Nawal M. Al Musayeib*, Sabrin R.M. Ibrahim*, Musarat Amina, Gadah A. Al Hamoud and Gamal A. Mohamed

Curviflorside and curviflorin, new naphthalene glycoside and flavanol from *Plicosepalus curviflorus*

DOI 10.1515/znc-2016-0180
Received September 6, 2016; revised September 26, 2016; accepted October 12, 2016

Abstract: The naphthalene glycosidecurviflorside [1,5-dihydroxy-8-methoxynaphthalene-2-*O*-β-D-xylopyranoside] (**3**) and the flavanol curviflorin [(+)-catechin-7-*O*-3″,4″-dihydroxybenzoate] (**4**), along with two known flavonoids: (+)-catechin (**1**) and quercetin (**2**) were isolated from the shoots of *Plicosepalu scurviflorus* Benth. (Loranthaceae) growing in Saudi Arabia and the chemical structures were elucidated by 2D-NMR spectroscopy.

Keywords: curviflorin; curviflorside; flavonoids; naphthalene; *Plicosepalus curviflorus*.

1 Introduction

Naphthalenes are reported from fungi, plants, insects, and liverworts. Naphthalenes possess a wide range of bioactivities: antimicrobial, antioxidant, cytotoxic, anti-inflammatory, anti-platelet aggregation, and antiprotozoal [1]. Several naphthalene-containing drugs are available, such as nafacillin, naftifine, tolnaftate, and terbinafine, which play a vital role in controlling microbial infection [2]. Flavan-3-ols are the most common group of flavonoids in dietare 3-ring phenolic compounds having multiple hydroxyl groups on the A, B, and C rings. They are considered functional ingredients of fruits, beverages, vegetables, food grains, dietary supplements, herbal remedies, and dairy products [3]. Many studies indicated that they exhibited several health beneficial effects by acting as antioxidant, anti-diabetic, anti-proliferative, neuro- and cardio-protective, antimicrobial, and antiviral agents [3–5]. Family Loranthaceae plays an important and complex role in the biological system in which species of this family live by interacting with insects, birds, and mammals [6]. This family comprises four genera: *Phragmanthera*, *Oncocalyx*, *Tapinanthus*, and *Plicosepalus*, which grow naturally in Saudi Arabia. These genera include six species, *Plicosepalus acacia*, *Plicosepalus curviflorus*, *Phragmanthera austroarabica*, *Oncocalyx schimperi*, *Oncocalyx glabratus*, and *Tapinanthus globiferus* spread in the north, west, and south of the Saudi Arabia [7]. Earlier investigations on genus *Plicosepalus* reported various biological activities such as antioxidant [8–10], antihepatotoxic [11], anti-diabetic [12–14], antiviral [10, 15], antimicrobial [8, 10, 16, 17], and cytotoxic [10, 18, 19] activities. A literature survey revealed that very little phytochemical work has been carried out on the genus *Plicosepalus*. Flavonoids [8, 14, 19], phenolic acids [5], triterpenes, sterols [14], and sesquiterpene lactones [20] have been isolated from different *Plicosepalus* species. Flavane gallates, triterpenes, and sterols have been isolated from *P. curviflorus* Benth. [8, 15]. *P. curviflorus* is a parasitic plant which is generally known as “Enam ElTalh” (in Arabic). It is found in north East Africa, East Africa, Yemen, and Saudi Arabia [21]. The stems of *P. curviflorus* are used for the treatment of cancer in Yemen [10] and traditionally used in Saudi Arabia for increasing lactation in cattle [21]. Moreover, *P. curviflorus* is used for the treatment of diabetes in Saudi Arabia folk medicine [22, 23]. The present work reports the isolation and structural elucidation of two new compounds (**3** and **4**), along with two known ones (Figure 1) from the shoots of *P. curviflorus*. Their structures were assigned by

***Corresponding authors: Nawal M. Al Musayeib,** Department of Pharmacognosy, College of Pharmacy, King Saud University, Riyadh 11451, Saudi Arabia, Phone: +966 598566807, E-mail: nawal.pharmacy@gmail.com; nalmusayeib@ksu.edu.sa; and **Sabrin R.M. Ibrahim,** Department of Pharmacognosy and Pharmaceutical Chemistry, College of Pharmacy, Taibah University, Al Madinah Al Munawwarah 30078, Saudi Arabia, Phone: +966 581183034, E-mail: sabrinshaur@gmail.com; sribrahim@taibahu.edu.sa; and Department of Pharmacognosy, Faculty of Pharmacy, Assiut University, Assiut 71526, Egypt
Musarat Amina and Gadah A. Al Hamoud: Department of Pharmacognosy, College of Pharmacy, King Saud University, Riyadh 11451, Saudi Arabia
Gamal A. Mohamed: Department of Natural Products and Alternative Medicine, Faculty of Pharmacy, King Abdulaziz University, Jeddah 21589, Saudi Arabia; and Department of Pharmacognosy, Faculty of pharmacy, Al-Azhar University, Assiut Branch, Assiut 71524, Egypt

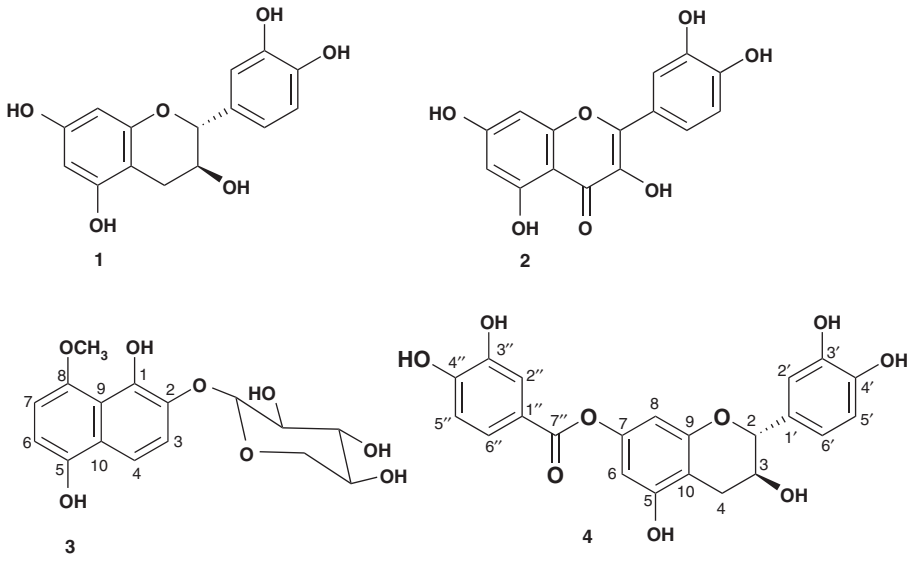

Figure 1: Structure of isolated compounds **1–4**.

extensive spectroscopic methods as well as comparison with the literature.

2 Materials and methods

2.1 General

Optical rotations were measured on a Perkin-Elmer Model 341 LC polarimeter (Perkin-Elmer, Waltham, MA, USA). Infrared (IR) spectra were measured with a Shimadzu Infrared-400 spectrophotometer (Shimadzu, Kyoto, Japan). The UV spectra were carried out in MeOH using a Perkin-Elmer Lambda 25 UV/VIS spectrophotometer (Perkin-Elmer, Waltham, MA, USA). Electrospray ionization mass spectrometry (ESIMS) spectra were recorded on a Finnigan MAT TSQ-7000 triple stage quadrupole mass spectrometer (Thermo Finnigan, Bremen, Germany). High-resolution electrospray ionization mass spectrometry (HRESIMS) spectra were obtained using an LTQ Orbitrap mass spectrometer (Thermo Fisher, Waltham, MA, USA). 1D and 2D nuclear magnetic resonance (NMR) spectra were measured on Bruker DRX 700 spectrometers (Bruker, Rheinstetten, Germany). Vacuum liquid chromatography (VLC) was performed using silica gel 60 (0.04–0.063 mm, Merck, Darmstadt, Germany). Column chromatographic separations were performed on silica gel 60 (0.04–0.063 mm, Merck, Darmstadt, Germany). Thin-layer chromatography (TLC) analyses were conducted on pre-coated silica gel F_{254} aluminum sheets (Merck, Darmstadt, Germany). Compounds were detected by spraying the sheets with *p*-anisaldehyde/H_2SO_4 reagent (Sigma-Aldrich Chemical Co., Taufkirchen, Germany) followed by heating at 110°C for 1–2 min.

2.2 Plant material

Shoots of *P. curviflorus* were collected in March 2013 from Abha, Saudi Arabia. The plant was identified by Dr. Mohamed Yousef, Prof. of Pharmacognosy, College of Pharmacy, King Saud University, Saudi Arabia. A voucher specimen (PC-3-2010) was deposited at the Department's herbarium.

2.3 Extraction and isolation

The air-dried powdered shoots (500 g) were extracted with MeOH (2×3 L, each) using soxhlet apparatus for 8 h at room temperature. The combined extracts were concentrated under reduced pressure to afford a dark green residue (14.0 g). The latter was suspended in distilled water (150 mL) and partitioned between *n*-hexane (3×500 mL), EtOAc (3×500 mL), and *n*-BuOH (3×500 mL) successively. Each fraction was concentrated to give *n*-hexane (4.1 g), EtOAc (2.9 g), *n*-BuOH (1.8 g), and aqueous (4.6 g) fractions. The EtOAc fraction (2.9 g) was subjected to VLC using $CHCl_3$: MeOH gradient to afford five subfractions: PC-1 to PC-5. Subfraction PC-2 (232 mg) was chromatographed over silica gel column (50 g×50×2 cm) using *n*-hexane : EtOAc gradients to get **1** (11.6 mg, yellow amorphous powder). Subfraction PC-2 (345 mg) was similarly treated as subfraction PC-1 to give **2** (34.7 mg, yellow amorphous powder).

Subfraction PC-3 (541 mg) was chromatographed over sephadex LH-20 column (100 g × 50 × 3 cm) using MeOH as an eluent to give two major subfractions: PC-3A (261 mg) and PC-3B (207 mg). Subfraction PC-3A was subjected to RP_{18} column (50 g × 50 × 2 cm) using MeOH : H_2O gradient to afford **3** (4.6 mg, white amorphous powder). Subfraction PC-3B (207 mg) was similarly treated as subfraction PC-3A to give **4** (6.2 mg, yellow amorphous powder).

Curviflorside (**3**): White amorphous powder (4.6 mg). $[\alpha]_D$: 52.3 (*c* 0.06, MeOH). UV (MeOH) λ_{max} (log ε): 237 (5.36), 258 (4.04), 297 (3.78) nm. IR (KBr) ν_{max}: 3425, 2934, 1625, 1518, 1070 cm^{-1}. NMR data (DMSO-d_6, 700 and 175 MHz), see Table 1. HRESIMS *m*/*z* 339.1075 (calcd for $C_{16}H_{19}O_8$, $[M+H]^+$, 339.1080).

Curviflorin (**4**): Yellow amorphous powder (6.2 mg). $[\alpha]_D$: + 15.3 (*c* 0.5, MeOH). UV (MeOH) λ_{max} (log ε): 218 (4.86), 277 (2.96) nm. IR (KBr) ν_{max}: 3356, 1732, 1614, 1519, 1463 cm^{-1}. NMR data (DMSO-d_6, 700 and 175 MHz), see Table 2. HRESIMS *m*/*z* 427.1033 (calcd for $C_{22}H_{19}O_9$, $[M+H]^+$, 427.1029).

3 Results and discussion

Compound **3** was obtained as white amorphous powder, and its molecular formula was defined as $C_{16}H_{18}O_8$ by HRESIMS pseudo-molecular ion peak at *m*/*z* 339.1075 $[M+H]^+$ (calcd for $C_{16}H_{19}O_8$, 339.1080), requiring eight degrees of unsaturation (see Supplementary Material, Figure S17). Seven of degrees of unsaturation were attributed to the naphthalene moiety and one for sugar moiety. The ESIMS revealed a fragment ion peak at *m*/*z* 190 $[(M+H)\text{-}149]^+$, indicating the loss of a pentose moiety. Its IR spectrum exhibited absorption bands for hydroxyl (3425 cm^{-1}) and aromatic (1625 and 1518 cm^{-1}) functionalities. The ^{13}C NMR and heteronuclear single quantum coherence (HSQC) data showed resonances for 16 carbon signals: 10 carbon signals in the range δ_C 108.1–152.6 for a naphthalene ring, five oxygen-bonded aliphatic carbons in the range δ_C 66.1–103.3 for pentose moiety, and methoxy group (δ_C 61.4) (see Supplementary Material, Figures S12 and S15). The ^1H NMR spectrum of **3** exhibited two pairs of *ortho*-coupled aromatic protons at δ_H 7.55 (d, J = 8.2 Hz, H-3), 7.70 (d, J = 8.2 Hz, H-4), and 7.47 (2H, d, J = 8.5 Hz, H-6, 7), correlating to the carbons at δ_C 112.0, 112.8, 110.7, and 109.1, respectively, in the HSQC spectrum characteristic for a *tetra*-substituted naphthalene moiety (Table 1). The heteronuclear multiple bond correlations (HMBC) of H-3 to C-1 and C-10; H-4 to C-1, C-2, C-3, and C-5; H-6 to C-8 and C-10; and H-7 to C-5 and C-9 confirmed the presence of such moiety (Figures 2 and S16). Moreover, the ^1H NMR spectrum showed characteristic signals of a sugar moiety

Table 1: NMR spectral data of compound **3** (DMSO-d_6, 700 and 175 MHz).

Position	δ_H [multiplicity, *J* (Hz)]	δ_C (multiplicity)	HMBC
1	–	152.6 C	–
2	–	140.1 C	–
3	7.55 d (8.2)	112.0 CH	1, 10
4	7.70 d (8.2)	112.8 CH	1, 2, 3, 5
5	–	149.0 C	–
6	7.47 d (8.5)	110.7 CH	8, 10
7	7.47 d (8.5)	109.1 CH	5, 9
8	–	148.9 C	–
9	–	108.1 C	–
10	–	123.5 C	–
1′	5.00 d (7.5)	103.3 CH	2
2′	3.41 m	73.5 CH	
3′	3.25 m	76.0 CH	
4′	3.43 m	69.8 CH	
5′	3.86 m	66.1 CH_2	
	3.38 m		
8-OCH_3	4.05 s	61.4 CH_3	8

Table 2: NMR spectral data of compound **4** (DMSO-d_6, 700 and 175 MHz).

Position	δ_H [multiplicity, *J* (Hz)]	δ_C (multiplicity)	HMBC
2	4.64 d (7.2)	81.6 CH	3, 4, 9, 1′, 2′, 6′
3	3.94 m	66.4 CH	2, 5, 10, 1′
4	2.67 dd (16.1, 5.2)	28.1 CH_2	2, 3, 5, 10
	2.45 dd (16.1, 8.2)		
5	–	155.6 C	–
6	6.13 d (2.0)	100.6 CH	5, 7, 8, 10, 7″
7	–	150.7 C	–
8	6.21 d (2.0)	101.2 CH	6, 7, 9, 10, 7″
9	–	156.6 C	–
10	–	106.2 C	–
1′	–	130.7 C	–
2′	6.75 brs	114.9 CH	2, 4′, 6′
3′	–	145.4 C	–
4′	–	146.1 C	–
5′	6.68 d (7.8)	115.6 CH	1′, 3′, 4′
6′	6.58 brd (7.8)	118.9 CH	2, 1′, 2′, 4′
1″	–	139.7 C	–
2″	7.09 d (2.2)	109.5 CH	1″, 4″, 6″, 7″
3″	–	145.9 C	–
4″	–	146.1 C	–
5″	6.95 d (8.2)	108.0 CH	1″, 3″, 6″
6″	7.06 dd (8.2, 2.2)	109.5 CH	1″, 2″, 4″, 7″
7″	–	164.9 C	–
3-OH	5.75 brs	–	–
5-OH	9.75 s	–	–
3″-OH	8.87 s	–	–
4″-OH	9.38 s	–	–

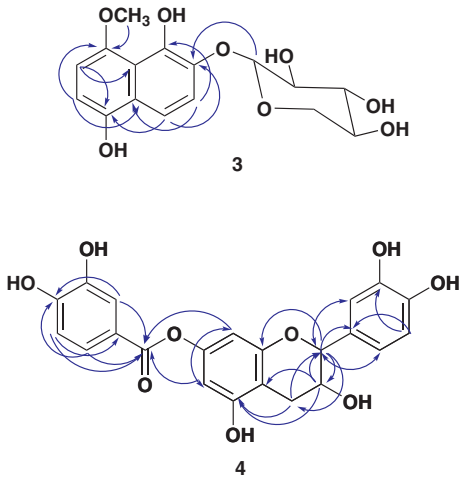

Figure 2: Some key HMBC correlations of **3** and **4**.

between δ_H 3.25 and 5.00, including an anomeric proton signal at δ_H 5.00 (d, J = 7.5 Hz, H-1′). The sugar was assigned as xylopyranose according to ^{13}C NMR data (Table 1), where signals belonging to the sugar moiety were three oxymethines at δ_C 69.8 (C-4′), 73.5 (C-2′), and 76.0 (C-3′), one oxymethylene at δ_C 66.1 (C-5′), and one anomeric oxymethine at δ_C 103.3 (C-1′) [1, 24]. The configuration at the anomeric center of the xylopyranosyl moiety (C-1′) was determined to be β based on the coupling constant value ($J_{1',2'}$ = 7.5 Hz). The sugar moiety was placed at C-2 on the basis of the ^3J HMBC correlation of the anomeric proton to C-2 (δ_C 140.1). Moreover, signals for methoxy group at δ_H 4.05/δ_C 61.4 were observed. Its attachment at C-8 was established by the HMBC cross peak of the methoxy group to C-8 (δ_C 148.9). On the basis of these data, compound **3** was identified as 1,5-dihydroxy-8-methoxynaphthalene-2-*O*-β-D-xylopyranoside. The trivial name curviflorside was given to it.

Compound **4** was obtained as yellow amorphous powder and gave positive tests for flavonoids [25, 26]. The HRESIMS spectrum of **4** gave a pseudo-molecular ion peak at m/z 427.1033 $[M+H]^+$, corresponding to the molecular formula $C_{22}H_{18}O_9$. The ESIMS spectrum showed a significant fragment ion peak at m/z 290 [M + H-(3,4-dihydroxybenzoyl)]$^+$. Its UV spectrum displayed absorption bands at 218 and 277 nm, which are characteristic for the presence of a flavan-3-ol moiety in **4** [27]. Its IR spectrum exhibited absorption bands for hydroxyl (3356 cm^{-1}), ester carbonyl (1732 cm^{-1}), and phenyl (1614, 1519, and 1463 cm^{-1}) moieties. The ^{13}C, distortionless enhancement by polarization transfer, and HSQC spectra of **4** showed the presence of 22 carbons, consisting of methylene, 8 aromatic methines, 2 oxymethines at δ_C 81.6 (C-2) and 66.4 (C-3), and 11 quaternary carbons, including one carbonyl at δ_C 164.9 (C-7″) (see Supplementary Material, Figures S19 and S20). The ^{1}H NMR spectrum showed resonances for two *meta*-coupled protons at δ_H 6.13 (d, J = 2.0 Hz, H-6) and 6.21 (d, J = 2.0 Hz, H-8) (Table 2). These signals showed HSQC cross peaks to the carbons, resonating at δ_C 100.6 and 101.2, respectively, consistent with a 5,7-dioxygenated A ring of flavane [28]. The ^{1}H NMR and ^{1}H-^{1}H correlation spectroscopy (COSY) also displayed an ABX system for 1,3,4-*tri*-substituted ring B at δ_H 6.75 (brs, H-2′), 6.68 (d, J = 7.8 Hz, H-5′), and 6.58 (brd, J = 7.8 Hz, H-6′) [29]. They showed HSQC cross peaks to carbon signals at δ_C 114.9, 115.6, and 118.9, respectively (Table 2). Moreover, two oxymethine protons at δ_H 4.64 (d, J = 7.2 Hz, H-2) and 3.94 (m, H-3) and methylene group at δ_H2.67 (dd, J = 16.1, 5.2 Hz, H-4A) and 2.45 (dd, J = 16.1, 8.2 Hz, H-4B) were observed, suggesting that **4** contained a catechin moiety. This moiety was confirmed by the observed ^{1}H-^{1}H COSY cross peaks and HMBC correlations of H-2 to C-4, C-9, C-1′, C-2′, and C-6′; H-3 to C-5, C-10, and C-1′; H-4 to C-2, C-3, C-5, and C-10; H-6 and H-8 to C-7 and C-10; H-2′ and H-6′ to C-2 and C-4′; and H-5′ to C-1′ and C-3′ (Figure 2). This was further secured by the ESIMS fragment ion peak at m/z 290 [M + H-(3,4-dihydroxybenzoyl)]$^+$. The ^{1}HNMR spectrum of **4** also displayed three coupled proton signals for a *tri*-substituted phenyl moiety at δ_H 7.09 (d, J = 2.2 Hz, H-2″), 6.95 (d, J = 8.2 Hz, H-5″), and 7.06 (dd, J = 8.2, 2.2 Hz, H-6″), indicating the presence of a 3,4-dihydroxybenzoyl moiety [30]. This was confirmed by ^{13}C NMR signals at δ_C 139.7 (C-1″), 109.5 (C-2″), 145.9 (C-3″), 146.1 (C-4″), 108.0 (C-5″), 109.5 (C-6″), and 164.9 (C-7″) and further secured by the observed HMBC correlations (Figure 2). Moreover, the four singlet signals at δ_H 5.75, 9.75, 8.87, and 9.38 were assigned to 3, 5, 3′, and 4′-OH groups, respectively. The connectivity of 3,4-dihydroxybenzoyl moiety at C-7 was established by the HMBC correlations of H-6 and H-8 to C-7″ at δ_C 164.9. Upon the hydrolysis of **4**, catechin and 3,4-dihydroxybenzoic acid were identified by co-TLC alongside authentic samples. On the basis of the above evidences, the structure of **4** was assigned as (+)-catechin-7-*O*-3″,4″-dihydroxybenzoate and named curviflorin.

The known compounds were identified as (+)-catechin (**1**) [31] and quercetin (**2**) [32, 33] by comparing their NMR spectral and physical data with the literature.

4 Conclusions

Four compounds (**1–4**) were isolated and characterized from the shoots of *P. curviflorus*; two of them are new natural products (**3** and **4**). Their structures were

determined on the basis of extensive spectroscopic data analysis.

Acknowledgments: This research was supported by the Research Center of the Female Scientific and Medical Colleges, Deanship of Scientific Research, King Saud University.

References

1. Ibrahim SR, Mohamed GA. Naturally occurring naphthalenes: chemistry, biosynthesis, structural elucidation, and biological activities. Phytochem Rev 2016;15:279–95.
2. Wilson CO, Gisvolds O. Textbook of organic medicinal and pharmaceutical chemistry. Lippincott, Williams and Wilkins, Philadelphia 2004:255.
3. Aron PM, Kennedy JA. Flavan-3-ols: nature, occurrence and biological activity. Mol Nutr Food Res 2008;52:79–104.
4. Braicu C, Pilecki V, Balacescu O, Irimie A, Neagoe IB. The relationships between biological activities and structure of flavan-3-ols. Int J Mol Sci 2011;12:9342–53.
5. Abdallah HM, El-Bassossy HM, Mohamed GA, El-halawany AM, Alshali KZ, Banjar ZM. Phenolics from *Garcinia mangostana* alleviate exaggerated vasoconstriction in metabolic syndrome through direct vasodilatation and nitric oxide generation. BMC Complement Altern Med 2016;16:359.
6. Watson DM. Mistletoe – a keystone resource in forests and woodlands worldwide. Annu Rev Ecol Syst 2001;32:219–49.
7. Waly NM. Anatomical and statistical analysis of six parasitic Loranthaceae species. Am J Res Commun 2013;1:317–32.
8. Bar JM, Ibrahim SR, Abou-Hussein DR. Plicosepalin A, a novel catechin-gallic acid derivative of inositolfrom *Plicosepalus curviflorus*. Z Naturforsch 2016;71:375–80.
9. Bamane FH, Badr JM, Amin OA. Antioxidant activities and flavonoid contents of selected plants belonging to family loranthaceae. Afr J Biotechnol 2012;11:14380–5.
10. Al-Fatimi M, Wurster M, Schroder G, Lindequist U. Antioxidant, antimicrobial and cytotoxic activities of selected medicinal plants from Yemen. J Ethnopharmacol 2007;111:657–6.
11. Yang LL, Yen KY, Kiso Y, Hikino H. Antihepatotoxic actions of Formosan plant drugs. J Ethnopharmacol 1987;19:103–10.
12. Osadebe PO, Okide GB, Akabogu IC. Study on anti-diabetic activities of crude methanolic extracts of *Loranthus micranthus* sourced from five different host trees. J Ethnopharmacol 2004;95:133–8.
13. Aldawsari HM, Hanafy A, Labib GS, Badr JM. Antihyperglycemic activities of extracts of the Mistletoes *Plicosepalusacacia* and *P. curviflorus* in comparison to their solid lipid nanoparticle suspension formulations. Z Naturforsch C. 2015;69:391–8.
14. Al-Taweel AM, Perveen S, Fawzy GA, Alqasoumi SI, El Tahir KE. New flavane gallates isolated from the leaves of *Plicosepalus curviflorus* and their hypoglycemic activity. Fitoterapia 2012;83:1610–5.
15. Lohezic-Le FD, Bakhtiar A, Bezivin C, Amoros M, Boustie J. Antiviral and cytotoxic activities of some Indonesian plants. Fitoterapia 2002;73:400–5.
16. Daud A, Gallo A, Sánchez AR. Antimicrobial properties of *Phrygilanthus acutifolius*. J Ethnopharmacol 2005;99:193–7.
17. Elegami AA, Elnima EI, Muddathir AK, Omer ME. Antimicrobial activity of *Plicosepalus acacia*. Fitoterapia 2001;72:431–4.
18. Fawzy GA, Al-Taweel AM, Perveen S. Anticancer activity of flavane gallates isolated from *Plicosepalus curviflorus*. Pharmacogn Mag 2014;10:S519–23.
19. Kim YK, Kim YS, Choi SU, Ryu SY. Isolation of flavonol rhamnosides from *Loranthus tanakae* and cytotoxic effect of them on human tumor cell lines. Arch Pharm Res 2004;27:44–7.
20. Okuda T, Yoshida T, Chen XM, Xie JX, Fukushima M. Corianin from *Coriaria japonica* A. Gray, and sesquiterpene lactones from *Loranthus parasiticus* Merr. used for treatment of schizophrenia. Chem Pharm Bull 1987;35:182–7.
21. Sher H, Alyemeni MN. Pharmaceutically important plants used in traditional system of Arab medicine for the treatment of livestock ailments in the Kingdom of Saudi Arabia. Afr J Biotechnol 2011;10:9153–9.
22. Elshanawani MA. Plants Used in Saudi Folk-Medicine, King Abdulaziz City for Science and Technology (KACST) publishing, Kingdom of Saudi Arabia 1996:236.
23. Mossa JS. A study on the crude antidiabetic drugs used in Arabian folk medicine. Int J Crude Drug Res 1985;23:137–45.
24. Yang Q, Yao C, Fang W. A new triglucosylated naphthalene glycoside from *Aloe vera* L. Fitoterapia 2010;81:59–62.
25. Mohamed GA, Ibrahim SR, Ross SA. New ceramides and isoflavone from the Egyptian *Iris germanica* L. rhizomes. Phytochem Lett 2013;6:340–4.
26. Markham K. Techniques of flavonoid identification. New York: Academic Press, 1982.
27. Mabry TJ, Markham KR, Thomas MB. The Systematic identification of flavonoids. New York, NY: Springer, 1970.
28. Harborne JB. The flavonoids: advances in research since 1986. London: Chapman and Hall, 1994.
29. Mohamed GA, Ibrahim SR, Al-Musayeib NM, Ross SA. New anti-inflammatory flavonoids from *Cadaba glandulosa* Forssk. Arch Pharm Res 2014;37:459–66.
30. El-Shanawany MA, Sayed HM, Ibrahim SR, Fayed MA, Radwan MM, Ross SA. A new isoflavone from *Blepharis ciliaris* of an Egyptian origin. Med Chem Res 2012:19:2346–50.
31. Sang S, Lapsley K, Rosen RT, Ho C. New prenylated benzoic acid and other constituents from almond hulls (*Prunus amygdalus* Batsch). J Agric Food Chem 2002;50:607–9.
32. Al-Musayeib NM, Mohamed GA, Ibrahim SR, Ross SA. Lupeol-3-O-decanoate, a new triterpene ester from *Cadaba farinosa* Forsk. growing in Saudi Arabia. Med Chem Res 2013;22:5297–302.
33. Mohamed GA, Ibrahim SR, Elkhayat ES, Ross SA, Sayed HM, El-Moghazy SA, et al. Blepharisides A and B, new flavonol glycosides from *Blepharis ciliaris* growing in Saudi Arabia. Phytochem Lett 2015;11:177–82.

Supplemental Material: The online version of this article (DOI: 10.1515/znc-2016-0180) offers supplementary material, available to authorized users.