

Phytochemical profile of stem extract of *Carthamus oxycantha* and identification of herbicidal and antimicrobial constituents

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Abstract: The present study was carried out to enlist herbicidal and antimicrobial compounds in the methanolic stem extract of *Carthamus oxycantha*, a problematic weed of Asteraceae. Methanolic stem extract was subjected to GC-MS analysis that revealed the presence of 150 constituents in the extract. The most abundant compound was Niacin (45.375%) followed by D-ribofuranose, 5-deoxy-5-(methylsulfinyl)-1,2,3-tris-O-(trimethylsilyl)- (14.528%); 9,12-octadecadienoic acid (Z,Z)-, methyl ester (4.951%); γ -tocopherol (4.638%); hexacosane (4.148%); 3-phenyllactic acid, 2TMS derivative (2.675%); 13-retinoic acid, (Z)-, TMS derivative (2.461%); 2,2,5,5-tetramethyl-4-ethyl-3-imidazoline-1-oxyl (2.276%); octadecanoic acid (1.851%); 2-deoxy-1,3,4,5-tetrakis-O-(trimethylsilyl); pentitol (1.757%); 3,5,5-trimethyl-4-(3-((trimethylsilyl)oxy)butyl)cyclohex-2-enone (1.505%); methyl 9.cis.,11.trans.t,13.trans.-octadecatrienoate (1.136%); and benzoic acid, 3-[(trimethylsilyl)oxy]-, trimethylsilyl ester (1.044%). Peak areas for the rest of the compounds were below 1%. Among the identified compounds, 9,12-octadecadienoic acid (Z,Z)-, methyl ester (3), hexacosane (5), 9,12-octadecadienoic acid (Z,Z)- (28), tetradecanoic acid, methyl ester (29), hexadecanoic acid, methyl ester (30), γ -sitosterol (33), 9,12,15-octadecatrienoic acid, (Z,Z,Z)- (48), dodecanoic acid (68) and eicosane (128) are known to possess antimicrobial activities. Compound 28 is also known for its herbicidal activity as a binary mixture with xanthoxyline. This study concludes that the stem extract of *C. oxycantha* primarily comprises antifungal and antibacterial compounds.

Keywords: antimicrobial; bioactive compounds; secondary metabolites; GC-MS; herbicidal; stem extract

Asteraceae is a large and widespread family of flowering plants, with 32 913 species commonly found in arid and semi-arid subtropical regions (Kew 2018). These plants are cultivated for their nutritional, medicinal, and ornamental value. These plants exhibit numerous pharmacological activities,

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such as antiviral, anti-diabetic, anti-tumour, antinociceptive, anti-inflammatory, hepatoprotective, anti-parasitic, anti-malarial, and wound-healing properties (Rafiq et al. 2024a). These activities are attributed to their phytochemical components, including essential oils, lignans, saponins, polyphenolic compounds, phenolic acids, sterols, and polysaccharides (Koc et al. 2015).

The allelopathic potential of *Asteraceous* crops and weeds has been utilized to manage weeds and plant pathogens (La Iacona et al. 2024 Rafiq et al. 2024b). In recent years, allelopathy research has concentrated on selecting plant extracts and allelochemicals for their potential as bioherbicides (Hasan et al. 2021). Numerous active allelochemicals, particularly phenolic compounds, have been identified, purified, and used for weed control (Kong et al. 2019). Many allelochemicals are water-soluble, allowing them to be applied as aqueous extracts, simplifying their application and reducing extraction costs (Cheng & Cheng 2015). However, plant extracts and allelochemicals are often tested under controlled conditions due to the challenges of obtaining field-based evidence (Mahé et al. 2022). Chon and Nelson (2010) reported that extracts, leachates and residues of different parts of *Asteraceous* plants can arrest seed germination and suppress seedling growth of crop plants and weeds. Gomaa et al. (2014) showed that aqueous extracts of dry shoot of *Sonchus oleraceus* completely inhibited the germination of three weeds, including *Melilotus indicus*, *Chenopodium murale* and *Brassica nigra* (Gomaa et al. 2014). It was also revealed that the aqueous extract of sunflower reduced germination and seedling growth of several weed species, e.g. *Parthenium hysterophorus*, *Chenopodium album* and *Coronopus didymus*, as well as crop plants such as wheat (Bashir et al. 2017; Naeem et al. 2018). Bashir et al. (2018) findings further indicated that aqueous extract of different parts of *Sonchus arvensis* reduced germination and seedling growth of maize. Over and above, aqueous extracts of the most feared weed, viz. *Parthenium hysterophorus* showed a significant effect on weeds of wheat, and its herb mulching can be utilized to manage weeds in soybeans (Afridi & Khan 2015; Siddiqui et al. 2018). Benvenuti et al. (2017) found that the pre- and post-herbicidal activity of *Artemisia annua* and *Xanthium strumarium* against *Amaranthus retroflexus* was due to their essential oils. Sesquiterpenes and monoterpenes are the ter-

pinoids that are mostly present in essential oils and responsible for their herbicidal activity (Weston & Duke 2003).

Moreover, *Ageratum conyzoides* possess admirable antifungal, insecticidal and herbicidal capacities (Javaid et al. 2020; Erida et al. 2023). *Asteraceous* weeds, namely *Cirsium arvense*, *S. oleraceus*, *A. conyzoides* and *Launea nudicaulis* are known for their antifungal activity against *Macrophomina phaseolina* (Banaras et al. 2015, 2017, 2020, 2021). Many biologically active compounds have been reported from *Asteraceous* weeds such as *A. conyzoides*, *S. oleraceus* and *Cirsium arvense* (Banaras et al. 2020; Ferdosi et al. 2021a, 2021b). Since many *Asteraceous* species are pioneer plants in agricultural as well as in natural ecosystems (Benvenuti 2004), they may represent an economic plant biomass for the isolation of allelochemicals (Vyvyan 2002) to be used as herbicidal and antimicrobial agents.

Carthamus oxycantha is a problematic weed of the family *Asteraceae*. It is found in dry places of Pakistan, Iran, Afghanistan, Iraq, India, Azerbaijan, Turkmenistan, Tajikistan and Kyrgyzstan (Dilshad et al. 2016). It is a medicinally important weed possessing anti-hyperlipidemic qualities and is also used in increasing blood circulation, reducing swelling and pain in injuries, and showing labour induction properties (Ahmad et al. 2009). Hesami (2012) reported that aqueous extracts of different parts of this weed can reduce the germination and growth of *Phaseolus vulgaris*. Siyar et al. (2018) found that aqueous leaf and root extracts of *C. oxycantha* reduced germination and seedling growth of various weeds of wheat crops, namely *Phalaris canariensis*, *Chenopodium album*, *Rumex dentatus* and *Lepidium didymum*. *C. oxycantha* has been previously reported for its antifungal potential against various phytopathogens, reducing fungal growth and spore germination (Aslam et al. 2024). Studies have reported bioactive compounds such as flavonoids, phenolics, and sesquiterpene lactones, which contribute to their antimicrobial properties (Tanasa et al. 2025). Notably, previous research has shown that extracts of *C. oxycantha* exhibit strong antifungal activity against *Fusarium* spp., *Aspergillus* spp., and *Alternaria* spp., suggesting its potential as a natural antifungal agent (Batool et al. 2025). However, studies regarding phytochemicals responsible for herbicidal or antimicrobial activities are lacking. This study aimed to identify various phytoconstituents present in methanolic stem

extract of *C. oxycantha* through GC-MS analysis and identification of herbicidal and antimicrobial constituents from the list.

MATERIAL AND METHOD

C. oxycantha is commonly found in cultivated fields in Punjab, Pakistan. Mature plants of *C. oxycantha* were collected from the University of the Punjab Lahore, Pakistan in June 2017 according to prescribed rules in The Pakistan Trade Control of Wild Fauna and Flora Act 2012. Plant Taxonomist identified species, assigned voucher No. AJ. 1001 (*C. oxycantha*). Plants were dried, stems were separated, cut into small pieces, and thoroughly crushed. Five grams of the crushed stem was soaked in 100 mL methanol and left for 2 weeks. The extract was separated from debris by passing it through a muslin cloth. The extract was filtered and stored in a glass vial to perform GC-MS.

GC-MS analysis was done following the procedure of Rafiq et al. (2017). A volume of 0.3 mL of methanolic stem extract obtained after filtration was transferred to GC vials and dried overnight in a SpeedVac system. The extract was subjected to methoximation with methoxyamine hydrochloride (Sigma) at 30 °C for 90 min. The sample was silylated with BSTFA/TCMS (Sigma) at 60 °C for 30 min. It was subjected to gas chromatography-mass spectrometry (GC-MS) on an Agilent 7890C gas chromatograph with a 5975C MSD. The GC oven program began at 80 °C and lasted 1 min. It ramped from 15 °C to 320 °C and was held for 3 min. Identification and quantification were conducted using

AMDIS with a manually curated retention-indexed GC-MS library, and additional identification was performed using the NIST17 and Wiley 11 GC-MS spectral libraries.

A literature survey was conducted to determine herbicidal, antifungal and antibacterial activities of major compounds identified through GC-MS.

RESULTS

150 compounds were identified in the methanolic stem extract of *C. oxycantha* (Figure 1, Table 1). Among these, niacin (1) was the predominant compound with a 43.375% peak area. D-Ribofuranose, 5-deoxy-5-(methylsulfinyl)-1,2,3-tris-O-(trimethylsilyl)- (2) was the second most abundant compound with a 14.528% peak area. The third most abundant compound was 9,12-octadecadienoic acid (Z,Z)-, methyl ester (3), with a 4.951% peak area. γ -Tocopherol (4) and hexacosane (5) had peak areas of 4.638% and 4.148%, respectively.

Moderately abundant compounds, with peak areas between 1% and 2%, included 3-Phenyllactic acid, 2TMS derivative (6), 13-Retinoic acid, (Z)-, TMS derivative (7), and 13-Retinoic acid, (Z)-, TMS derivative (8).

Less abundant compounds with peak areas between 0.1 and 1% were δ -tocopherol (14), 1-monolinolein, 2TMS derivative (15), isoquinoline, 1-[(3,4-diethoxyphenyl)methyl]-6,7-diethoxy- (16), 1-dodecanol, TMS derivative (17), suberic acid, 2TMS derivative (18), 2(3H)-benzofuranone, 3-(methoxymethylene)- (19), 1-o-methyl 3-O-(2-trimethylsilyl) propanedioate (20), 4-hydroxybutanoic acid,

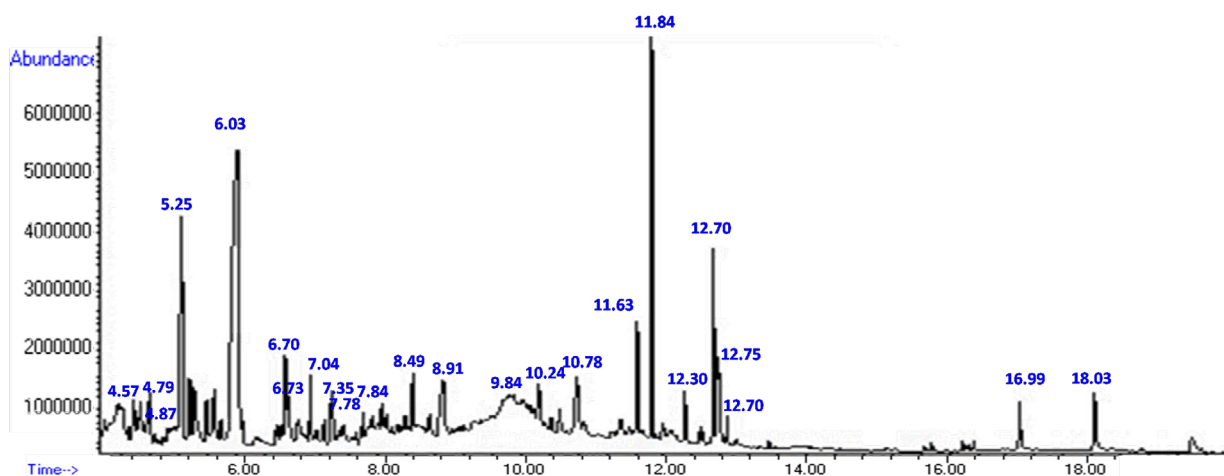


Figure 1. GC-MS chromatogram of methanolic stem extract of *Carthamus oxycantha*

Table 1. Compounds identified from methanolic stem extract of *Carthamus oxycantha* through GC-MS analysis

No.	Names of compounds	Formula	Weight (g/mole)	Retention time (min)	Peak area (%)
1	Niacin	C ₆ H ₅ NO ₂	123.10	6.47	45.375
2	D-ribofuranose, 5-deoxy-5-(methylsulfinyl)-1,2,3-tris-O-(trimethylsilyl)-	C ₁₅ H ₃₆ O ₅ SSi ₃	412.15	8.41	14.528
3	9,12-Octadecadienoic acid (Z,Z)-, methyl ester	C ₁₉ H ₃₄ O ₂	294.25	12.52	4.951
4	γ-Tocopherol	C ₂₈ H ₄₈ O ₂	416.67	17.32	4.638
5	Hexacosane	C ₂₆ H ₅₄	366.42	13.75	4.148
6	3-Phenyllactic acid, 2TMS derivative	C ₁₅ H ₂₆ O ₃ Si ₂	310.14	9.02	2.675
7	13-Retinoic acid, (Z)-, TMS derivative	C ₂₃ H ₃₆ O ₂ Si	372.24	15.26	2.461
8	2,2,5,5-Tetramethyl-4-ethyl-3-imidazoline-1-oxyl	C ₉ H ₁₇ N ₂ O	169.13	4.86	2.276
9	Octadecanoic acid	C ₁₈ H ₃₆ O ₂	284.27	12.90	1.851
10	2-Deoxy-1,3,4,5-tetrakis-O-(trimethylsilyl)pentitol	C ₁₇ H ₄₄ O ₄ Si ₄	424.23	9.15	1.757
11	3,5,5-Trimethyl-4-(3-((trimethylsilyl)oxy)butyl)cyclohex-2-enone	C ₁₆ H ₃₀ O ₂ Si	282.20	10.57	1.505
12	Methyl 9.cis.,11.trans.t,13.trans.-octadecatrienoate	C ₁₉ H ₃₂ O ₂	292.24	13.46	1.136
13	Benzoic acid, 3-[(trimethylsilyl)oxy]-, trimethylsilyl ester	C ₁₃ H ₂₂ O ₃ Si ₂	282.11	8.82	1.044
14	δ-Tocopherol	C ₂₇ H ₄₆ O ₂	402.65	16.85	0.917
15	1-Monolinolein, 2TMS derivative	C ₂₇ H ₅₄ O ₄ Si ₂	498.35	16.14	0.854
16	Isoquinoline, 1-[(3,4-diethoxyphenyl)methyl]-6,7-diethoxy-	C ₂₄ H ₂₉ NO ₄	395.21	13.36	0.845
17	1-Dodecanol, TMS derivative	C ₁₅ H ₃₄ OSi	258.23	8.79	0.716
18	Suberic acid, 2TMS derivative	C ₁₄ H ₃₀ O ₄ Si ₂	318.16	9.83	0.565
19	2(3H)-Benzofuranone, 3-(methoxymethylene)-	C ₁₀ H ₈ O ₃	176.04	8.37	0.559
20	1-O-methyl 3-O-(2-trimethylsilylethyl) propanedioate	C ₉ H ₁₈ O ₄ Si	218.09	4.28	0.476
21	4-Hydroxybutanoic acid, 2TMS derivative	C ₁₀ H ₂₄ O ₃ Si ₂	248.12	5.90	0.475
22	Glycerol, 1,2-di(TMS)-	C ₉ H ₂₄ O ₃ Si ₂	236.12	5.55	0.462
23	Silane, [1,3,5-benzenetriyltris(oxy)]tris[trimethyl-	C ₁₅ H ₃₀ O ₃ Si ₃	342.15	14.99	0.412
24	1,2,3-Butanetriol, 3TMS derivative	C ₁₃ H ₃₄ O ₃ Si ₃	322.18	6.50	0.397
25	Octadecane, 1,1'-[(1-methyl-1,2-ethanediyl)bis(oxy)]bis-	C ₃₉ H ₈₀ O ₂	580.61	15.80	0.313
26	4-Hydroxybenzyl alcohol, 2TMS derivative	C ₁₃ H ₂₄ O ₂ Si ₂	268.13	8.32	0.291
27	Cetene	C ₁₆ H ₃₂	224.25	8.97	0.262
28	9,12-Octadecadienoic acid (Z,Z)-	C ₁₈ H ₃₂ O ₂	280.24	12.77	0.252
29	Tetradecanoic acid, methyl ester	C ₁₅ H ₃₀ O ₂	242.22	9.98	0.232
30	Hexadecanoic acid, methyl ester	C ₁₇ H ₃₄ O ₂	270.25	11.40	0.198
31	Pentanedioic acid, 2-methyl-, bis(trimethylsilyl) ester	C ₁₂ H ₂₅ NO ₅ Si ₂	319.12	7.55	0.186
32	1-(Palmitoyloxy)-3-((trimethylsilyl)oxy)propan-2-yl (Z)-hexadec-9-enoate	C ₃₈ H ₇₄ O ₅ Si	638.53	19.23	0.179
33	γ-Sitosterol	C ₂₉ H ₅₀ O	414.38	19.41	0.145
34	Phloretic acid, 2TMS derivative	C ₁₅ H ₂₆ O ₃ Si ₂	310.14	10.32	0.113
35	Glucose, 5TMS derivative	C ₂₁ H ₅₂ O ₆ Si ₅	540.26	12.25	0.112
36	1,4-Bis(3-methoxy-4-((trimethylsilyl)oxy)phenyl)tetrahydro-1H,3H-furo[3,4-c]furan	C ₂₆ H ₃₈ O ₆ Si ₂	502.22	19.33	0.093
37	Acetin, bis-1,3-trimethylsilyl ether	C ₁₁ H ₂₆ O ₄ Si ₂	278.13	5.40	0.053
38	L-Proline, 1-(trifluoroacetyl)-, trimethylsilyl ester	C ₁₂ H ₁₈ F ₃ NO ₃	281.12	6.96	0.033
39	1-Hexacosene	C ₂₆ H ₅₂	364.40	13.08	0.025
40	Benzoic acid, 4-hydroxy-3-methoxy-, methyl ester	C ₁₀ H ₁₂ O ₄	196.07	8.47	0.024
41	Methyl galactoside (1S,2R,3S,4R,5R)-, 4TMS derivative	C ₁₉ H ₄₆ O ₆ Si ₄	482.23	11.39	0.015

Table 1. to be continued...

No.	Names of compounds	Formula	Weight (g/mole)	Retention time (min)	Peak area (%)
42	2-Furoic acid, TMS derivative	C ₈ H ₁₂ O ₃ Si	184.05	4.95	0.014
43	Salicylic acid	C ₇ H ₆ O ₃	138.03	6.60	0.010
44	Benzeneacetamide, TMS derivative	C ₁₁ H ₁₇ NOSi	207.10	7.95	0.008
45	Acetic acid, 2-[(6-methoxy-4-methyl-2-quinoliny)thio]-, hydrazide	C ₁₃ H ₁₅ N ₃ O ₂ S	277.08	11.28	0.008
46	9-Hexadecenoic acid, methyl ester, (Z)-	C ₁₇ H ₃₂ O ₂	268.24	11.27	0.006
47	1H-Pyrazole, 3,5-diphenyl-4-tricyclo[3.3.1.1.3,7]dec-1-yl-	C ₂₅ H ₂₆ N ₂	354.21	18.08	0.004
48	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	C ₁₈ H ₃₂ O	264.24	12.81	0.004
49	2,2'-Bipyridine	C ₁₀ H ₈ N ₂	156.06	7.88	0.003
50	1-Pentanol, 5-chloro-, acetate	C ₇ H ₁₃ ClO ₂	164.06	4.35	0.003
51	Bis(2-ethylhexyl) phthalate	C ₂₄ H ₃₈ O ₄	390.27	15.11	0.002
52	4-Hydroxy-2,2',4',6'-tetrachlorobiphenyl, trimethylsilyl ether	C ₁₅ H ₁₄ Cl ₄ OSi	377.95	16.11	0.002
53	Pyridine, 2-pentyl-	C ₁₃ H ₁₃ N	183.10	5.65	0.002
54	2-methylidene-6,10,14-trimethylpen2-methylidene-6,10,14-trimethylpentadecanoic acid silylated	C ₂₂ H ₄₄ O ₂ Si	368.31	11.72	0.002
55	5-Amino-8-hydroxyquinoline, N,O-bis(trimethylsilyl)-	C ₁₅ H ₂₄ N ₂ OSi ₂	304.14	16.35	0.002
56	3-Vanilpropanol, bis(trimethylsilyl)-	C ₁₆ H ₃₀ O ₃ Si ₂	326.17	10.74	0.002
57	Azelaic acid	C ₉ H ₁₆ O ₄	188.10	9.34	0.002
58	9-Octadecenamide, (Z)-	C ₁₈ H ₃₅ NO	281.27	14.10	0.002
59	l-Isoleucine, N-trifluoroacetyl-	C ₈ H ₁₂ F ₃ NO ₃	227.07	6.48	0.002
60	N,N-Bis(2-hydroxyethyl)-p-toluidine	C ₁₁ H ₁₇ NO ₂	195.12	14.38	0.002
61	9-Octadecenoic acid, (E)-, TMS derivative	C ₂₁ H ₄₂ O ₂ Si	354.29	13.26	0.002
62	Pimelic acid, 2TMS derivative	C ₁₃ H ₂₈ O ₄ Si ₂	304.15	9.09	0.002
63	2,3-Butanediol, 2TMS derivative	C ₁₀ H ₂₆ O ₂ Si ₂	234.14	4.08	0.002
64	DL-Glyceraldehyde, tris(trimethylsilyl) ether	C ₁₂ H ₃₀ O ₃ Si ₃	306.15	9.71	0.002
65	Benzoic acid, 3,4-bis[(trimethylsilyl)oxy]-, trimethylsilyl ester	C ₁₄ H ₂₄ O ₄ Si ₂	312.12	10.76	0.002
66	Decanedioic acid, dibutyl ester	C ₁₈ H ₃₄ O ₄	314.24	12.95	0.002
67	D-Ribofuranose, 2,3,5-tris-O-(trimethylsilyl)-, bis(trimethylsilyl) phosphate	C ₂₀ H ₅₁ O ₈ PSi ₅	590.21	14.69	0.002
68	Dodecanoic acid	C ₁₂ H ₂₄ O ₂	200.17	8.72	0.002
69	Malic acid 1-ethyl ester, 2TMS	C ₁₂ H ₂₆ O ₅ Si ₂	306.13	8.21	0.002
70	Hexanoic acid, 3-trimethylsilyloxy, trimethylsilyl ester	C ₁₂ H ₂₈ O ₃ Si ₂	276.15	6.59	0.002
71	L-Valine, 2TMS derivative	C ₁₁ H ₂₇ NO ₂ Si ₂	261.15	5.75	0.002
72	α-Linolenic acid, TMS derivative	C ₂₁ H ₃₈ O ₂ Si	350.26	13.27	0.002
73	Salicylic acid, 2TMS derivative	C ₁₃ H ₂₂ O ₃ Si ₂	282.11	8.42	0.002
74	Methyl 3-(3,4-bis(tert.-butyldimethylsilyl)oxyphenyl)prop-2-enoate	C ₂₂ H ₃₈ O ₄ Si ₂	422.23	13.80	0.002
75	Hexadecanoic acid, 4-[(trimethylsilyl)oxy]butyl ester	C ₂₃ H ₄₈ O ₃ Si	400.33	15.87	0.002
76	Vanillyl alcohol, 2TMS derivative	C ₁₄ H ₂₆ O ₃ Si ₂	298.14	9.41	0.002
77	Benzoic acid, 4-[(trimethylsilyl)oxy]-, trimethylsilyl ester	C ₁₃ H ₂₃ NO ₂ Si ₂	281.12	9.31	0.002
78	Androst-4-ene-3,17-dione, 15-hydroxy-, (15.α.)-	C ₁₉ H ₂₆ O ₃	302.18	14.55	0.002
79	Butanoic acid, 3,4-bis[(trimethylsilyl)oxy]-, trimethylsilyl ester	C ₁₃ H ₃₂ O ₄ Si ₃	336.16	7.72	0.002
80	Acetoacetic acid, bis(trimethylsilyl)- deriv.	C ₁₀ H ₂₂ O ₃ Si ₂	246.11	6.18	0.002
81	L-Proline, 5-oxo-1-(trimethylsilyl)-, trimethylsilyl ester	C ₁₁ H ₂₃ NO ₃ Si ₂	273.12	8.51	0.002
82	2-Trimethylsilyloxyheptanoic acid, trimethylsilyl ester	C ₁₃ H ₃₀ O ₃ Si ₂	290.17	7.12	0.002

Table 1. to be continued...

No.	Names of compounds	Formula	Weight (g/mole)	Retention time (min)	Peak area (%)
83	Dodecane	C ₁₂ H ₂₆	170.200	5.55	0.002
84	Cyclononasiloxane, octadecamethyl-	C ₁₈ H ₅₄ O ₉ Si ₉	666.160	10.71	0.002
85	Fructofuranoside, methyl 1,3,4,6-tetrakis-O-(trimethylsilyl)-, .alpha.-D-	C ₁₉ H ₄₆ O ₆ Si ₄	482.230	10.55	0.002
86	3-Trimethylsiloxyoctanoic acid, trimethylsilyl ester	C ₁₄ H ₃₂ O ₃ Si ₂	304.189	8.06	0.002
87	2-Aminoethanol, N-acetyl-, O-TMS	C ₇ H ₁₇ NO ₂ Si	175.103	5.64	0.002
88	Galactopyranose, 5TMS derivative	C ₂₁ H ₅₂ O ₆ Si ₅	540.261	17.97	0.002
89	2-Ethylhexanol, TMS derivative	C ₁₁ H ₂₆ OSi	202.175	4.66	0.002
90	7,9-Di-tert-butyl-1-oxaspiro(4,5)deca-6,9-diene-2,8-dione	C ₁₇ H ₂₄ O ₃	276.173	11.47	0.002
91	9-Octadecenoic acid (Z)-, 2,3-bis[(trimethylsilyl)oxy]propyl ester	C ₂₇ H ₅₆ O ₄ Si ₂	500.372	16.14	0.002
92	1-Monopalmitin, 2TMS derivative	C ₂₅ H ₅₄ O ₄ Si ₂	474.356	15.29	0.002
93	1H-Indole-2-carboxylic acid, 1-(trimethylsilyl)-5-[(trimethylsilyl)oxy]-, trimethylsilyl ester	C ₁₈ H ₃₁ NO ₃ Si ₃	393.161	11.54	0.002
94	Levogluconone	C ₆ H ₆ O ₃	126.032	4.87	0.002
95	Bohlmann k2631	C ₁₅ H ₂₀ O ₂	232.146	11.92	0.002
96	Hydracrylic acid, 2TMS derivative	C ₉ H ₂₂ O ₃ Si ₂	234.111	5.02	0.002
97	Diazene, (4-methoxy-1-naphthalenyl)(4-nitrophenyl)-	C ₁₇ H ₁₃ N ₃ O ₃	307.096	10.84	0.002
98	Decanedioic acid, bis(2-ethylhexyl) ester	C ₂₆ H ₅₀ O ₄	426.371	16.35	0.002
99	Traumatic acid, (E)-, 2TMS derivative	C ₁₈ H ₃₆ O ₄ Si ₂	372.215	12.39	0.002
100	4-Methoxybenzyl alcohol, TMS derivative	C ₁₁ H ₁₈ O ₂ Si	210.108	7.42	0.002
101	D-Fructose, 5TMS derivative	C ₂₁ H ₅₂ O ₆ Si ₅	540.261	6.72	0.002
102	5-O-Coumaroyl-D-quinic acid, 5TMS	C ₃₁ H ₅₈ O ₈ Si ₅	698.298	17.32	0.002
103	Silane, dimethyl(4-(2-phenylprop-2-yl)phenoxy)tridecyloxy-	C ₃₀ H ₄₈ O ₂ Si	468.342	17.37	0.002
104	1H-Indole, 1-(trimethylsilyl)-2,5-bis[(trimethylsilyl)oxy]-	C ₁₇ H ₃₁ NO ₂ Si ₃	365.166	10.94	0.002
105	1,2,3,4,5,6-Hexa-O-trimethylsilyl-myo-inositol	C ₂₄ H ₆₀ O ₆ Si ₆	612.301	11.83	0.002
106	8a-Methyl-3,5-dimethylenedecahydronaphtho[2,3-b]furan-2(3H)-one	C ₁₅ H ₂₀ O ₂	232.146	11.79	0.002
107	n-Tetracosanol-1	C ₂₄ H ₅₀ O	354.386	14.23	0.002
108	Phenylethyl Alcohol, TMS derivative	C ₁₁ H ₁₈ OSi	194.113	5.87	0.002
109	Eicosanoic acid, methyl ester	C ₂₁ H ₄₂ O ₂	326.318	13.86	0.002
110	Monomethyl succinate, trimethylsilyl ester	C ₈ H ₁₆ O ₄ Si	204.082	5.36	0.002
111	3-Hydroxy-2,3-dihydromaltol, 2-O-TMS	C ₁₂ H ₂₄ O ₄ Si ₂	288.121	7.89	0.002
112	Xylonic acid, 2,3,4-tris-O-(trimethylsilyl)-, .delta.-lactone, D-	C ₁₄ H ₃₂ O ₅ Si ₃	364.156	9.42	0.002
113	Phosphoric acid, bis(trimethylsilyl)monomethyl ester	C ₇ H ₂₁ O ₄ PSi ₂	256.072	5.42	0.002
114	5-Propyl-10,11-dihydro-5H-dibenzo[a,d]cyclohepten-5,10-imine hydrochloride	C ₁₈ H ₁₉ N	249.152	12.85	0.002
115	Oleic acid, butyl ester	C ₂₂ H ₄₂ O ₂	338.318	13.83	0.002
116	Pantothenic acid tritms	C ₁₈ H ₄₁ NO ₅ Si ₃	435.229	11.97	0.002
117	L-Valine, TMS derivative	C ₈ H ₁₉ NO ₂ Si	189.119	4.53	0.002
118	Benzeneacetic acid	C ₈ H ₈ O ₂	136.052	6.07	0.002
119	Heneicosanoic acid, methyl ester	C ₂₂ H ₄₄ O ₂	340.334	14.41	0.002
120	D-Glucose, 2,3,4,5,6-pentakis-O-(trimethylsilyl)-, O-methyl-oxime	C ₂₂ H ₅₅ NO ₆ Si ₅	569.288	11.42	0.002
120	2,5-Cyclohexadiene-1,4-dione, 2,6-bis(1,1-dimethylethyl)-	C ₁₄ H ₂₀ O ₂	196.074	8.08	0.002
122	Piperidine, 1-[5-(1,3-benzodioxol-5-yl)-1-oxo-2,4-pentadienyl]-, (Z,Z)-	C ₁₇ H ₁₉ NO ₃	285.136	16.19	0.002

Table 1. to be continued...

No.	Names of compounds	Formula	Weight (g/mole)	Retention time (min)	Peak area (%)
123	Benzoic acid, 3,4,5-tris(trimethylsiloxy)-, trimethylsilyl ester	C ₁₉ H ₃₈ O ₅ Si ₄	458.180	11.73	0.002
124	Xylitol, 5TMS derivative	C ₂₀ H ₅₂ O ₅ Si ₅	512.266	10.07	0.002
125	2-O-Glycerol- α -D-galactopyranoside, hexa-TMS	C ₂₇ H ₆₆ O ₈ Si ₆	686.337	13.99	0.002
126	Triethylene glycol, 2TMS derivative	C ₁₂ H ₃₀ O ₄ Si ₂	294.168	8.30	0.002
127	Hexadecanoic acid, ethyl ester	C ₁₈ H ₃₄ O ₂	282.256	11.84	0.002
128	Eicosane	C ₂₀ H ₄₂	282.329	11.87	0.002
129	Octahydro-1H-cyclopenta[b]pyridin-4-ol	C ₈ H ₁₅ NO	141.115	4.26	0.002
130	Pentanedioic acid, 2TMS derivative	C ₁₁ H ₂₄ O ₄ Si ₂	276.121	7.44	0.002
131	1H-Pyrrole-2,5-dione, 3-ethyl-4-methyl-	C ₇ H ₇ NO ₂	137.048	5.90	0.002
132	Vanillic Acid, 2TMS derivative	C ₁₄ H ₂₄ O ₄ Si ₂	312.121	10.35	0.002
133	Undecanedioic acid, 2TMS derivative	C ₁₇ H ₃₆ O ₄ Si ₂	360.215	11.85	0.002
134	Propanetriol, 2-methyl-, tris-O-(trimethylsilyl)-	C ₁₃ H ₃₄ O ₃ Si ₃	322.182	7.87	0.002
135	Spiro[decahydroquinoline-4,2'-tetrahydrofuran], 1,2-dimethyl-5'-hydroxymethyl-	C ₁₅ H ₂₇ NO ₂	253.204	10.49	0.002
136	trimethylsilyl 11-((trimethylsilyl)oxy)dodecanoate	C ₁₈ H ₄₀ O ₃ Si ₂	360.252	10.58	0.002
137	2'-Hydroxy-6'-methoxyacetophenone, TMS derivative	C ₁₂ H ₁₈ O ₃ Si	238.103	8.23	0.002
138	Olean-18-en-3-ol, O-TMS, (3 β .)	C ₃₃ H ₅₈ OSi	498.426	19.52	0.002
139	Ethosuximide, N-tert-butyl dimethylsilyl-	C ₁₃ H ₂₅ NO ₂ Si	255.165	6.61	0.002
140	Chondrillasterol	C ₂₉ H ₄₈ O	412.371	19.41	0.002
141	Pregn-4-ene-3,20-dione, 11,17-bis[(trimethylsilyl)oxy]-, bis(O-methyloxime), (11 β .)-	C ₂₉ H ₅₂ N ₂ O ₄ Si ₂	548.347	17.52	0.002
142	1-Linolenylglycerol, 2TMS derivative	C ₂₇ H ₅₂ O ₄ Si ₂	496.340	16.18	0.002
143	Toxin HT 2, 2TMS derivative	C ₂₈ H ₄₈ O ₈ Si ₂	568.289	13.40	0.002
144	Octanoic acid, trimethylsilyl ester	C ₁₁ H ₂₄ O ₂ Si	216.155	6.15	0.002
145	Docosanoic acid, 13-[[2,3,4,6-tetrakis-O-(trimethylsilyl)-D-glucopyranosyl]oxy]-	C ₄₀ H ₈₆ O ₈ Si ₄	806.540	13.46	0.002
146	Trimethylsilyl 3-((trimethylsilyl)oxy)pentanoate	C ₁₁ H ₂₆ O ₃ Si ₂	262.142	5.91	0.002
147	L-Leucine, TMS derivative	C ₉ H ₂₁ NO ₂ Si	203.134	5.14	0.002
148	trans-Sinapyl alcohol, 2O-TMS	C ₁₇ H ₃₀ O ₄ Si ₂	354.168	18.49	0.002
149	L-Isoleucine, TMS derivative	C ₉ H ₂₁ NO ₂ Si	203.134	5.36	0.002
150	Pyroglutamic acid, TMS derivative	C ₈ H ₁₅ NO ₃ Si	201.082	8.29	0.002

2TMS derivative (21), glycerol, 1,2-di(TMS)- (22), silane, [1,3,5-benzenetriyltris(oxy)]tris(trimethyl- (23), 1,2,3-butanetriol, 3TMS derivative (24), octadecane, 1,1'-[(1-methyl-1,2-ethanediyl)bis(oxy)]bis- (25), 4-hydroxybenzyl alcohol, 2TMS derivative (26), cetene (27), 9,12-octadecadienoic acid (Z,Z)- (28), methyl tetradecanoate (29), hexadecanoic acid, methyl ester (30), pentanedioic acid, 2-methyl-, bis(trimethylsilyl) ester (31), 1-(palmitoyloxy)-3-((trimethylsilyl)oxy)propan-2-yl (Z)-hexadec-9-enoate (32), γ -sitosterol (33), phloretic acid, 2TMS derivative (34), and glucose, 5TMS derivative (35). 9,12-octadecadienoic acid (Z,Z)- (28) (Table 1). The rest of the 115 compounds were least abundant, with peak areas less than 0.1% (Table 1).

DISCUSSION

Niacin, the predominant compound identified in the methanolic stem extract of *C. oxycantha*, is also known as nicotinic acid, a form of vitamin B3. Niacin is a well-known high-density cholesterol-raising drug that benefits patients at risk of atherosclerotic cardiovascular disease (Garg et al. 2017). Beyond its cardiovascular benefits, Niacin and its derivatives exhibit important biological activities, including antimicrobial properties. For example, nicotinamide, commercially formed from nicotinic acid, is effective against *Mycobacterium tuberculosis* and HIV (Murray 2003). Also, nicotinic acid

benzylidene hydrazide derivatives have shown antimycobacterial activity (Narang et al. 2012).

Among the least abundant compounds 9,12,15-octadecatrienoic acid, (Z,Z,Z)- (48) exhibited nematocidal activity (Nishanthini et al. 2014). Dodecanoic acid (68), also known as lauric acid, significantly reduced the growth of *Pythium ultimum* and *Rhizoctonia solani* in agar culture at 100 µM concentration, while in liquid culture, fungal growth was completely arrested at a concentration of 50 µM (Walters et al. 2003). Similarly, eicosane (128) isolated from ethyl acetate fraction of *Streptomyces* strain KX852460 extract showed strong antifungal activity against *Rhizoctonia solani* (Ahsan et al. 2017). Structures and properties of various herbicidal and antimicrobial compounds are given in Table 2 and Figure 2.

Hexacosane, another abundant compound, is a hydrocarbon known for its antibacterial activity against various bacterial strains, such as *Salmonella typhi*, *Klebsiella pneumoniae*, *Proteus vulgaris*, and *Staphylococcus aureus* (Rukaiyat et al. 2015), as well as *Escherichia coli* (Singh & Singh 2003). This highlights its potential application in developing antibacterial agents.

9,12-Octadecadienoic acid (Z,Z)- (28), also known as linoleic acid, is a long-chain unsaturated fatty acid that has demonstrated antibacterial activity by inhibiting bacterial enoyl-acyl carrier protein reductase FabI (Zheng et al. 2005). Additionally, linoleic acid has shown herbicidal activity against *Amaranthus tricolor* when used as a binary mixture with xanthoxylone (Chotsaeng et al. 2017).

γ-Sitosterol (33), identified among the compounds, was isolated from *Saccostrea glomerata*

(Sydney rock oyster) and exhibited both antifungal and antibacterial activities (Karthikeyan et al. 2014). This suggests its potential use in combating fungal and bacterial infections.

Fatty acid methyl esters (FAME) such as compounds 3, 29, and 30 are known for their antimicrobial properties. Agoramoorthy et al. (2007) reported that FAME extracts from *Excoecaria agallocha* inhibited the growth of various *Candida* species and several bacterial species, including *Escherichia coli*, *Pseudomonas aeruginosa*, *Bacillus subtilis*, *Staphylococcus aureus*, and *Micrococcus luteus*. Similarly, Sati et al. (2017) demonstrated the inhibitory activity of FAME extracts from *Quercus leucotrichophora* against different bacterial species.

Furthermore, extracts from various plants in the *Chenopodiaceae* family, especially *Salicornia brachiata*, have been shown to have antimicrobial effects against numerous bacterial and fungal species (Chandrasekaran et al. 2007). According to Pinto et al. (2017), FAMES in soybean and sunflower oils possess potent antifungal activity against different *Paracoccidioides lutzii* and *P. brasiliensis* isolates. Moreover, Synowiec et al. (2017) reported that a mixture of peppermint (*Mentha piperita*) essential oil and sunflower FAME exhibited herbicidal effects on lambsquarters (*Chenopodium album*) and barnyardgrass (*Echinochloa crus-galli*), reducing the length and biomass of these weeds. *Carthamus oxyacantha* M.Bieb is a promising repository of active phytochemicals. These bioactive compounds identified in GC MS analysis work synergistically to promote the plant's antioxidant, anticancer, and immunomodulatory capabilities (Baban et al. 2023).

Table 2. Potential herbicidal and antimicrobial compounds in methanolic stem extract of *Carthamus oxyacantha*

Compound No.	Name	Activity	Reference
3	9,12-Octadecadienoic acid (Z,Z)-, methyl ester	antimicrobial	Wei et al. (2011)
5	Hexacosane	antimicrobial	Rukaiyat et al. (2015); Singh and Singh (2003)
28	9,12-Octadecadienoic acid (Z,Z)-	antibacterial, herbicidal	Zheng et al. (2005); Chotsaeng et al. (2017)
29	Tetradecanoic acid, methyl ester	antibacterial, antifungal	Chandrasekaran et al. (2011)
30	Hexadecanoic acid, methyl ester	antibacterial, antifungal	Chandrasekaran et al. (2011)
33	γ-Sitosterol	antimicrobial	Karthikeyan et al. (2014); Canli et al. (2017)
48	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	nematicidal	Nishanthini et al. (2014)
68	Dodecanoic acid OR lauric acid	antifungal	Walters et al. (2003)
128	Eicosane	antifungal	Ahsan et al. (2017)

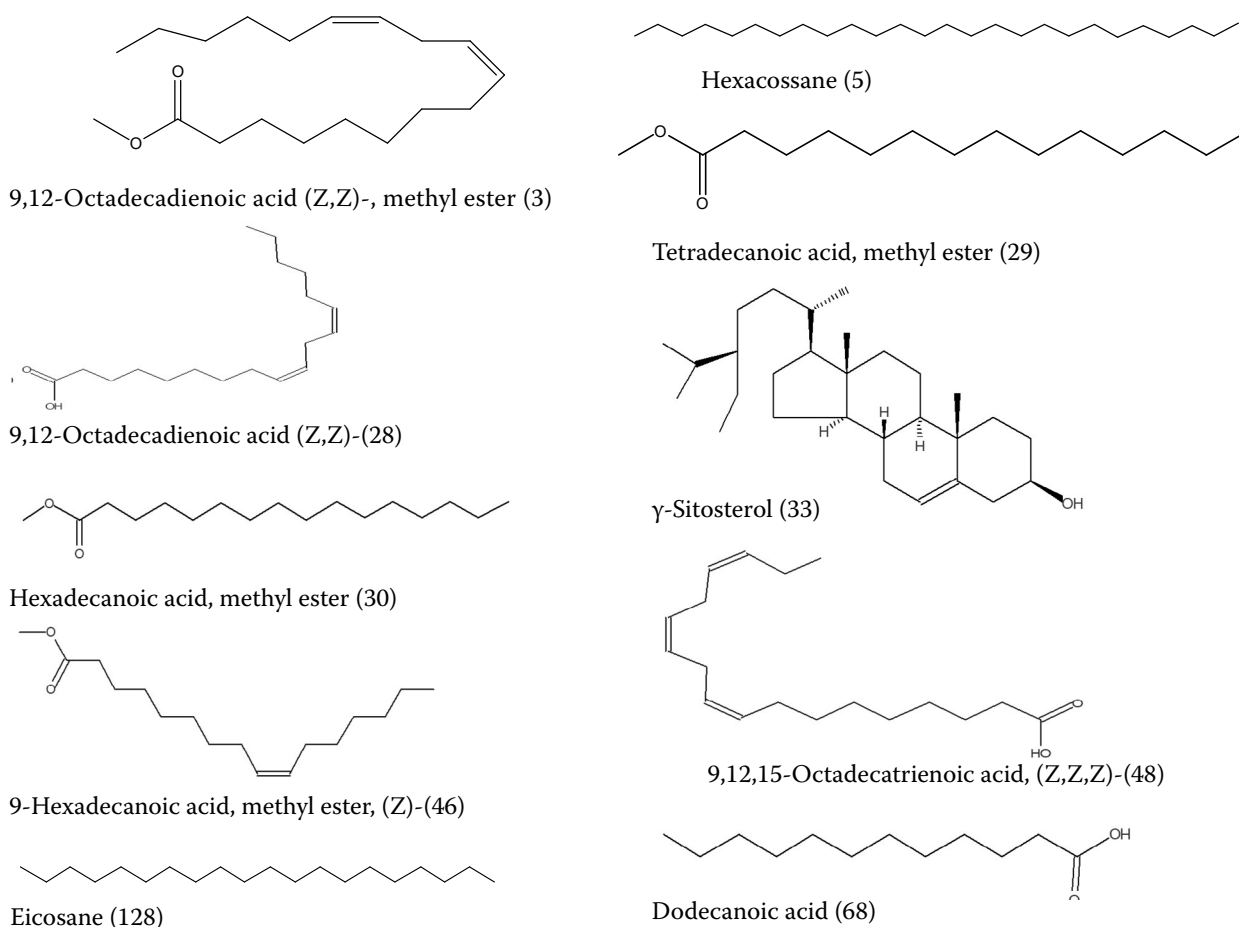


Figure 2. Structures of potential herbicidal and antimicrobial compounds in methanolic stem extract of *Carthamus oxyacantha*

This study concludes that the methanolic stem extract of *C. oxyacantha* is a rich source of antimicrobial and some herbicidal constituents. Further studies are suggested to isolate these identified bioactive constituents for their possible use in producing natural product-based pesticides to reduce environmental pollution.

REFERENCES

- Afridi R.A., Khan M.A. (2015): Comparative effect of water extract of *Parthenium hysterophorus*, *Datura alba*, *Phragmites australis* and *Oryza sativa* on weeds and wheat. *Sains Malaysiana*, 44: 693–699.
- Agoramoorthy G., Chandrasekaran M., Venkatesalu V., Hsu M.J. (2007): Antibacterial and antifungal activities of fatty acid methyl esters of the blind-your-eye mangrove from India. *Brazilian Journal of Microbiology*, 38: 739–742.
- Ahmad S.S., Wahid A., Bukhsh E., Ahmad S., Kakar S.R. (2009): Antihyperlipidemic properties of *Carthamus oxyacantha*. *Pakistan Journal of Science*, 61: 116–121.
- Ahsan T., Chen J., Zhao X., Irfan M., Wu Y. (2017): Extraction and identification of bioactive compounds (eicosane and dibutyl phthalate) produced by *Streptomyces* strain KX852460 for the biological control of *Rhizoctonia solani* AG-3 strain KX852461 to control target spot disease in tobacco leaf. *AMB Express*, 7: 54–63.
- Aslam N., Akbar M., Andolfi A. (2024): Allelopathic interactions of *Carthamus oxyacantha*, *Macrophomina phaseolina* and maize: Implications for the use of *Carthamus oxyacantha* as a natural disease management strategy in maize. *Plos One*, 19: e0307082.
- Baban M.M., Ahmad S.A., Abu-Odeh A.M., Baban M., Talib W.H. (2023): Anticancer, immunomodulatory, and phytochemical screening of *Carthamus oxyacantha* M. Bieb growing in the North of Iraq. *Plants*, 131: 42.
- Banaras S., Javaid A. (2015): Management of *Macrophomina phaseolina* by extracts of *Launea nudicaulis*. *Mycopath*, 13: 7–11.

- Banaras S., Javaid A., Shoaib A., Ahmed E. (2017): Antifungal activity of *Cirsium arvense* extracts against a phytopathogenic fungus *Macrophomina phaseolina*. *Planta Daninha*, 35: e017162738.
- Banaras S., Javaid A., Khan I.H. (2020): Potential antifungal constituents of *Sonchus oleraceus* against *Macrophomina phaseolina*. *International Journal of Agriculture and Biology*, 24: 1376–1382.
- Banaras S.A., Javaid, Khan I.H. (2021): Bioassays guided fractionation of *Ageratum conyzoides* extract for the identification of natural antifungal compounds against *Macrophomina phaseolina*. *International Journal of Agriculture and Biology*, 25: 761–767.
- Bashir T., Anum W., Ali A., Gaffar L., Raza M.U. (2018): Allelopathic effects of perennial sow thistle (*Sonchus arvensis* L.) on germination and seedling growth of maize (*Zea mays* L.). *Allelopathy Journal*, 43: 105–116.
- Bashir U., Javaid A., Bajwa R. (2017): Effects of aqueous extracts of sunflower (*Helianthus annuus* L.) on germination and seedling growth of the selected wheat (*Triticum aestivum* L.) varieties. *Bangladesh Journal of Botany*, 46: 1323–1332.
- Batool R., Nazar, A., Adnan M., Khursheed Z., Mohsin F., Hussain W. (2025): Cross culture comparison in ethnopharmacological uses of plants between two geographical regions of Northwest Pakistan. *Ethnobotany Research and Applications*, 30: 1–21.
- Benvenuti S. (2004): Weed dynamics in the Mediterranean urban ecosystem: ecology, biodiversity and management. *Weed Research*, 5: 341–354.
- Benvenuti S., Cioni P.L., Flamini G., Pardossi A. (2017): Weeds for weed control: Asteraceae essential oils as natural herbicides. *Weed Research*, 57: 342–353.
- Canli K., Şimşek Ö., Yetgin A., Altuner E.M. (2017): Determination of the chemical composition and antimicrobial activity of *Frankenia hirsuta*. *Bangladesh Journal of Pharmacology*, 12: 463–469.
- Chandrasekaran M., Kannathasan K., Venkatesalu V. (2007): Antimicrobial activity of fatty acid methyl esters of some members of Chenopodiaceae. *Zeitschrift für Naturforschung C*, 63: 331–336.
- Chandrasekaran M., Senthilkumar A., Venkatesalu V. (2011): Antibacterial and antifungal efficacy of fatty acid methyl esters from the leaves of *Sesuvium portulacastrum* L. *European review for medical Medical and pharmacological Pharmacological Sciences*, 15: 775–780.
- Cheng F., Cheng Z. (2015): Research progress on the use of plant allelopathy in agriculture and the physiological and ecological mechanisms of allelopathy. *Frontier in Plant Sciences*, 6: 1020.
- Chon S.U., Nelson C.J. (2010): Allelopathy in Compositae plants. A review. *Agronomy for Sustainable Development*, 30: 349–358.
- Chotsaeng N., Laosinwattana C., Charoenying P. (2017): Herbicidal activities of some allelochemicals and their synergistic behaviors toward *Amaranthus tricolor* L. *Molecules*, 22: 1841.
- Dilshad M., Riaz N., Saleem M., Shafiq N., Ashraf M., Ismail T. (2016): New lipoxygenase and cholinesterase inhibitory sphingolipids from *Carthamus oxyacantha*, *Natural Product Research*, 30: 1787–1795.
- Erida G., Ichsan C.N., Syamsuddin T., Khan I.H., Javaid A. (2023): Potential of secondary metabolites of *Ageratum conyzoides* L. in weed management: A review. *Allelopathy Journal*, 58: 23–40.
- Ferdosi M.F.H., Javaid A., Khan I.H., Munir A. (2021a): Bioactive components in methanolic flower extract of *Ageratum conyzoides*. *Pakistan Journal of Weed Science Research*, 27: 181–190.
- Ferdosi M.F.H., Khan I.H., Javaid A. (2021b): GC-MS examination of methanolic extract of *Cirsium arvense* flower. *Pakistan Journal of Weed Science Research*, 27: 173–180.
- Garg A., Sharma A., Krishnamoorthy P., Garg J., Virmani D., Sharma T. (2017): Role of niacin in current clinical practice: a systematic review. *American Journal of Medicine*, 130: 173–178.
- Gomaa N.H., Hassan M.O., Fahmy G.M., González L., Hammouda O., Atteya A.M. (2014): Allelopathic effects of *Sonchus oleraceus* L. on the germination and seedling growth of crop and weed species. *Acta Botanica Brasilica*, 28: 408–416.
- Hasan M., Ahmad-Hamdani M.S., Rosli, A.M., Hamdan, H. (2021): Bioherbicides: An eco-friendly tool for sustainable weed management. *Plants*, 10: 1212.
- Hesammi E. (2012): Allelopathic effects of *Carthamus oxyacantha* and *Chenopodium mural* on germination and initial growth of *Phasaelous vulgaris*. *International Journal of Farming and Allied Sciences*, 1: 54–56.
- Javaid N., Shah M.H., Khan I.H., Javaid A., Waleed S.M. (2020): Herbicidal activity of *Ageratum conyzoides* against parthenium weed. *Pakistan Journal of Weed Science Research*, 26: 137–146.
- Karthikeyan S.C., Velmurugan S., Donio M.B.S., Michaelbabu M., Citarasu T. (2014): Studies on the antimicrobial potential and structural characterization of fatty acids extracted from Sydney rock oyster *Saccostrea glomerata*. *Annals of Clinical Microbiology and Antimicrobials*, 13: 332.
- Kew (2018): The Plant List: Compositae. Royal Botanic Gardens Kew and Missouri Botanic Garden. Available at: <http://www.theplantlist.org/1.1/browse/A/Compositae/> (accessed November 8, 2018).
- Koc S., Isgor B.S., Isgor Y.G., Shomali Moghaddam N., Yildirim O. (2015): The potential medicinal value of plants from Asteraceae family with antioxidant defense enzymes as biological targets. *Pharmaceutical Biology*, 53: 746–751.

- Kong C.H., Xuan T.D., Khanh T.D., Tran H.D. Trung, N.T. (2019): Allelochemicals and signaling chemicals in plants. *Molecules*, 24: 2737.
- La Iacona M., Lombardo S., Mauromicale G., Scavo A., Pandino G. (2024): Allelopathic activity of three wild Mediterranean Asteraceae: *Silybum marianum*, *Cynara cardunculus* var. *sylvestris*, *Galactites tomentosus*. *Agronomy*, 14: 575.
- Mahé I., Chauvel B., Colbach N., Cordeau S., Gfeller A., Reiss A., Moreau D. (2022): Deciphering field-based evidences for crop allelopathy in weed regulation. A review. *Agronomy for Sustainable Development*, 42: 50.
- Murray M.F. (2003): Nicotinamide: An oral antimicrobial agent with activity against both *Mycobacterium tuberculosis* and human immunodeficiency virus. *Clinical Infectious Diseases*, 36: 453–460.
- Naeem M.I., Cheema Z.A., Ihsan M.Z., Hussain Y., Mazari A., Abbas H.T. (2018): Allelopathic effects of different plant water extracts on yield and weeds of wheat. *Planta Daninha*, 36: e018177840.
- Narang R., Narasimhan B., Sharma S., Sriram D., Yogeeswari P., Clercq E.D. (2012): Synthesis, antimycobacterial, antiviral, antimicrobial activities, and QSAR studies of nicotinic acid benzylidene hydrazide derivatives. *Medicinal Chemistry Research*, 21: 1557–1576.
- Nishanthini A., Mohan V.R., Jeeva S. (2014): Phytochemical, FT-IR, and GC-MS analysis of stem and leaf of *Tiliacora acuminata* (Lan.) Hook F & Thomas (Menispermaceae). *International Journal of Pharmaceutical Sciences and Research*, 5: 3977–3986.
- Pinto M.E.A., Araújo S.G., Morais M.I., Sá N.P., Lima C.M., Rosa C.A., Siqueira E.P., Johann S., et al. (2017): Antifungal and antioxidant activity of fatty acid methyl esters from vegetable oils. *Anais da Academia Brasileira de Ciencias*, 89: 1671–1681.
- Rafiq M., Javaid A., Shoaib A. (2017): Possible antifungal and antibacterial constituents in inflorescence extract of *Carthamus oxyacantha*. *Mycopath*, 15: 89–95.
- Rafiq M., Javaid A., Kanwal A., Anwar A., Khan I.H., Kanwal Q., Cheng C. (2024a): GC-MS analysis and antifungal potential of flower extract of *Acacia nilotica* subsp. *Indica* against *Macrophomina phaseolina*. *Microbial Pathogenesis*, 194: 106819.
- Rafiq M., Shoaib A., Javaid A., Parveen S., Hassan M.A., Nawaz H.H., Cheng C. (2024b): Application of Asteraceae biomass and biofertilizers to improve potato crop health by controlling black scurf disease. *Frontiers in Plant Science*, 15: 1437702.
- Rukaiyat M., Garba S., Labaran S. (2015): Antimicrobial activities of hexacosane isolated from *Sanseveria liberica* (Gerome and Labroy) plant. *Advancement in Medicinal Plant Research*, 3: 120–125.
- Sati A., Sati S.C., Sati, N., Sati, O.P. (2017): Chemical composition and antimicrobial activity of fatty acid methyl ester of *Quercus leucotrichophora* fruits. *Natural Product Research*, 31: 713–717.
- Siddiqui M.H., Khalid S., Shehzad M., Shah Z.A. (2018): *Parthenium hysterophorus* herbage mulching: a potential source of weeds control in soybean (*Glycine max*). *Planta Daninha*, 36: e01817099.
- Singh B., Singh S. (2003): Antimicrobial activity of terpenoids from *Trichodesma amplexicaule* Roth. *Phytotherapy Research*, 17: 814–816.
- Siyar S., Majeed A., Muhammad Z., Ullah R., Islam S.I. (2018): Allelopathic management of some noxious weeds by the aqueous extracts of *Parthenium hysterophorus* and *Carthamus oxyacantha*. *Polish Journal of Natural Sciences*, 33: 223–231.
- Synowiec A., Halecki W., Wielgusz K., Byczyńska M., Czaplicki S. (2017): Effect of fatty acid methyl esters on the herbicidal effect of essential oils on corn and weeds. *Weed Technology*, 31: 301–309.
- Tanasa M.V., Negreanu-Pirjol T., Olariu L., Negreanu-Pirjol B.S., Lepadatu A.C., Anghel L., Rosoiu N. (2025): Bioactive compounds from vegetal organs of *Taraxacum* species (Dandelion) with biomedical applications: A Review. *International Journal of Molecular Sciences*, 26: 450.
- Vyvyan J.R. (2002): Allelochemicals as leads for new herbicides and agrochemicals. *Tetrahedron*, 58: 1631–1646.
- Walters D.R., Walker R.L., Walker K.C. (2003): Lauric acid exhibits antifungal activity against plant pathogenic fungi. *Journal of Phytopathology*, 151: 228–230.
- Wei L.S., Wee W., Siong J.Y.F., Syamsumir D.F. (2011): Characterization of anticancer, antimicrobial, antioxidant properties and chemical compositions of *Peperomia pellucida* leaf extract. *Acta Medica Iranica*, 49: 670–674.
- Weston L.A., Duke S.O. (2003): Weed and crop allelopathy. *Critical Reviews in Plant Sciences*, 22: 367–389.
- Zheng C.J., Yoo J.S., Leeb T.G., Choc H.Y., Kimd Y.H., Kim W.G. (2005): Fatty acid synthesis is a target for antibacterial activity of unsaturated fatty acids. *FEBS Letters*, 579: 5157–5162.

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