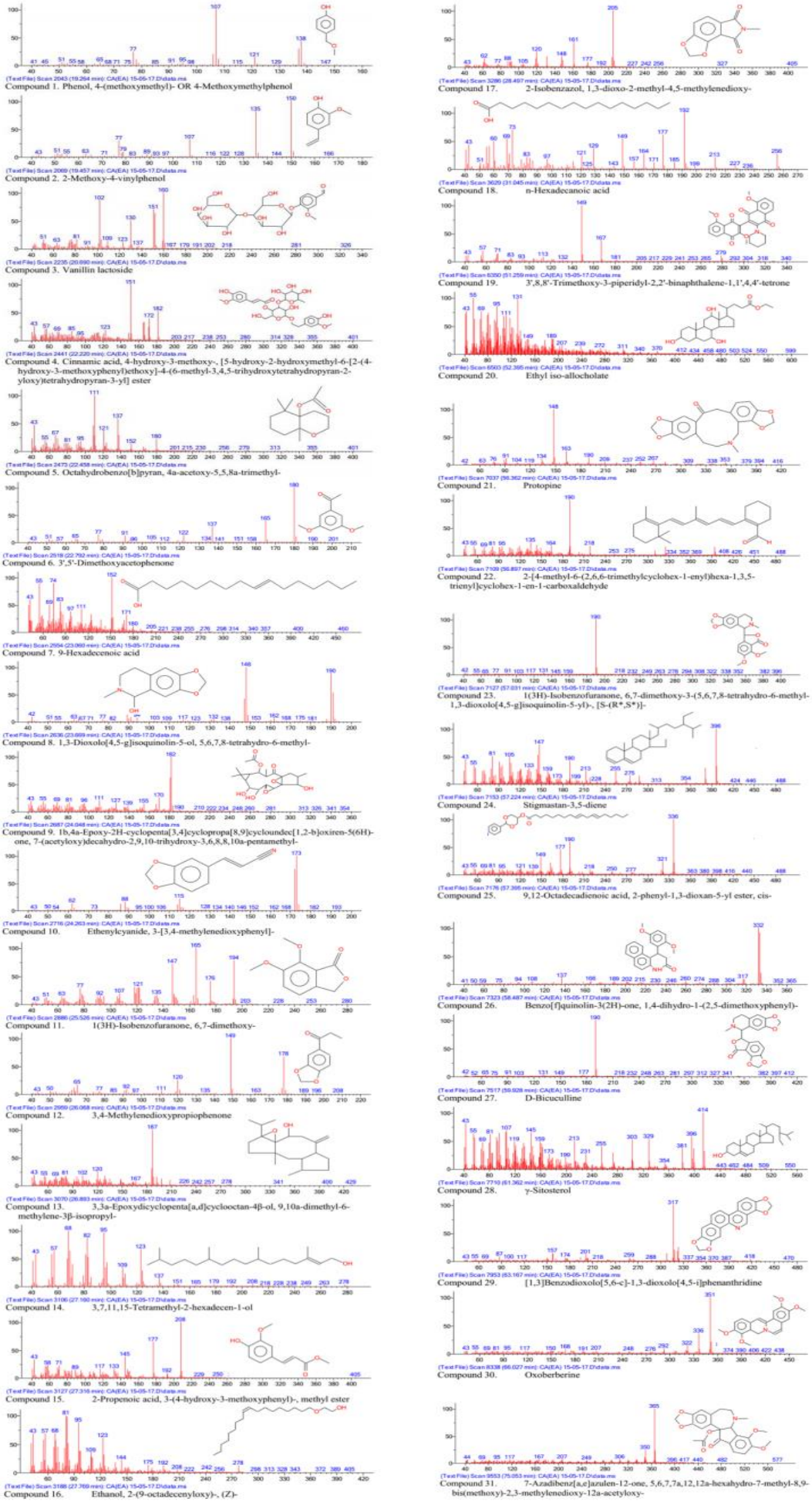

Figure 6: Mass spectra of identified compounds from Ethyl acetate fraction of *C. adiantifolia.*

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