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Terpenic and Phenolic Compounds from *Sideritis stricta*

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From the overground parts of an endemic *Sideritis* species, *S. stricta*, 4 diterpenes, sideridiol (**1**), isosidol (**2**), isolinearol (**3**), and linearol (**4**); 2 flavonoid glycosides, isoscutellarein 7-*O*-[6‴-*O*-acetyl-*β*-D-allopyranosyl-(1→2)]-*β*-D-glucopyranoside (**5**), and isoscutellarein 7-*O*-[6‴-*O*-acetyl-*β*-D-allopyranosyl-(1→2)]-6″-*O*-acetyl-*β*-D-glucopyranoside (**6**); a methoxyflavone, xanthomicrol (**7**); and a phenylethanoid glycoside, verbascoside (=acteoside) (**8**) were isolated. The structures of the isolated compounds were established based on spectroscopic evidence (UV, IR, 1D- and 2D-NMR, MS).

Key Words: *Sideritis stricta*, Lamiaceae, diterpenoids, flavonoids, flavonoid glycosides, methoxyflavones, phenylethanoid glycosides.

Introduction

The genus *Sideritis* L. (Lamiaceae), composed of annual and perennial herbs or small shrubs, is widely distributed in the Mediterranean region. This genus comprises more than 150 species[1] and is represented by 46 species in the Flora of Turkey[2]. Many species of the genus growing in the western Mediterranean region, especially in Spain and Portugal, have been studied in order to determine their chemical constituents for a long time and phytochemical data have been successfully used in chemotaxonomic studies. Although Turkey is the second biggest source of the genus *Sideritis*, except for reports on essential oils, phytochemical information on the genus is still scanty. The number of the studies on diterpenoids of Turkish *Sideritis* species has increased[3−10], but there are only a few reports on its phenolics[10−13].

In a continuation of our phytochemical studies on Turkish *Sideritis* species, we now report the isolation and structure elucidation of the diterpenes sideridiol (**1**), isosidol (**2**), isolinearol (**3**), and linearol (**4**); 2 flavonoid glycosides, isoscutellarein 7-*O*-[6‴-*O*-acetyl-*β*-D-allopyranosyl-(1→2)]-*β*-D-glucopyranoside (**5**), and isoscutellarein 7-*O*-[6‴-*O*-acetyl-*β*-D-allopyranosyl-(1→2)]-6″-*O*-acetyl-*β*-D-glucopyranoside (**6**); a

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methoxyflavone, xanthomicrol (**7**); and a phenylethanoid glycoside, verbascoside (=acteoside) (**8**) from *S. stricta* Boiss. & Heldr. apud Bentham, which is endemic to Turkey. Compounds **2** and **3** and the phenolics (**5-8)** are reported from *S. stricta* for the first time in this study. *S. stricta*, which has been used as a herbal tea in Southern Anatolia, is known for its carminative and appetizing properties[14].

Experimental

General experimental procedures

The UV spectra (λ_{max}) were recorded on a Shimadzu UV-160 A spectrophotometer. The IR spectra (ν_{max}) were determined on a Perkin-Elmer 2000 FT-IR spectrophotometer. EI-MS were recorded on a Varian MAT 731 (EI, 70eV). NMR measurements in $CDCl_3$ for diterpenes and CD_3OD for flavonoids and phenylethanoids at room temperature were performed on Bruker AMX 300 and Bruker DRX 500 spectrometers (^{1}H NMR: 300.13 and 500 MHz, ^{13}C NMR: 75.5 and 125 MHz). Chemical shifts δ were given in ppm and coupling constants J in Hz and the spectra were referenced against residual non-deuterated solvent. Silica gel 60 (63-200 μm, Merck) was used for vacuum-liquid chromatography (VLC) (column 5.2 x 20 cm, i.d.) and open column chromatography. Polyamide (Polyvinyl-polypyrrolidone, Woelm) and Sephadex LH-20 (Pharmacia) were also used for open CC. MPLC separations were performed on a Labomatic glass column (1.8 x 35.2 cm) packed with LiChroprep RP-18 (Merck) using a Lewa M5 peristaltic pump. Pre-coated silica gel 60 F_{254} aluminium plates (0.2 mm, Merck) were used for TLC. Plates were examined by UV fluorescence and sprayed with 1% vanillin in conc. H_2SO_4, followed by heating at 105 °C for 1-2 min.

Plant material

Sideritis stricta Boiss. & Heldr. apud Bentham was collected from between Belek and Selge, Belek district, Antalya province, in Southern Anatolia, Turkey, in July 1999. Voucher specimens (HUEF 99132) have been deposited at the Herbarium of the Faculty of Pharmacy, Hacettepe University, Ankara, Turkey.

Extraction and isolation

The air-dried and powdered aerial parts of *S. stricta* (500 g) were extracted with acetone (2500 mL x 2) at room temperature. The combined acetone extracts were dried in vacuo at 40 °C. The total extract (30 g) was initially fractionated by VLC on silica gel (petroleum→ →MeOH) to give 8 main fractions (A-H). Fraction C was chromatographed on silica gel CC ($CHCl_3$ →$CHCl_3$-MeOH; 97:3) and then subfraction C2 was subjected to MPLC (MeOH-H_2O; 70:30→MeOH) to yield fractions C2a-h. Subfractions C2d and C2f were subjected to silica gel CC using the same solvent systems (cyclohexane:acetone 90:10). From subfraction C2f compounds **1** (15 mg) and **2** (15 mg) were obtained. Compound **3** (7 mg) was isolated from subfraction C2d. Compound **4** (4 mg) was also purified from both subfractions C2d and C2f in small quantities. On the other hand, repeated chromatography of subfraction C2b on a Sephadex column (MeOH) gave compound **7** (17 mg). Fraction G was separated on polyamide CC with ethylacetate-methanol-ethylmethylketone-acetone (90:10:5:5→80:20:5:5). Subfractions G3 and G5, which are rich in flavonoids, were applied to silica gel CC ($CHCl_3$-MeOH 90:10), affording compounds **6** (17 mg) and **5** (16 mg), respectively. Compound **8** (55 mg) was purified from subfraction G6 by Sephadex CC (MeOH).

Results

Sideridiol (**1**): White needles. UV λ_{max}nm ($CHCl_3$) = 248; IR ν_{max} (KBr) cm^{-1} = 3433 (OH), 2926 (C-H), 1646, 856 (C=C); EI-MS: (m/z)= 304.3 $[M]^+$, 286.2 $[M\text{-}H_2O]^+$ for $C_{20}H_{32}O_2$;^{13}C, ^1H NMR ($CDCl_3$, ^{13}C: 125 MHz,^1H: 500 MHz): Table 1.

Table 1. ^{13}C and ^1H NMR spectroscopic data* for **1-4** ($CDCl_3$).

C/H	δ_C ppm				δ_H ppm, J (Hz)			
Atom	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1	39.9	38.3	38.4	38.5	0.68 m 1.71 †	1.09 s 1.81 s	0.80 m 1.82 †	0.99 † 1.87 †
2	17.9	23.4	26.4	26.6	1.44 †	1.62 † 1.73 †	1.65 †	1.68 †
3	35.1	74.6	72.3	72.4	1.11 d (11.0) 1.52 m	4.86 dd (7.0, 11.0)	3.46 dd (7.0, 11.0)	3.53 t (8.0)
4	37.1	38.7	41.9	42.0				
5	38.2	37.0	37.8	38.3	1.72 q	1.90 d (4.5)	1.63 †	1.76 s
6	26.2	26.0	26.7	27.5	1.52 †	1.57 †	1.53 †	1.65 † 1.72†
7	75.4	74.9	74.9	77.0	3.56 bs	3.58 bs	3.58 bs	3.60 bs
8	53.5	53.2	53.1	48.1				
9	44.1	44.1	43.9	50.4	1.32†	1.32 †	1.32 m	1.47 †
10	39.2	41.7	39.1	38.9				
11	18.3	18.5	18.4	18.0	1.44 †	1.44 †	1.44 †	1.57 †
12	24.9	24.9	24.8	33.7	1.44 †	1.44 †	1.44 †	1.49 † 1.68 †
13	44.7	44.7	44.6	43.8	2.31 bs	2.31 bs	2.32 bs	2.68 bs
14	42.1	42.0	42.0	38.4	1.32 m 1.86 d (11.0)	1.32 † 1.82 †	1.32 † 1.83 †	1.17 m 1.83 †
15	129.9	130.0	130.3	45.2	5.41 s	5.50 s	5.45 s	2.26 s
16	144.1	143.8	143.9	155.2				
17	15.5	15.4	15.4	103.7	1.67 s	1.67 s	1.67 s	4.79 bs 4.82 bs
18	70.5	64.1	66.0	66.2	2.87 d (11.0) 3.42 d (11.0)	2.93 d (11.0) 3.26 d (11.0)	3.92 d (11.0) 4.01 d (11.0)	3.98 d (11.0) 4.04 d (11.0)
19	17.6	12.7	11.8	12.1	0.64 s	0.61 s	0.70 s	0.75 s
20	17.7	18.0	18.0	18.1	1.00 s	1.02 s	1.01 s	1.05 s
$CO\mathit{CH}_3$		21.2	21.2	21.4		2.00 s	2.04 s	2.08 s
$\mathit{CO}CH_3$		171.8	171.9	172.1				

*All carbon and proton resonances were assigned on the basis of 2D NMR (COSY, HSQC and HMBC) experiments.
†Signal patterns are unclear due to overlapping.

Isosidol (**2**): Amorphous white powder. UV λ_{max} nm ($CHCl_3$) = 247,5; IR ν_{max} (KBr) cm^{-1}= 3440 (OH), 2929 (C-H), 1650, 850 (C=C), 1714 (ester C=O); EI-MS: (m/z) = 362.3 $[M]^+$, 314.2 $[M\text{-}H_2O\text{-}2CH_3]^+$ for $C_{22}H_{34}O_4$; ^{13}C, ^1H NMR ($CDCl_3$, ^{13}C: 125 MHz,^1H: 500 MHz): Table 1.

Isolinearol (**3**): Amorphous white powder. UV λ_{max} nm ($CHCl_3$) = 247,5; IR ν_{max} (KBr) cm^{-1} = 3440 (OH), 2929 (C-H), 1650, 850 (C=C), 1714 (ester C=O); EI-MS: (m/z) = 362.3 $[M]^+$, 326.3 $[M\text{-}2H_2O]^+$ for $C_{22}H_{34}O_4$; ^{13}C, ^1H NMR ($CDCl_3$, ^{13}C: 125 MHz,^1H: 500 MHz): Table 1.

Linearol (**4**): Colourless prisms. UV λ_{max} nm ($CHCl_3$) = 247,5; IR ν_{max} (KBr) cm^{-1}= 3462 (OH), 2930 (C-H), 1655, 875 (C=C), 1715 (ester C=O); EI-MS: (m/z) = 362.3 $[M]^+$, 344.3 $[M\text{-}H_2O]^+$, 326.3 $[M\text{-}2H_2O]^+$ for $C_{22}H_{34}O_4$; ^{13}C, ^1H NMR ($CDCl_3$, ^{13}C: 75.5 MHz,^1H: 300.13 MHz): Table 1.

Isoscutellarein 7-*O*-[6‴-*O*-acetyl-β-D-allopyranosyl-(1→2)]-β-D-glucopyranoside (5): Amorphous yellow powder. UV λ_{max}nm (MeOH): 276, 303, 325(sh); (NaOMe): 247, 275, 377; ($AlCl_3$): 280, 322, 347; ($AlCl_3$+HCl): 281, 322, 345 (sh); (NaOAc): 275, 304, 329 (sh), 386; (NaOAc+H_3BO_3): 276, 305, 327 (sh); IR ν_{max} (KBr) cm^{-1}= 3403 (OH), 1661(γ−pyrone C=O), 1727 (ester C=O), 1508, 1607 (aromatic ring); $C_{29}H_{32}O_{17}$; ^{13}C, ^1H NMR (CD_3OD, ^{13}C: 75.5 MHz,^1H: 300.13 MHz): Table 2.

Isoscutellarein 7-*O*-[6‴-*O*-acetyl-β-D-allopyranosyl-(1→2)]-6″-*O*-acetyl-β-D-glucopyranoside (**6**): Amorphous yellow powder. UV λ_{max}nm (MeOH): 277, 303, 325(sh); (NaOMe): 247, 276, 377; ($AlCl_3$): 282, 323, 350; ($AlCl_3$+HCl): 281, 322, 347 (sh); (NaOAc): 275, 304, 329 (sh), 386; (NaOAc+H_3BO_3): 276, 305, 327 (sh); IR ν_{max} (KBr) cm^{-1}= 3414 (OH), 1655 (γ−pyrone C=O), 1727 (ester C=O), 1508, 1600 (aromatic ring); $C_{31}H_{34}O_{18}$; ^{13}C, ^1H NMR (CD_3OD, ^{13}C: 75.5 MHz,^1H: 300.13 MHz): Table 2.

Xanthomicrol (**7**): Amorphous yellow powder; UV λ_{max}nm (MeOH): 280, 328; (NaOMe): 275, 391; ($AlCl_3$): 285, 309, 359, 396 (sh); ($AlCl_3$+HCl): 278, 310, 350, 395 (sh); (NaOAc): 276, 350, 397; (NaOAc+H_3BO_3): 279, 330, 397; IR ν_{max} (KBr) cm^{-1} = 3278 (OH), 1655 (γ-pyrone C=O), 1506, 1562, 1605 (aromatic ring); EI-MS: (m/z) = 344.2 $[M]^+$, 329.2 $[M\text{-}CH_3]^+$ for $C_{18}H_{16}O_7$; ^{13}C, ^1H NMR (CD_3OD, ^{13}C: 75.5 MHz,^1H: 300.13 MHz): Table 2.

Verbascoside (**8**): Amorphous yellow powder; UV λ_{max}nm (MeOH) = 220, 234 (sh), 290, 329; IR ν_{max} (KBr) cm^{-1} = 3392 (OH), 1699 (conjugated ester C=O), 1631 (conjugated C=O), 1604, 1523 (aromatic ring), $C_{29}H_{36}O_{15}$; ^{13}C, ^1H NMR (CD_3OD, ^{13}C: 75.5 MHz,^1H: 300 MHz) (data not shown).

Discussion

Acetone extract of the aerial parts of *S. stricta* was fractionated over VLC, followed by open CC on silica gel, Polyamide, Sephadex and/or MPLC to yield compounds **1-8** (see Figure).

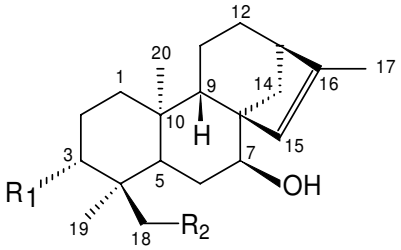
Compounds **1-3** were isolated as white resins whose UV spectra showed characteristic absorbance at ca. 248 nm (see Results section). The IR spectrum of **1** exhibited bands typical for kaurene type diterpenes at 3433, 2926, 1646, and 856 cm^{-1}.The molecular formula of **1** was established as $C_{20}H_{32}O_2$ on the basis of pseudomolecular ions appearing in the negative EI-MS (m/z, 304.3 $[M]^+$, 286.2 $[M\text{-}H_2O]^+$) and was in good agreement with the observation of 3 methyl, 8 methylene, 5 methine and 4 quaternary carbon resonances in its ^{13}C NMR spectrum (see Table 1). The ^1H NMR spectrum (see Table 1) showed an AB system of doublets at δ_H 2.87 and 3.42 (J_{AB}= 11.0 Hz), a broad singlet at δ_H 3.56, and 3 singlets at δ_H 0.64, 1.00 and 1.67. On the other hand, in the COSY spectrum interactions between protons showed 4 spin systems [a) H_2-1/ H_2-2/ H_2-3, b) H-5/ H_2-6/ H-7, c) H-9/ H_2-11/ H_2-12/ H-13/ H_2-14 and d) H-15/ Me-17] in addition to oxymethylene signals at δ_H 2.87 and 3.42 (J_{AB}=11 Hz) and 2 methyl resonances at δ_H0.64 and δ_H 1.00. ^{13}C NMR and DEPT-135 spectra revealed signals at δ_C 144.1 and 129.9, which were assigned to the olefinic carbons at C-16 and C-15, respectively (spin system d). ^{13}C NMR spectrum showed 2 oxygenated carbon signals (δ_C 75.4 and 70.5). Of these, the carbon resonance at δ_C 70.5 (CH_2) displayed HSQC correlations with oxymethylene protons (δ_H 2.87 and 3.42 J_{AB}=11 Hz) forming an AB system. In the HSQC spectrum

Table 2. ^{13}C and ^{1}H NMR spectroscopic data* for **5-7** (CD_3OD_3).

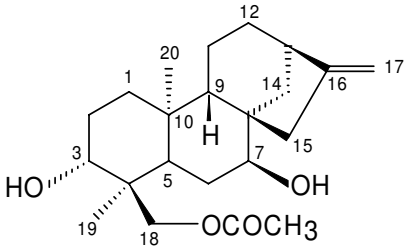
C/H	δ_C ppm			δ_H ppm, J (Hz)		
Atom	**5**	**6**	**7**	**5**	**6**	**7**
Aglycone						
2	166.3	166.6	164.2			
3	103.9	103.7	102.6	6.71 s	6.63 s	6.89 s
4	184.3	184.5	182.6			
5	154.0	154.0	148.6			
6	101.5	101.7	135.8	6.80 s	6.71 s	
7	151.9	151.7	152.5			
8	129.6	129.9	132.7			
9	145.2	145.2	145.2			
10	107.5	107.7	106.2			
1′	123.1	123.1	121.0			
2′	129.9	129.9	128.6	7.98 d (8.8)	7.92 d (8.8)	7.95 d (8.8)
3′	117.1	117.0	116.2	6.99 d (8.8)	6.94 d (8.8)	6.96 d (8.8)
4′	162.9	163.0	161.6			
5′	117.1	117.0	116.2	6.99 d (8.8)	6.94 d (8.8)	6.96 d (8.8)
6′	129.9	129.9	128.6	7.98 d (8.8)	7.92 d (8.8)	7.95 d (8.8)
6-OCH_3			60.6			3.82 s
7-OCH_3			61.9			3.92 s
8-OCH_3			61.5			4.02 s
5-OH						12.79 bs
Glucose						
1″	102.7	102.6		4.99 d (7.4)	4.92 d (7.5)	
2″	84.0	84.1		3.73 dd (7.4, 9.0)	3.70 †	
3″	77.4	77.4		3.69 †	3.70 †	
4″	70.8	71.4		3.50 †	3.44 t (9.5)	
5″	78.5	75.7		3.52 m	3.67 †	
6″	62.2	64.7		3.96 dd (12.0, 2.0)	4.46 †	
				3.78 dd (12.0, 5.0)	4.30 †	
Allose						
1‴	104.2	104.4		5.08 d (8.1)	5.07 d (8.1)	
2‴	73.0	73.0		3.45 dd (8.1, 2.8)	3.47†	
3‴	72.5	72.6		4.11 dd (2.8, 3.2)	4.13 dd (2.8, 3.2)	
4‴	68.4	68.4		3.64 dd (3.2, 10.0)	3.65 dd (3.2, 10.0)	
5‴	73.4	73.4		4.06 m	4.12 m	
6‴	65.0	65.0		4.34 dd (12.0, 2.0)	4.33 †	
				4.25 dd (12.0, 5.0)	4.26 †	
COCH_3	21.0	20.8		2.00 s	2.02 s	
COCH$_3$	172.6	172.8				
COCH_3		20.8			2.15 s	
COCH$_3$		173.0				

* All carbon and proton resonances were assigned on the basis of 2D NMR (COSY, HSQC and HMBC) experiments.
† Signal patterns are unclear due to overlapping.

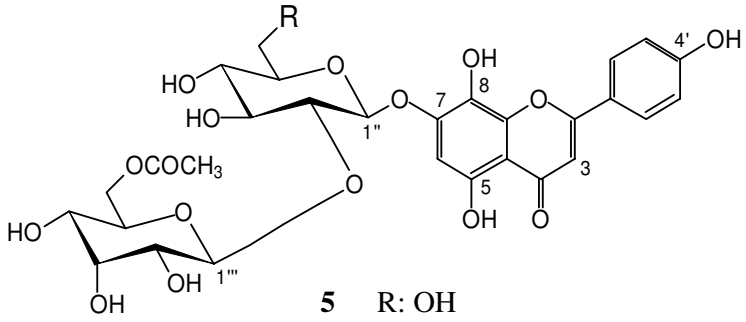
short-range correlations between the carbon resonance at δ_C 75.4 (CH) and a broad singlet at δ_H 3.56 was indicative of a secondary hydroxyl group at C-7. The COSY experiment clarified that the secondary hydroxyl group was at spin system b. In the ^{1}H NMR spectrum a downfield methyl signal at δ_H 1.67 was indicative of an allylic methyl function. The COSY spectrum also indicated correlations between this methyl group (δ_H 1.67) and the olefinic proton at δ_H 5.41 (H-15) (spin system d). Long-range couplings between signals observed in ^{13}C and ^{1}H NMR spectra were explained by HMBC experiments. HMBC cross-peaks between methyl protons and carbons showed that methyl groups (δ_H 1.67, 1.00, 0.64) are at C-16 (Me-17), C-10 (Me-20) and C-4 (Me-19), respectively. 1D and 2D NMR experiments allowed the structure of **1** to be determined as sideridiol[15,16].



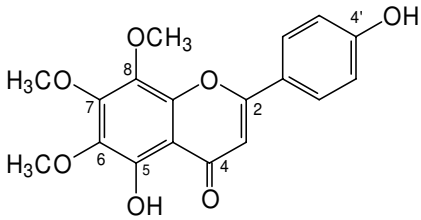
1 R_1: H R_2:OH
2 R_1: $OCOCH_3$ R_2:OH
3 R_1: OH R_2: $OCOCH_3$



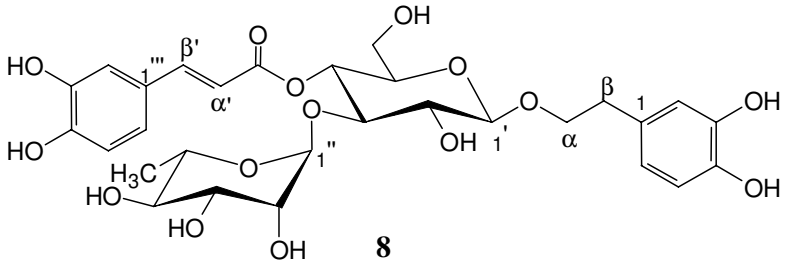
4



5 R: OH
6 R: $OCOCH_3$



7



8

Figure. Terpenic (**1-4**) and phenolic (**5-8**) compounds isolated from *Sideritis stricta*.

The IR spectra of **2** and **3** were very similar to that of **1**, and an additional band at 1714 cm^{-1}suggested the presence of an ester carbonyl function. The negative EI-MS of **2** and **3** exhibited a pseudomolecular ion $[M]^+$ at m/z 362.3, which is compatible with the molecular formula $C_{22}H_{34}O_4$ (see Results section). The ^1H and ^{13}C NMR spectra of **2** and **3** (Table 1) exhibited signals similar to those of sideridiol (**1**), with the only difference being the presence of a resonance for an acetyl group at C-3 in **2** (δ_H 2.00, 3H, s, δ_C 21.2 and 171.8) and an equatorial hydroxymethylene at C-4 in **3** (δ_H 2.04, 3H, s, δ_C 21.2 and 171.9), respectively. In addition, the ^1H NMR spectrum of **3** indicated a secondary hydroxyl group at C-3 (δ_H 3.46 dd, J= 7.0, 11.0). Based on ^1H and ^{13}C NMR spectra and 2D NMR experiments, the structures of **2** and **3** were identified as isosidol and isolinearol, respectively[17].

Compound **4** was isolated as colourless prisms. The UV, IR and negative EI-MS spectra of **4** were very similar to those of **2** and **3** (see Results section). The ^1H NMR spectrum of compound **4** (see Table 1) showed signals characteristic of 2 tertiary methyls (δ_H 0.75 and 1.05), an exocyclic methylene (δ_H 4.79 br s and 4.82 br s), an acetoxymethylene group (δ_H 3.98 d, 4.04 d, J_{AB}=11.0 Hz) and 2 secondary hydroxyl groups (δ_H 3.53 t, J=8.0 Hz and 3.60 bs), which were in accordance with the structure of an *ent*-kaur-16-ene type diterpene. 2D-NMR experiments (COSY, HSQC and HMBC) also supported the proposed structure and showed hydroxyl groups to be at C-3 and C-7. Consideration of 1D and 2D NMR data proved the structure of **4** to be linearol[4,6,17].

Compounds **5**-**8** were isolated as amorphous yellow powders. The molecular formulae of **5** and **6** were determined to be $C_{29}H_{32}O_{17}$ and $C_{31}H_{34}O_{18}$, respectively. The UV absorptions recorded at 276, 303, 325(sh), and 277, 303, 325(sh), respectively, and spectroscopic data with shifting reagents were indicative of a flavone skeleton[18]. The IR spectra indicated absorption bands for hydroxyl, $\gamma-$pyrone carbonyl, ester carbonyl and aromatic ring (see Results section). In the ^1H NMR spectrum of **5** (see Table 2), 2 singlets at δ_H 6.80 and 6.71 were assigned to H-6 and H-3, respectively. The 4′-monosubstitution on the B ring was indicated by 2 pairs of ortho-coupled (J=8.8 Hz) doublets at δ_H 6.99 (H-3′/5′) and 7.98 (H-2′/6′), which appeared as an AA′BB′ system. In addition, 2 anomeric proton signals at δ_H 5.08 (d, J=8.1 Hz) and 4.99 (d, J=7.4 Hz) indicated its diglycosidic structure. Assignments of all proton and carbon resonances were achieved by COSY and HMQC experiments, which showed that the sugars are β-allopyranose and β-glucopyranose, respectively. The appearance of a downfield signal at δ_C 84.0 for C-2″ resonances of the glucose unit and the long-range correlations between this carbon and the anomeric proton of the allose unit (δ_C 104.2) in the HMBC spectrum revealed the presence of a (1→2) glycosidic linkage between allose and glucose. The ^1H NMR spectrum of **5** exhibited an acetoxymethyl signal at δ_H 2.00 (s, 3H). Acetoxymethyl function was determined to be at H_2-6‴ of the allose unit due to the downfield shift of H_2-6‴ [δ_H 4.25 (dd, J_{AB}=12.0, 5.0 Hz) and 4.34 (dd, J_{AB}=12.0; 2.0 Hz)] and the HMBC cross-peak between these protons and acetoxyl function. Additionally, in the HMBC spectrum, a long-range correlation between C-7 and H-1″ established the linkage point of aglycone and sugar moiety. Based on the above results and comparison with the published data, compound **5** was identified as isoscutellarein 7-*O*-[6‴-*O*-acetyl-β-D-allopyranosyl-(1→2)]-β-D-glucopyranoside[19,20]. The ^1H and ^{13}C NMR spectra of **6** (see Table 2) were almost identical to those of compound **5**. However, in the ^1H NMR spectrum of **6**, there was an additional acetoxymethyl singlet at δ_H 2.15, which was attached to C-6″. This was confirmed by the downfield shift of H-6″ (δ_H 4.46 and 4.30) of the glucose unit and HMBC correlations between these protons and acetoxymethyl function. Thus, compound **6** was characterised as isoscutellarein 7-*O*-[6‴-*O*-acetyl-β-D-allopyranosyl-(1→2)]-6″-*O*-

acetyl-β-D-glucopyranoside[20].

The molecular formula of **7** was established as $C_{18}H_{16}O_7$ by means of negative ion mode EI-MS (m/z, 344.2 $[M]^+$, 329.2 $[M\text{-}CH_3]^+$) together with ^{13}C NMR data (see Table 2). The UV spectroscopic data with diagnostic reagents were indicative of a flavone skeleton[11]. IR bands for hydroxyl, $\gamma-$pyrone carbonyl and the aromatic ring were observed (see Results section). The aromatic region of the ^1H NMR spectrum of **7** (see Table 2) showed a characteristic resonance for H-3 of a flavone at δ_H 6.89 (1H, s, δ_C 102.6 by HSQC) and indicated the presence of *p*-hydroxyphenyl group (δ_H 6.96, d, J=8.8 Hz, H-3′/5′ and δ_H 7.95, d, J=8.8 Hz, H-2′/6′). In the ^1H NMR spectrum a broad singlet at δ_H 12.79 was assigned a hydroxyl group at C-5. The remaining resonances in the ^1H NMR spectrum of **7** were those of 3 methoxyl groups at δ_H 3.82 (s, 3H), 3.92 (s, 3H), and 4.02 (s, 3H). In the HMBC spectrum, the long-range connectivities between methoxyl protons and C-6, C-7 and C-8 supported the sites of methoxyl functions on the flavone skeleton. Thus, compound **7** was identified as 5,4′-dihydroxy-6,7,8-trimethoxy-flavone, which is a known compound, xanthomicrol[21].

Compound **8** was characterised as verbascoside (=acteoside), which is a widespread phenylethanoid glycoside in Lamiaceae, by comparing its spectroscopic (UV, IR, ^1H and ^{13}C NMR) data with previously published data and by direct comparison with the authentic sample on a TLC plate[22].

Consequently, as a part of our ongoing phytochemical studies on *Sideritis* species, in this study we investigated the terpenic and phenolic constituents of *S. stricta*. Kilic (2006) has reported the isolation and structure elucidation of 10 diterpenoids including sideridiol (**1**) and linearol (**4**) from *S. stricta* collected in Antalya province, Turkey[3]. However, in this study, we characterised 2 more *ent*-kaurene diterpenes, isosidol (**2**) and isolinearol (**4**). Moreover, phenolic compounds (**5-8**) were reported from *S. stricta* for the first time.

The taxonomy of the genus *Sideritis* is rather difficult. Chemotaxonomy has proved useful in the study of systematic problems within this genus, as well as verification of interspecific hybrids. Since so many chemical studies have been performed on western Mediterranea and Macaronesian *Sideritis*, the chemotaxonomy of the species growing in those areas has already been established. According to these data, diterpenoids and flavonoids are chemotaxonomic markers for the genus *Sideritis*[23−25]. It is reported that while species from the western Mediterranea and Macaronesia contain *ent*-kaurene, labdane, atisane, trachilobane and beyerane diterpenoids, eastern Mediterranean species usually contain *ent*-kaurene diterpenoids[4,5]. In our study, we isolated *ent*-kaurene type diterpenes, in agreement with these reports.

The flavonoids, both glycosides and aglycones, from western Mediterranean and Macaronesian *Sideritis* species, have been extensively studied over 25 years in order to establish its chemotaxonomy. Results indicate that the geographical location of different taxa of *Sideritis* could influence their diversity of flavonoids[24,25]. In addition to isoscutellarein glycosides and xanthomicrol reported in this study (**5-7**), from several *Sideritis* species growing in Turkey, chrysoeriol mono- and di-glycosides[13], chrysoeriol caffeoyl-glucosides and chrysoeriol coumaroyl-glucoside[10], methylisoscutellarein glycosides and apigenin coumaroyl-glucoside[12], methylhypolaetin glycosides, hydoxychrysoeriol glycosides[11], salvigenin[11,13] and circimaritin[5,11] have been isolated so far. However, since there are only a few sets of data on the flavonoids of Turkish *Sideritis* species, it is premature to make a general chemotaxonomic conclusion.

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