Asian Journal of Chemistry; Vol. 33, No. 11 (2021), 2767-2773

ASIAN JOURNAL OF CHEMISTRY

https://doi.org/10.14233/ajchem.2021.23396

Chemical Constituents of *Suaeda monoica* and its Biological Activity

AHMED A.M. ABDELGAWAD*, and TAHA A.I. EL BASSOSSY

Medicinal and Aromatic Plants Department, Desert Research Center, Cairo, Egypt

*Corresponding author: E-mail: ahmedawad26@hotmail.com

Received: 1 July 2021; *Accepted*: 21 August 2021; *Published online*: 20 October 2021; AJC-20561

The ethanolic extract of the aerial parts of *Suaeda monoica* was successively fractionated using petroleum ether, dichloromethane, ethyl acetate and methanol. The GC-MS analysis of dichloromethane fraction has resulted in the identification of 24 non-polar compounds. *N,N*-dimethyl-1-dodecanamine (19.13%), methyl (*Z*)-9-oleate (18.1%) and 2-methoxy-3-(2-propenyl)phenol (12.14%) were the major components and fatty acids methyl esters represented the major class of this nonpolar components. Phytochemical study of the ethyl acetate and methanol fractions led to isolation and identification of seven known compounds identified as pyrogallol, ferulic acid, luteolin, (+)-catechien, gallic acid, naringin and naringenin. Dichloromethane, ethyl aetate and methanol fractions exhibited weak to moderate antioxidant activity using DPPH free radical scavenging method. Ethyl acetate and methanol fractions showed no antifungal activity and weak to good antibacterial activity by diffusion agar technique, while the dichloromethane showed potent activity against all the tested strains. Different fractions revealed weak lipase inhibitory effect.

Keywords: *Suaeda monoica*, GC-MS analysis, Phenolics, Flavonoids, Antimicrobial, Antiobesity, Antioxidant activity.

INTRODUCTION

The investigation of the efficacy of plant-based drugs has been paid great attention because of their few side effects, cheap and easy availability [1,2]. Nowadays, there has been focus on study of antioxidant from plant origins that produced their effect on oxygen reactive species and are thus helpful in producing health benefits through protecting human body [3]. Halophytes or salt tolerant plants are able to grow in extremely saline habitats and tolerate salinity by various eco-physiological mechanisms. The word "Halos" means saline and "Phyte" means plant in origin. Halophytes are known for their ability to withstand and quench toxic reactive oxygen species (ROS), since they are equipped with a powerful antioxidant system that includes enzymatic and non-enzymatic components [4]. Family Chenopodiaceae comprises about 103 genera and 1300 species [5] of mostly perennial herbs, many of which are adapted to saline soils and live-in salt marshes or arid, saline soils. Members of the Chenopodiaceae are typically xerophytic in the Arabian desert and are frequently reported in floristic works of the region. The genus *Suaeda* is a halophyte comprises about 75 species, which usually grow in sandy and saline sea coast, salt marshes, desert soil and salt steppes and mainly distributed in the northern hemisphere but some are sub-cosmopolitan [6].

Suaeda monoica is a mangrove herb belongs to the family Chenopodiaceae. It is distributed in coasts of tropical Africa, southern part of the Arabian Peninsula, coastal regions of India and Pakistan and the Dead sea region in Palestine and Jordan. The plant in appearance resembles to *Suaeda maritima* but is smaller in size and possesses simple edible leaves [7,8]. In Egypt, it occurs in the oases of the western desert, desert east of the Nile, the red sea coastal strip, Gebel Elba and the surrounding mountainous region and the entire Sinai Peninsula [9-11]. Traditionally, the leaf from *S. monoica* is known to be used as a medicine for hepatitis and scientifically, it is reported to be used as ointment for wounds and possess antiviral activity because of the presence of triterpenoids, sterols [12]. In view of this and in continuation of our studies on the medicinal phytotherapy [13-17], the objective of this work is to investigate the chemical composition of halophyte *S. monoica* aerial parts, in addition to its biological activity as antimicrobial, antioxidant and antiobesity.

EXPERIMENTAL

The aerial parts of *Suaeda monoica* were collected during the flowering period from South Sinai (Wadi Sudr), Egypt in April 2019 and identified by herbarium team of desert research center, Cairo, Egypt.

Extraction and isolation: Air-dried and milled aerial parts of *S. monoica* (800 g) were extracted with ethanol (80%) four-time (4 × 2.5L) by maceration (72 h each time) at room temperature until exhaustion. The filtrate was concentrated under reduced pressure at 40 ºC to yield a sticky dark gum 34.3 g. The crude extract was suspended in 500 mL distilled water and successively partitioned with petroleum ether (PE), dichloromethane (DCM), ethyl acetate (EA) and methanol (MeOH). Each fraction was concentrated *in vacuo* to yield dry extracts (16.2, 5.2, 3.7, 6.5 g), respectively. The DCM, EA and MeOH fractions firstly were subjected to 1 MM paper chromatography (PC) run in butanol/acetic acid/water (4:1:5) (BAW) and acetic acid (15%). Based on PC profile under visible and ultraviolet light (UV), DCM fraction was subject to gas chromatography-mass spectrometry (GC-MS) analysis. Ethyl acetate (3.7 g) was applied to silica gel column chromatography (230-400 mesh) and eluted using *n*-hexane/ethyl acetate mixture with increasing polarity to afford 14 subfractions. Based on thin-layer chromatography (TLC) profiles on silica gel eluted with *n*-hexane/ethyl acetate, similar subfractions were combined and further separated using silica gel column chromatography with *n*-hexane/ethyl acetate with increasing polarity to afford compounds **1-3** (55, 67 and 49 mg, respectively). Methanolic fraction (6.5 g) was applied to polyamide column chromatography eluted with MeOH/H_2O with increasing polarity to afford 27 subfractions. Based on PC running in BAW, combined subfractions 7-10 and 12-17 were individually separated by preparative PC using BAW and purified with Sephadex LH-20 column chromatography (CC) using MeOH to give compounds **4-6** (85, 63 and 52 mg). Compound **7** (103 mg) was isolated from the combined fractions 21-23 by preparative PC using the eluent BAW (4:1:5) and purified by Sephadex LH-20 CC eluting with MeOH.

Gas chromatography-mass spectrometry (GC-MS) analysis: GC-MS analyses of DCM fraction were performed at the Regional Center for Mycology and Biotechnology (RCMB) at Al- Azhar University, on Thermo Scientific Trace 1310 Gas Chromatograph attached with ISQ LT single quadrupole mass spectrometer, operating in the EI mode at 70 eV, equipped with a split/splitless injector (200 ºC). Helium was used as carrier gas (1 mL/min) and the capillary columns used were an DP5-MS (30 m × 0.25 mm; film thickness 0.25 mm). The transfer line temperature was kept at 290 ºC and 300 ºC respectively with electron multiplier voltage of 1 kV. Identification and interpretation of phytoconstituents on mass-spectrum GC-MS was conducted using the reference library of the National Institute of Standards and Technology (NIST), along with Willey 5 and mass finder, as well as data reported by Adams [18]. The constituent percentages were measured based on the peak area.

DPPH radical scavenging activity: The antioxidant activity of extract was assessed by the decoloration solution of 2,2′-diphenyl-1-picrylhydrazyl (DPPH) radical according to Letelier *et al.* [19] in Regional Center for Mycology and Biotechnology Al-Azhar University, Cairo, Egypt (RCMB). This assay was realized essentially by the method described by Joyeux *et al.* [20] and its modification by Viturro *et al.* [21]. Freshly prepared (0.004% w/v) methanol solution of DPPH radical was prepared and stored at 10 ºC in the dark. A methanol solution of the tested extracts was prepared. A 40 µL aliquot of the methanol solution was added to 3 mL of DPPH solution. Absorbance measurements were recorded immediately with a UV-visible spectrophotometer (Milton Roy, Spectronic 1201). The decrease in absorbance at 515 nm was determined continuously, with data being recorded at 1 min intervals until the absorbance stabilized (16 min). The absorbance of the DPPH radical without antioxidant (control) and the reference compound ascorbic acid were also measured. All the determinations were performed in three replicates and averaged. The percentage inhibition (PI) of the DPPH radical was calculated according to the formula:

$$PI = \frac{AC - AT}{AC} \times 100 \quad (1)$$

where AC = Absorbance of the control at t = 0 min and AT = absorbance of the sample with DPPH at t = 16 min. The 50% inhibitory concentration (IC_{50}), the concentration required to 50% DPPH radical scavenging activity was estimated from graphic plots of the dose response curve using GraphPad Prism software (San Diego, CA. USA).

Antimicrobial activity: Microbial strains were used in this study: Fungi strains as *Aspergillus fumigatus* (RCMB 002008) and *Candida albicans* RCMB 005003 (1) ATCC 10231; Gram-positive strains as *Staphylococcus aureus* ATCC 25923, *Bacillus subtilis* RCMB 015 (1) NRRL B-543 and *Streptococcus mutants* RCMB 017 (1) ATCC 25175; Gram-negative strains as *Escherichia coli* ATCC 25922 and *Proteus vulgaris* RCMB 004 (1) ATCC 13315 and *Klebsiella pneumonia* RCMB 003 (1) ATCC 13883. Ketoconazole used as the standard positive control agents against fungi strains while *Gentamycin* used against bacteria strains. Antimicrobial effect of DCM, EA and MeOH extracts was performed by diffusion agar technique at Regional Center for Mycology and Biotechnology (RCMB), Al-Azhar University, Egypt according to CLSI [22,23]. The tested organisms were inoculated in nutrient broth and incubated overnight at 37 ºC to adjust the turbidity to 0.5 McFarland standards giving a final inoculum of 1.5×10^8 CFU/mL. Agar plate was lawn cultured with standardized microbial culture broth. Plant extracts of 10 mg/mL concentration were prepared in DMSO. Wells of 6 mm were bored in the inoculated media with the help of sterile cork-borer (6 mm). Each well was filled with 100 µL extract. It was allowed to diffuse for about 30 minutes at room temperature and incubated for 24 h at 37 ºC (bacterial strains) and for 7 days at 25 ºC (fungal strains). After incubation, plates were observed for the formation of a clear zone around the well which corresponds to the antimicrobial activity of tested compounds. The zone of inhibition (ZOI) was observed and measured in mm.

***In vitro* antiobesity using pancreatic lipase inhibitory assay:** The lipase inhibition activity of plant extract was deter-

mined as per the method proposed by Kim *et al.* [24]. In brief, the porcine pancreatic lipase activity was measured using *p*-nitrophenyl butyrate (NPB) as a substrate. Lipase solution (100 µg/mL) was prepared in a 0.1 mM potassium phosphate buffer (pH 6.0). To determine the lipase inhibitory activity, samples with different concentrations (1000 to 7.81 µg/mL) were pre-incubated with 100 µg/mL of lipase for 10 min at 37 ºC. The reaction was then started by adding 0.1 mL NPB substrate. After incubation at 37 ºC for 15 h, the amount of *p*-nitrophenol released in the reaction was measured using Multiplate Reader. Each experiment was performed in triplicates. The results were expressed as percentage inhibition, which was calculated using the formula:

$$\text{Inhibitory activity (\%)} = \left(1 - \frac{A_s}{A_c}\right) \times 100$$

where, A_s is the absorbance in the presence of test substance and A_c is the absorbance of control. The IC_{50} value was defined as the concentration of lipase inhibitor to inhibit 50% of its activity under the assay conditions.

RESULTS AND DISCUSSION

Chemical composition: The GC-MS of DCM fraction of *Suaeda monoica* aerial parts led to the identification and qualification of 24 components accounting 97.26% of the total components present (Fig. 1). *N,N*-dimethyl-1-dodecanamine (19.13%), methyl (*Z*)-9-oleate (18.1%), 2-methoxy-3-(2-propenyl)phenol (12.14%), 2-methyl-5-(1-methylethyl)phenol (7.47%), nizatidine (6.78%), 10-epi-eudesmol (6.36%), methyl palmitate (5.46%) were the major components of the DCM fraction. Fatty acids ester (FAEs) such as methyl palmitate,

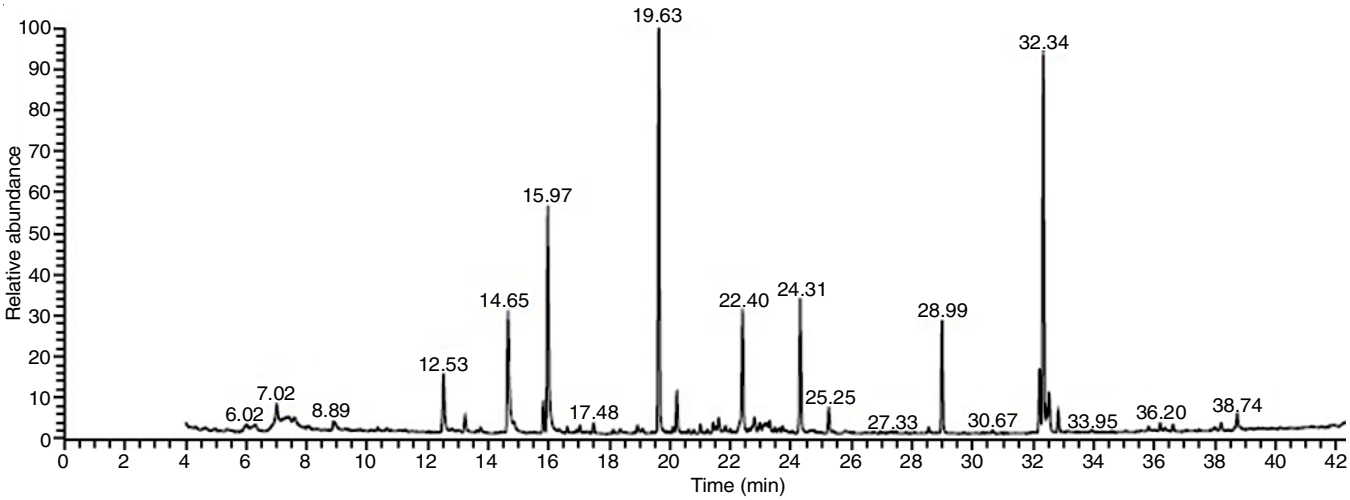

Fig. 1. GC chromatogram of the DCM fraction of the aerial parts of *S. monoica*

TABLE-1
CHEMICAL COMPOSITION OF THE DCM FRACTION OF THE AERIAL PARTS OF *S. monoica*

Retention time	Compound name	Area (%)	m.f.	m.w.
7.02	Benzyl chloride	1.21	C_7H_7Cl	126
8.89	Undecane	0.63	$C_{11}H_{24}$	156
12.53	3,7-Dimethyl-6-octen-1-ol	3.47	$C_{10}H_{20}O$	156
13.23	3,7-Dimethyl-(Z)-2,6-octadien-1-ol	0.91	$C_{10}H_{18}O$	154
14.66	2-Methyl-5-(1-methylethyl)-phenol	7.47	$C_{10}H_{14}O$	150
15.82	Citronellol acetate	1.49	$C_{12}H_{22}O_2$	198
15.97	2-Methoxy-3-(2-propenyl)-phenol	12.14	$C_{10}H_{12}O_2$	164
17.48	Caryophyllene	0.51	$C_{15}H_{24}$	204
19.64	*N,N*-Dimethyl-1-dodecanamine	19.13	$C_{14}H_{31}N$	213
20.23	2-Methoxy-4-(2-propenyl)-phenol	2.08	$C_{10}H_{12}O_2$	164
21.01	(R)-lavandulyl acetate	0.45	$C_{12}H_{20}O_2$	196
21.43	(-)-Spathulenol	0.52	$C_{15}H_{24}O$	220
21.61	4-Butylbenzoic acid, 2-phenylethyl ester	0.83	$C_{19}H_{22}O_2$	282
22.40	10-Epi-Eudesmol	6.36	$C_{15}H_{26}O$	222
22.79	α-Acorenal	1.00	$C_{15}H_{24}$	204
23.30	Caryophyllene oxide	0.45	$C_{15}H_{24}O$	220
24.31	Nizatidine	6.78	$C_{12}H_{21}N_5O_2S_2$	331
25.25	Bisabolol oxide B	1.42	$C_{15}H_{26}O_2$	238
28.99	Methyl palmitate	5.46	$C_{17}H_{34}O_2$	270
32.21	Methyl octadeca-9,12-dienoate	2.89	$C_{19}H_{34}O_2$	294
32.34	Methyl (Z)-9-oleate	18.1	$C_{19}H_{36}O_2$	296
32.53	*N,N'*-Dibenzyl-*N,N'*-dimethylethylenediamine	1.62	$C_{18}H_{24}N_2$	268
32.83	Methyl stearate	1.03	$C_{19}H_{38}O_2$	298
38.74	Glycidyl oleate	1.31	$C_{21}H_{38}O_3$	338

methyl octadeca-9,12-dienoate, methyl (Z)-9-oleate, methyl stearate, glycidyl oleate and citronellol acetate represented the major class of non-polar components present in this fraction (30.28%) (Table-1). The chemical structure of the identified compounds is illustrated in Fig. 2.

The chemical investigation of ethyl acetate (EA) fraction led to the isolation of three compounds **1-3** using silica gel column chromatography (230-400 mesh) and eluted using *n*-hexane/ethyl acetate. While polyamide column chromatography eluted with methanol/water followed by preparative PC using BAW and purification with Sephadex LH-20 column chromatography (CC) using MeOH led to isolation of four compounds **4-7**. The structures of the isolated compounds (Fig. 3) were elucidated by interpretation of their spectral data, including ^{1}H and ^{13}C NMR and by comparison with those reported data in the related literature. The identified compounds were

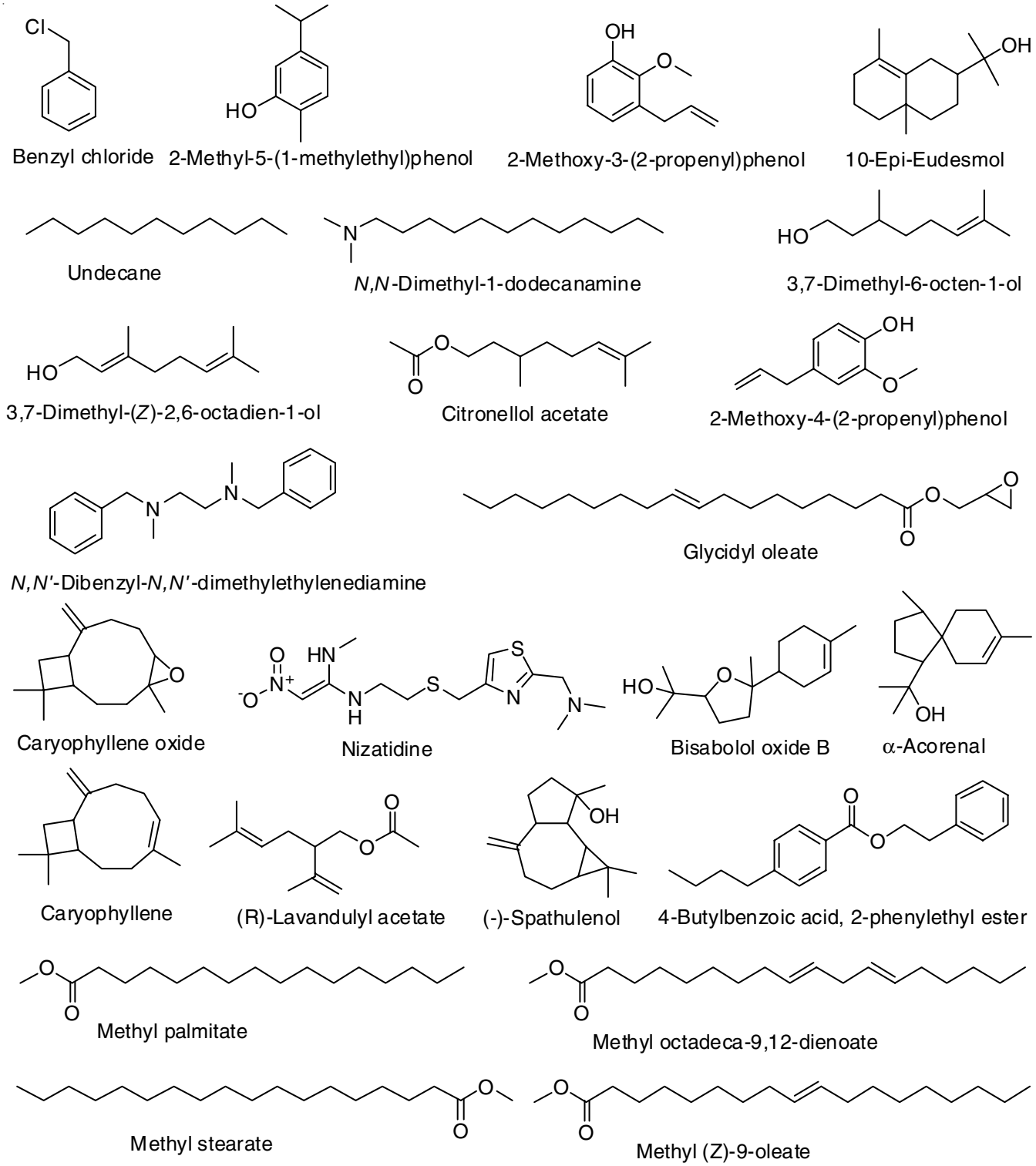

Fig. 2. Chemical structure of identified constituents from DCM fraction of *S. monoica*

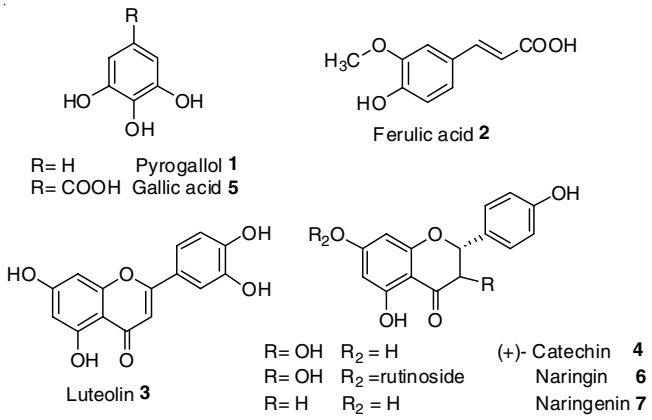

Fig. 3. Chemical structure of isolated constituents from ethyl acetate and methanol fractions

pyrogallol (**1**), ferulic acid (**2**), luteolin (**3**), (+)-catechin (**4**), gallic acid (**5**), naringin (**6**) and naringenin (**7**).

Compound **1** was isolated from the EA fraction as white crystals, which showed molecular formula is $C_6H_6O_3$ with *m/z* 126 in ESI-Ms, λ_{max} MeOH: 273 nm; ^{1}H NMR 7.70 (1H, m, *J* = 7.5 Hz, H-5), 6.39 (1H, d, *J* = 6.50 Hz, H-4), 6.24 (1H, d, *J* = 6.50 Hz, H-6) 2.35 (1H, s, OH). The previous data presented is relative identical with data of pyrogallol.

Compound **2** was isolated as yellow crystals found to possess chromatographic properties and exhibited a *Mr* of 194 in ESI-MS analysis , UV λ_{max} MeOH: 220, 240, 390 nm; ^{1}H NMR (400 MHz, DMSO-d_6); δ 7.02(1H, d, *J* = 2.4 Hz, H-3), 7.32 (1H, dd, *J* = 9 and 2.5 Hz, H-5), 6.65(1H, d, *J* = 9 Hz, H-6), 7.71 (1H, d, *J* = 15 Hz, H-7 [β]), 6.47 (1H, d, *J* = 15 Hz, H-8 [α]), 3.81(3H, s, OCH_3). ^{13}C NMR; δ 172.4 (C=O), 147.2 (C-1), 149.3 (C-2), 143.5 (C-7), 134.62 (C-4), 122.54 (C-5), 119.5 (C-6), 117.8 (C-8), 115.24 (C-3), 55.8 (C-OCH_3). The presented data predicted the compound structure of ferulic acid.

Compound **3** was isolated as yellow powder; EI-MS: *m/z* 286 $[M]^+$, 287 $[M + H]^+$; ^{1}H NMR (400 MHz, DMSO-d_6): δ 6.19 (1H, s, H-6), 6.53 (1H, br. s, H-8), 6.71 (1H, s, H-3), 6.81 (1H, d, *J* = 8.5 Hz, H-5′),7.23 (1H, dd, *J* = 8.5, 2.1 Hz, H-6′), 7.51 (1H, d, *J* = 2.1 Hz, H-2′); ^{13}C NMR: δ 182.1 (C-4), 164.8 (C-7), 164.9 (C-2), 161.7 (C-5), 158.1 (C-9), 149.6 (C-4′), 145.4 (C-3′), 121.9 (C-1′), 119.3 (C-6′), 117.5 (C-5′), 115.2 (C-2′), 104.7 (C-10), 103.3 (C-3), 98.7 (C-6), 92.6 (C-8). These data predicted the compound structure of luteolin.

Compound **4**: ^{1}H NMR (MeOH-d_4, 400 MHz): δ 2.50 (1H, dd, *J* = 8.2, 16.2 Hz, H-4b), 2.85 (1H, dd, *J* = 5.2, 16.2 Hz, H-4a), 3.98 (1H, m, H-3), 4.56 (1H, d, *J* = 7.4 Hz, H-2), 5.85 (1H, d, *J* = 2.4 Hz, H-6), 5.93 (1H, d, *J* = 2.4 Hz, H-8), 6.75 (3H, m, H-2′, H-5′, H-6′); ^{13}C NMR: δ 28.90 (C-4), 69.22 (C-3), 83.26 (C-2), 95.51 (C-8), 96.69 (C-6), 101.21 (C-10), 115.67 (C-2′), 116.50 (C-5′), 120.47 (C-6′), 132.64 (C-1′), 146.69 (C-3′, C-4′), 157.36 (C-7), 158.04 (C-5), 158.29 (C-9). The outlined data was harmony with those of catechin data in literature.

Compound **5**: ^{1}H NMR (400 MHz, MeOH-d_4): δ 7.01 (s, 2H, H-2, H-6); ^{13}C NMR: δ 109.22 (C-2, C-6), 121.15 (C-1), 137.77 (C-4), 145.11 (C-3, C-5), 166.82 (C=O). This data was similar to gallic acid data.

Compound **6** was separated as white needle crystals; exhibited molar mass (*m/z*): 580; ^{1}H NMR (400 MHz, MeOH-d_4): Naringenin moiety δ 2.73 (1H, d, *J* = 14.0 Hz, H-3a), 3.22 (1H, dd, *J* = 14, 17.6 Hz, H-3b), 5.32 (1H, d, *J* = 12.8 Hz, H-2), 6.02 (2H, s, H-6 and H-8), 6.81 (2H, d, *J* = 8.4 Hz, H-3′ and H-5′) and 7.31 (2H, d, *J* = 8.4 Hz, H-2′ and H-6′); glucose 5.09 (1H, d, *J* = 7.2 Hz, H-1″), 3.37-3.85 (5H, m, glucose protons); rhamnose 4.54 (1H, s, H-1‴), 3.37-3.92 (5H, m, rhamnose protons) and 1.12 (3H, d, *J* = 6.5 Hz, CH_3 rhamnose). ^{13}C NMR (400 MHz, DMSO-d_6): Naringenin moiety δ 44.4 (C-3), 81.0, (C-2), 96.8 (C-8), 97.9 (C-6), 105.5 (C-10), 116.37 (C-3′,5′), 129.1 (C-2′,6′), 131.5 (C-10), 157.9 (C-4′), 162.7 (C-9), 163.1 (C-5), 168.1 (C-7) and 197.1 (C-4); Glucose 61.3 (C-6″), 71.2 (C-4″), 77.4 (C-5″), 78.6 (C-3″), 79.8 (C-2″) and 99.0 (C-1″); rhamnose 18.3 (C-6‴), 69.2 (C-5‴), 71.8 (C-3‴), 72.2 (C-2‴), 73.7 (C-4‴) and 100.5 (C-1‴). The outlined data suggested the chemical structure of the compound to be naringin.

Compound **7** was isolated as a pale yellow needles and showed EI-MS *m/z:* 272. ^{1}H NMR (400 MHz, MeOH-d_4): δ 2.66 (1H, dd, *J* = 16.8, 2.9 Hz, H-3eq), 3.20 (1H, dd, *J* = 13.2, 16.8 Hz, H-3ax), 5.45 (1H, dd, *J* = 12.4, 2.9 Hz, H-2), 5.92 (2H, s, H-6 and 8), 6.81 (2H, d, *J* = 8.0 Hz, H-32 and 52), 7.35 (2H, d, *J* = 8.0 Hz, H-22, 62). ^{13}C NMR: δ 42.4 (C-3), 78.2 (C-2), 94.9 (C-8), 95.8 (C-6), 102.1 (C-10), 115.3 (C-3′ and 5′), 128.2 (C-2′ and 6′), 129.0 (C-1′), 157.8 (C-4′),163.1 (C-9), 163.6 (C-5), 166.7 (C-7), 196.2 (C-4). The outlined data suggested the chemical structure of the compound to be aglycon structure of naringin which known as naringenin.

Antioxidant activity: The antioxidant activity of different solvent extracts of *S. monoica* aerial parts were indexed by DPPH radical scavenging activity. The scavenging effect on DPPH radical was varied significantly with respect to different fractions. During the DPPH radical scavenging assay, the highest scavenging activity was recorded in polar fraction (MeOH) followed by ethyl acetate and the least in dichloromethane (DCM) fraction, where the ethyl acetate and methanol fractions exhibited weak and moderate antioxidant activity with IC_{50} 165.4 and 98.2 µg/mL, respectively, while DCM fraction showed very weak antioxidant activity with IC_{50} 332.9 µg/mL (Table-2). The activity of polar compounds in methanol fraction is may be due to the presence of flavonoids and phenolic compounds which are characterized by their powerful antioxidant activity in the extract. However, the high percentage of salts accumulation in the leaves and stems of *S. monica* plant may effect on its activity and ability as antioxidant agent. *S. monica* plant which presents far away seashores had potent antioxidant than other which near to seashore.

Antimicrobial activity: The antimicrobial activity of the aerial parts of *S. monoica* was evaluated by diffusion agar technique. All the tested extracts showed very weak or no antifungal activity against the tested strains in comparison with ketoconazole reference drug. Ethyl acetate fraction showed weak antibacterial activity against all tested while methanol fraction showed moderate antibacterial activity against all tested strains except *Escherichia coli* showed relative potent activity with 23 mm inhibition zone as compared to gentamycin reference

TABLE-2
ANTIOXIDANT ACTIVITY OF DCM, EA AND MeOH FRACTIONS OF *S. monoica*

Conc. (µg/ml)	DPPH scavenging (%)			
	Ascorbic acid	DCM	EA	MeOH
1280	98.91	88.05	93.58	94.37
640	97.83	82.74	90.47	92.84
320	95.64	48.63	77.21	87.68
160	92.31	29.74	49.05	59.74
80	90.25	19.84	31.47	45.21
40	83.09	10.06	17.02	31.16
20	71.38	3.68	7.16	19.58
10	48.52	1.74	3.37	10.66
5	40.36	ND	ND	ND
2.5	34.57	ND	ND	ND
0	0	0	0	0
IC_{50} (µg/mL)	10.6±0.8	332.9±24.7	165.4±11.2	98.2±9.8

IC_{50} value is the concentration required to result in a 50% antioxidant activity, ND = Not determined.

drug. In contrast to the DCM fraction, which showed potent antibacterial activity against all tested strains. This is may be related to the high percentage of liopidal components, which have antimicrobial activity [25,26]. Mean zone of inhibition in mm produced on a range of pathogenic microorganisms, results are given in Table-3.

Antiobesity activity: Obesity is regarded as a disorder of lipid metabolism and the enzymes. It is a serious and chronic disease that can have a negative effect on many systems in human body, which results from an imbalance between energy intake and expenditure. It is caused by altered lipid metabolic processes including lipogenesis and lipolysis. Overweight and obesity may increase the risk of many health problems, including diabetes, heart disease, osteoarthritis and certain cancers [27]. Which caused by excess caloric intake [28] and this can be improved by inhibiting pancreatic lipase activity and by inhibiting or delaying lipid absorption [29]. Inhibition of α-amylase activity and inhibition of carbohydrate absorption also play an important role in the prevention and treatment of diabetes [30]. α-Amylase, one of the digestive enzyme secreted from the pancreas and salivary glands, is involved in an important biological process such as digestion of carbohydrates. Many crude drugs inhibit α-amylase activity showed strong anti-obesity activity by inhibiting pancreatic lipase and suppressing the increase of body weight induced by a high-fat diet. Literature reports that saponins from natural products *i.e*. saponin [31,32], phenolic compounds [33] and flavonoids [34] showed strong antiobesity activity by inhibiting pancreatic lipase and suppressing the increase of body weight induced by a high-fat diet.

In present study, *S. monica* didn't contain any saponin compounds but have traces of terpenoid compounds and fair content of flavonoid and phenolic compounds. Therefore, the results showed that the DCM and EA fractions had very weak lipase inhibitory effect with IC_{50} 232.9 and 168.43 µg/mL, respectively. On the other side, the MeOH fraction exhibited a fair antiobesity activity with IC_{50} 97.12 µg/mL in comparison with IC_{50} 23.8 µg/mL for orlistat standard reference drug (Table-4).

TABLE-4
ANTIOBESITY ACTIVITY OF DCM, EA AND MeOH OF *S. monoica* AERIAL PARTS

Conc. (µg/mL)	Mean of lipase inhibitory (%)			
	Control	DCM	EA	MeOH
1000	93.25±1.5	66.32±1.5	78.12±1.5	86.42±1.5
500	86.35±2.1	60.14±0.92	66.42±0.87	71.11±0.87
250	80.12±0.58	52.16±1.22	55.21±1.7	62.75±1.7
125	65.34±1.5	36.35±0.73	38.41±1.01	41.17±1.01
62.5	60.35±2.1	16.37±1.30	22.23±0.92	32.13±0.45
31.25	54.36±2.6	7.32±0.82	15.64±2.4	14.12±0.94
15.63	45.25±3.1	0	8.11±2.1	8.91±0.51
7.81	29.31±1.4	0	0	0
IC_{50}	23.80	232.91	168.43	97.12

Conclusion

Suaeda monoica aerial parts was fractionated successively with increasing polarities starting with petroleum ether and ended to methanol. Fractions were applied to gas chromatography-mass spectrometry, Sephadex LH-20 column chromatography (CC), paper chromatography (PC) and thin-layer chromatography (TLC) which resulted 24 lipoidal identified from dichloromethane by GC-MS, three phenolic and four flavonoid compounds separated and identified from ethyl acetate (EA) and methanol (MeOH) by chromatographic methods. Different extracts showed weak to fair biological activity with potent antibacterial activity for dichloromethane extract. Although phenolic and flavonoid contents in this plant, the presence of collected *S. monoica* plant near to the seashore may contribute

TABLE-3
ANTIMICROBIAL ACTIVITY OF DCM, EA AND MeOH OF *S. monoica*. AERIAL PARTS

Tested microorganisms	DCM	EA	MeOH	(Control)
Fungi				Ketoconazole
Aspergillus fumigatus (RCMB 002008)	5	No activity	No activity	17
Candida albicans RCMB 005003 (1) ATCC 10231	7	No activity	No activity	20
Gram-positive bacteria				Gentamycin
Staphylococcus aureus ATCC 25923	18	9	12	24
Bacillus subtilis RCMB 015 (1) NRRL B-543	17	8	13	26
Streptococcus mutants RCMB 017 (1) ATCC 25175	19	11	12	21
Gram-negatvie bacteria				Gentamycin
Escherichia coli ATCC 25922	21	9	23	30
Proteus vulgaris RCMB 004 (1) ATCC 13315	19	7	14	25
Klebsiella pneumonia RCMB 003 (1) ATCC 13883	20	8	13	25

to decrease the effect of its active substances in aerial parts due to the increasing salts accumulation in the plant leaves and stems.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

REFERENCES

1. P.D. Kumara, G.L. Jayawardane and A.P. Aluwihare, *Ceylon Med. J.*, **46**, 69 (2014); https://doi.org/10.4038/cmj.v46i2.6499
2. S.K. Chatterjee, I. Bhattacharjee and G. Chandra, *Asian Pac. J. Trop. Med.*, **4**, 35 (2011); https://doi.org/10.1016/S1995-7645(11)60028-X
3. J. Patra, N. Dhal and H. Thatoi, *Asian Pac. J. Trop. Med.*, **4**, 727 (2011); https://doi.org/10.1016/S1995-7645(11)60182-X
4. R. Ksouri, W. Megdiche, H. Falleh, N. Trabelsi, M. Boulaaba, A. Smaoui and C. Abdelly, *C. R. Biol.*, **331**, 865 (2008); https://doi.org/10.1016/j.crvi.2008.07.024
5. L. Boulos, Flora of Egypt, Al-Hadara Publishing, Cairo, pp. 114–115 (1999).
6. L. Boulos, *Kew Bull.*, **46**, 291 (1991); https://doi.org/10.2307/4110599
7. S. Ravikumar, M. Gnanadesigan, J.S. Serebiah and S.J. Inbaneson, *Life Sci. Med. Res.*, **2**, 1 (2010).
8. S. Ravikumar, M. Gnanadesigan, S.J. Inbaneson and A. Kalaiarasi, *Indian J. Exp. Biol.*, **49**, 455 (2011).
9. J.R.L. Allen, *Quat. Sci. Rev.*, **19**, 1155 (2000); https://doi.org/10.1016/S0277-3791(99)00034-7
10. K. Kubitzki, Eds: J.G. Rohwer and V. Bittrich, The Families and Genera of Vascular Plants, In: Flowering Plants Dicotyledons: Magnoliid, Hamamelid and Caryophyllid Families, Berlin, Heidelberg, Gmbh: Springer, Verlag, vol. 2 (2013).
11. Y.A. El-Amier, E.S.F. El-Halawany and A.K. Khudhair, *Int. J. Nat. Sci. Res.*, **5**, 31 (2017); https://doi.org/10.18488/journal.63.2017.52.31.42
12. W.M. Bandaranayake, *Mangroves Salt Marshes*, **2**, 133 (1998); https://doi.org/10.1023/A:1009988607044
13. F.A. Ahmed and T.A. El-Bassossy, *Asian J. Pharm. Clin. Res.*, **13**, 40 (2020); https://doi.org/10.22159/ajpcr.2020.v13i3.36503
14. F.A. Ahmed, A.M.D. El-Mesallamy and T.A.I. El-Bassossy, *Acta Pol. Pharm.*, **76**, 653 (2019); https://doi.org/10.32383/appdr/105607
15. S. El-Desouky, A. Abdelgawad, A. El-Hagrassi, U. Hawas and Y.-K. Kim, *Acta Pol. Pharm.*, **76**, 691 (2019); https://doi.org/10.32383/appdr/105158
16. E.M. Atta, K.H. Hegab, A.A.M. Abdelgawad and A.A. Youssef, *Saudi Pharm. J.*, **27**, 584 (2019); https://doi.org/10.1016/j.jsps.2019.02.006
17. A.M.D. El-Mesallamy, M. El-Gerby, M.H.M.A.E. Azim and A. Awad, *J. Essent. Oil-Bear. Plants*, **15**, 900 (2012); https://doi.org/10.1080/0972060X.2012.10662592
18. R.P. Adams, Identification of Essential Oil Components by Gas Chromatography/Mass Spectrometry, Allured Publishing Corporation, Ed.: 4 (2007).
19. M.E. Letelier, A. Molina-Berrios, J. Cortés-Troncoso, J. Jara-Sandoval, M. Holst, K. Palma, M. Montoya, D. Miranda and V. González-Lira, *J. Toxicol. In Vitro*, **22**, 279 (2008); https://doi.org/10.1016/j.tiv.2007.08.002
20. M. Joyeux, A. Lobstein, R. Anton and F. Mortier, *Planta Med.*, **61**, 126 (1995); https://doi.org/10.1055/s-2006-958030
21. C. Viturro, A. Molina and G. Schmeda-Hirschmann, *Phytother. Res.*, **13**, 422 (1999); https://doi.org/10.1002/(SICI)1099-1573(199908/09)13:5<422::AID-PTR462>3.0.CO;2-M
22. CLSI Method for Antifungal Disk Diffusion Susceptibility Testing of Yeasts, Wayne, Pennsylvania, 1898, USA (2004).
23. CLSI Performance Standards for Antimicrobial Disk Susceptibility Tests, Approved Standard, CLSI document M02-A11, Wayne, Pennsylvania, 19087, USA, Ed.: 7 (2012).
24. Y.S. Kim, Y.M. Lee, H. Kim, J. Kim, D.K. Jang, J.H. Kim and J.S. Kim, *J. Ethnopharmacol.*, **130**, 621 (2010); https://doi.org/10.1016/j.jep.2010.05.053
25. G. Manoj, S.H. Manohar and H.N. Murthy, *Nat. Prod. Res.*, **26**, 2152 (2012); https://doi.org/10.1080/14786419.2011.633082
26. S. Choudhary, O. Silakari and P.K. Singh, *Mini Rev. Med. Chem.*, **18**, 1452 (2018); https://doi.org/10.2174/1389557518666180416150552
27. M.J. Pagliassotti, E.C. Gayles and J.O. Hill, *Ann. N. Y. Acad. Sci.*, **827**, 431 (1997); https://doi.org/10.1111/j.1749-6632.1997.tb51853.x
28. B.M. Spiegelman and J.S. Flier, *Cell*, **104**, 531 (2001); https://doi.org/10.1016/S0092-8674(01)00240-9
29. R.S. Padwal and S.R. Majumdar, *Lancet*, **369**, 71 (2007); https://doi.org/10.1016/S0140-6736(07)60033-6
30. F.A. van52 de Laar, *Vasc. Health Risk Manag.*, **4**, 1189 (2008); https://doi.org/10.2147/VHRM.S3119
31. L.K. Han, Y. Kimura, M. Kawashima, T. Takaku, T. Taniyama, T. Hayashi, Y.N. Zheng and H. Okuda, *Int. J. Obes. Relat. Metab. Disord.*, **25**, 1459 (2001); https://doi.org/10.1038/sj.ijo.0801747
32. L.K. Han, Y.N. Zheng, B.J. Xu, H. Okuda and Y. Kimura, *J. Nutr.*, **132**, 2241 (2002); https://doi.org/10.1093/jn/132.8.2241
33. M. Nakai, Y. Fukui, S. Asami, Y. Toyoda-Ono, T. Iwashita, H. Shibata, T. Mitsunaga, F. Hashimoto and Y. Kiso, *J. Agric. Food Chem.*, **53**, 4593 (2005); https://doi.org/10.1021/jf047814+
34. H. Kamisoyama, K. Honda, Y. Tominaga, S. Yokota and S. Hasegawa, *Biosci. Biotechnol. Biochem.*, **72**, 3225 (2008); https://doi.org/10.1271/bbb.80469