Phytochemistry Letters 7 (2014) 52–56

Contents lists available at ScienceDirect

Phytochemistry Letters

journal homepage: www.elsevier.com/locate/phytol

Further cycloartane and friedelane triterpenoids from the leaves of *Caloncoba glauca*

James D. Simo Mpetga [a,b], Hong-Ping He [b], Xiao-Jiang Hao [b], Ying Leng [c], Pierre Tane [a,*]

[a] Laboratory of Natural Products Chemistry, Department of Chemistry, University of Dschang, P.O. Box 67, Dschang, Cameroon
[b] State Key Laboratory of Phytochemistry and Plant Resources in West China, Kunming Institute of Botany, Chinese Academy of Sciences, Kunming 650204, People's Republic of China
[c] Shanghai Institute of Materia Medica, Chinese Academy of Sciences, Shanghai 201203, People's Republic of China

ARTICLE INFO

Article history:
Received 7 July 2013
Received in revised form 6 September 2013
Accepted 26 September 2013
Available online 16 October 2013

Keywords:
Caloncoba glauca
Cycloartane
Friedelane
11β-Hydroxysteroid dehydrogenase

ABSTRACT

Three new triterpenoids, caloncobic acid C (**1**), caloncobalactone C (**2**) and glaucalactone B (**3**) were isolated from the leaves of *Caloncoba glauca*. Their structures were elucidated on the basis of spectroscopic evidence. These compounds were evaluated for their inhibitory activities against human and mouse 11β-hydroxysteroid dehydrogenase type 1 and type 2.

1. Introduction

In recent papers, we described the isolation and chemical characterization of cycloartane and friedelane-type triterpenoids with moderate biological activities, from fragmentary phytochemical examinations of the fruits and the leaves of *Caloncoba glauca* (P. Beauv.) Gilg (Flacourtiaceae) (Mpetga et al., 2012a,b). In continuation of structural investigations of compounds from the leaves of this plant, we herein report on the isolation and structural assignment of three new triterpenoids. The inhibitory activities of these compounds against two isozymes of 11β-hydroxysteroid dehydrogenase (11β-HSD1 and 11β-HSD2) are also discussed.

2. Results and discussion

Fractionation over silica gel column of the methanol extract from the leaves of *C. glauca* yielded five main fractions. Repeated purifications of the smallest one led to the isolation of the new triterpenoids **1**–**3** (Fig. 1).

Compound **1** was obtained as a white powder. Its molecular formula was established as $C_{30}H_{48}O_6$ on the basis of the HR-EI-MS spectrum showing the $[M]^+$ peak at *m/z* 504.3442, and by NMR data (Table 1). Absorption bands at 3431 and 1705 cm^{-1} in the IR spectrum suggested the presence of hydroxyl and carbonyl groups, respectively. The ^1H NMR spectrum (Table 1) revealed two upfield shifted doublets at δ_H 0.90 (1H, *J* = 3.9 Hz) and 0.56 (1H, *J* = 4.0 Hz) characteristic of the cyclopropyl methylene group of cycloartane-type triterpenes (Kodai et al., 2010; Sun et al., 2011). Signals of six tertiary and a secondary methyl groups were apparent at δ_H 1.16 (6H, s), 1.14 (3H, s), 1.12 (3H, s), 1.04 (3H, s), 1.01 (3H, s) and 0.95 (3H, d, *J* = 6.3 Hz), respectively. Signals assignable to two protons attached to carbons bearing a hydroxyl group were also discerned at δ_H 4.05 (1H, t-like) and 3.26 (1H, brd, *J* = 10.1 Hz), respectively. The ^{13}C NMR spectrum (Table 1) displayed only 29 resonances of which signals at δ_C 79.7, 78.7 and 73.9 were attributed, respectively to two tertiary and a quaternary hydroxyl-bearing carbons. The carbon resonance at δ_C 219.1 was assigned to a ketone carbonyl group. The ^1H and ^{13}C NMR data of compound **1** were similar to those of caloncobic acid B (Mpetga et al., 2012b) except for the replacement of the hydroxyl group at C-3 of the latter by a keto group, and the presence of an additional carbinol in **1** (δ_H 4.05 and δ_C 78.7). Despite the absence of a signal attributable to the carbon of a carboxylic acid group in the ^{13}C NMR spectrum of **1**, the resonance of a quaternary aliphatic carbon at δ_C 62.8 was indicative of the C-14 carbon atom of a cycloartane bearing a carboxylic group at this position (Mpetga et al., 2012a,b). The presence of a carboxylic group was confirmed in the HMBC spectrum (Fig. 2) with the signals at δ_H 1.78 (H-8) and 1.90 (H-15) showing cross-peaks which projection in the carbon axis corresponded to a carbon at δ_C 181.9 (C-30). The position of the additional hydroxyl group was found at C-16 based on the ^1H–^1H COSY correlations (Fig. 2) between H-16 (δ_H 4.05) and H_2-15

* Corresponding author. Tel.: +237 77619546/94690393; fax: +237 33451735.
E-mail addresses: ptane109@gmail.com, ptane@yahoo.com (P. Tane).

1874-3900/$ – see front matter © 2013 Phytochemical Society of Europe. Published by Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.phytol.2013.09.015

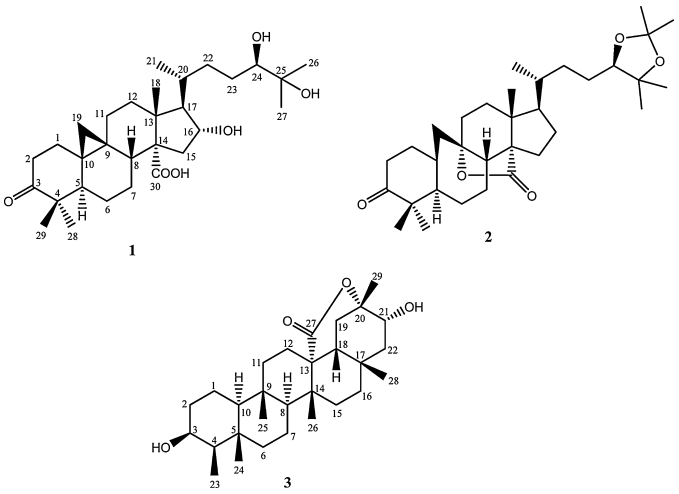

Fig. 1. Chemical structures of compounds **1**–**3**.

(δ_H 2.07 and 1.90) and H-17 (δ_H 1.54). This was further confirmed by the correlations observed in the HMBC spectrum from H-16 to C-14 (δ_C 62.8) and C-20 (δ_C 35.0). According to literature, the ^{13}C NMR chemical shift for C-24 can be regarded as a characteristic parameter in the determination of the absolute configurations of C-24 (Kim et al., 2008; Linnek et al., 2011). The configuration of the C-24 chiral center of compound **1** was determined by comparing its ^{13}C resonance (δ_C 79.7) with that of 3,16,24,25-tetrahydroxy-9,19-cycloartane-29-oic acid (δ_C 79.2) (Choi et al., 1996), secaubrytriol (δ_C 79.8) (Grougnet et al., 2006) and cyclomacroside C (δ_C 79.8) (Iskenderov et al., 2009a), having the 24*R*-configuration. A 24*S*-configuration gives a resonance at δ_C 78.6–78.8 (Horo et al., 2010; Polat et al., 2009). Similarly, the C-16 carbon atom of analogous compounds having a 16β-oriented hydroxyl group resonates at δ_C 72.9–75.2 (Choi et al., 1996; Gutierrez-Lugo et al., 2002; Horo et al., 2010). In contrast, a C-16 carbon atom having a 16α-OH resonates at upper field (δ_C 78.1) (Gutierrez-Lugo et al., 2002). Thus, the experimental results permitted the conclusion that **1** has the 16α-OH orientation, and its structure was established as 16α,24(*R*),25-trihydroxy-3-oxocycloartan-30-oic acid and was assigned the trivial name caloncobic acid C.

Compound **2** was obtained as a white powder. Its molecular formula, $C_{33}H_{52}O_5$, was derived from NMR spectral data (Table 1) and confirmed by the HR-EI-MS ion peak at *m/z* 528.3792 $[M]^+$. The

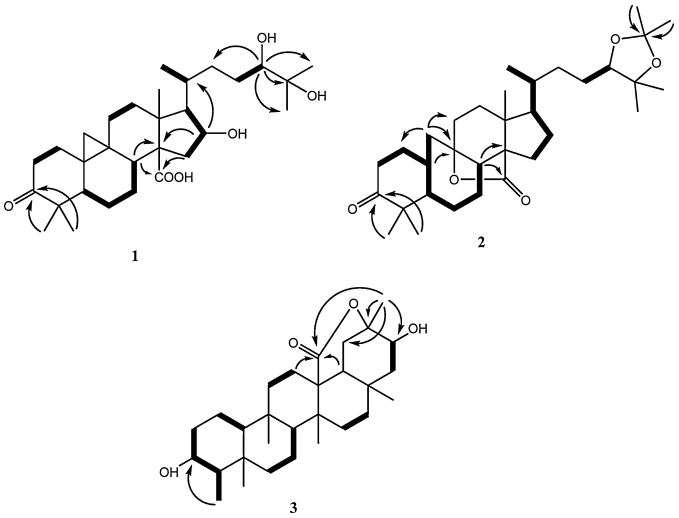

Fig. 2. Important HMBC (H ⟶ C) and ^{1}H–^{1}H COSY (▬) correlations of **1**–**3**.

IR absorption bands at 1758 and 1702 cm^{-1} suggested the presence of carbonyl functionalities. In the ^{1}H NMR spectrum (Table 1), singlets of seven tertiary methyl groups were observed at δ_H 1.40, 1.32, 1.23, 1.14, 1.08, 1.07 and 0.94, respectively, and a doublet corresponding to a secondary methyl group appeared at δ_H 0.90 (J = 6.5 Hz). Signal of an oxymethine proton was also observed at δ_H 3.62 (dd, J = 8.6, 3.6 Hz). The ^{13}C NMR spectrum (Table 1) resolved 33 carbon resonances sorted out by DEPT and HSQC experiments as eight quaternary carbons, six methine, eleven methylene and eight methyl groups. Signals due to carbonyl functions were recognized at δ_C 216.4 and 180.7, while an oxygenated methine carbon and three oxygenated quaternary aliphatic carbons arose respectively at δ_C 83.4, 106.3, 86.3 and 80.1. Detailed assignment of all NMR signals was achieved by analysis of 2D NMR spectra including HSQC, ^{1}H–^{1}H COSY and HMBC. The non equivalent methylene protons at δ_H 2.17 (dd, J = 15.2, 9.4 Hz) and 1.87 (d, J = 15.0 Hz) showed cross-peaks in the HMBC spectrum (Fig. 2) with C-1 (δ_C 29.0) and C-11 (δ_C 34.2), implying the above methylene group to be located at C-19 as for cycloartane skeletons. The absence in the ^{1}H NMR spectrum of the characteristic upfield doublets for the H_2-19 protons of cycloartanes (Horo et al., 2010; Nian et al., 2010), and the absence of correlations between H_2-11 and C-10, and between H_2-1 and C-9 in the HMBC spectrum suggested that the C-9–C-10 bond of the cyclopropane ring has been lost and therefore compound **2** is a 9,10-*seco*-cycloartane triterpenoid. Both ^{1}H and ^{13}C NMR data of **2** were very similar to those of caloncobalactone B (Mpetga et al., 2012b), with the marked differences being the replacement of an oxygenated methine carbon (δ_C 76.7) in caloncobalactone B by a ketal carbon at δ_C 106.3 in **2**, and the appearance of two additional methyl groups. The HMBC correlations between the additional methyl groups at δ_H 1.40 and 1.32 and the quaternary carbon at δ_C 106.3, together with the relatively deshielded values of C-24 (δ_C 83.4) and C-25 (δ_C 80.1) gave evidence for the presence of a 24,25-*O*,*O*-isopropylidene moiety in the molecule. The resonance of C-24 carbon atom at δ_C 83.4 suggested a 24*R*-configuration on comparison with the chemical shift at this position of 24*R* (δ_C 83.8) and 24*S* (δ_C 81.4) analogs (Iskenderov et al., 2009b). Accordingly, compound **2** was elucidated as 24(*R*),25-*O*,*O*-isopropylidene-3,30-dioxo-9,10-*seco*-cycloartane-30,9α-lactone, and trivially named caloncobalactone C.

Compound **3** was obtained as a white powder. Its molecular formula was deduced as $C_{29}H_{46}O_4$ from the HR-EI-MS ion peak at *m/z* 458.3395 $[M]^+$, in conjunction with NMR data (Table 1). The IR spectrum displayed absorption bands indicating hydroxyl (3413 cm^{-1}) and carbonyl (1709 cm^{-1}) groups, respectively. The ^{1}H NMR spectrum (Table 1) revealed five tertiary methyl singlets at δ_H 1.30, 1.19, 0.93, 0.89 and 0.87, and one secondary methyl doublet at δ_H 0.90 (partially overlapped). Signals of two methine carbinol protons were also observed at δ_H 3.67 (m) and 3.59 (brd, J = 3.6 Hz), respectively. The ^{13}C NMR spectrum (Table 1) exhibited 29 carbon signals assigned by DEPT and HSQC experiments as six methyls, six methines (two oxygenated), 10 methylenes and seven quaternary carbons (two oxygenated, including a carbonyl). The upfield methyl signal at δ_C 12.0 was typical for the Me-23 of friedelan-3-ol triterpenoids (Mahato and Kundu, 1994; Mpetga et al., 2012b). The 1D NMR data of compound **3** were closely related to those of glaucalactone (Mpetga et al., 2012b). Major differences in their ^{13}C NMR spectra were the presence of a quaternary carbon at δ_C 84.5 for compound **3** instead of a methine carbon (δ_C 87.4) as for glaucalactone, and the disappearance of signals due to an exomethylene in the latter compound, replaced by a tertiary methyl at δ_C 25.0 in **3**. The HMBC correlations (Fig. 2) of the above methyl group at δ_H 1.30 (Me-29) with C-19 (δ_C 23.7), C-20 (δ_C 84.5) and C-21 (δ_C 73.1) gave evidence for these various positions. The location of a hydroxyl group at C-3 was also confirmed by the

Table 1
^{1}H (400 MHz) and ^{13}C (100 MHz) NMR data of compounds **1**–**3**.

Position	**1**[b]		**2**[c]		**3**[d]	
	δ_H (*J* in Hz)	δ_C	δ_H (*J* in Hz)	δ_C	δ_H (*J* in Hz)	δ_C
1	1.63 m	34.7	1.67[a]	29.0	1.35 m	16.7
	1.82[a]		2.02 m		1.56[a]	
2	2.22 m	38.2	2.37 dt (14.9, 4.7)	36.8	1.51 m	35.7
	2.80 td (13.8, 6.3)		2.46 m		1.83 m	
3	–	219.1	–	216.4	3.67 m	72.8
4	–	51.1	–	48.5	1.21 m	50.2
5	1.73 dd (12.5, 3.1)	49.4	1.83 m	48.3	–	38.5
6	1.04 m	22.0	1.23[a]	25.5	1.02 m	42.4
	1.52[a]		1.96 m		1.69 m	
7	1.29 m	28.3	1.27 m	23.7	1.31[a]	18.4
	1.43[a]		1.52 m		1.45 m	
8	1.78[a]	46.8	2.07 dd (11.4, 2.4)	51.9	2.69 dd (11.0, 1.0)	49.6
9	–	21.2	–	86.4	–	37.3
10	–	28.6	2.68 m	28.8	0.98 brd (11.6)	61.7
11	1.32 m	29.7	1.61 m	34.2	1.11 m	36.4
	2.39 m		1.81[a]		1.56[a]	
12	1.66 m	35.0	1.69[a]	34.5	1.73 m	28.2
	1.82[a]		1.79[a]		1.81 m	
13	–	50.1	–	45.3	–	49.9
14	–	62.8	–	64.1	–	40.7
15	1.90 dd (13.8, 9.0)	44.0	1.45[a]	23.5	1.39 m	28.6
	2.07 brd (13.7)		1.73 m		1.63[a]	
16	4.05 m	78.7	1.36 m	28.3	1.16 m	37.1
			2.23 m		1.63[a]	
17	1.54 brd (8.0)	62.9	1.69[a]	51.9	–	32.5
18	1.16[a]	19.4	0.94 s	14.8	1.86 m	42.9
19	0.56 d (4.0)	31.1	1.87 brd (15.0)	40.0	1.91 brd (14.3)	23.7
	0.90 d (3.9)		2.17 dd (15.2, 9.4)		2.23 dd (14.5, 3.1)	
20	1.82[a]	35.0	1.42 m	35.7	–	84.5
21	0.95 d (6.3)	19.3	0.90 d (6.5)	18.0	3.59 brd (3.6)	73.1
22	1.47 m	33.4	1.25[a]	32.6	1.24 brd (9.8)	37.8
	1.78[a]		1.45[a]		1.95 dd (9.6, 4.2)	
23	1.45[a]	28.5	1.24[a]	26.2	0.90 d (5.6)	12.0
	1.51[a]		1.64 m			
24	3.26 brd (10.1)	79.7	3.62 dd (8.6, 3.6)	83.4	0.93 s	16.7
25	–	73.9	–	80.1	0.89 s	18.9
26	1.16[a]	25.8	1.08 s	22.8	0.87 s	15.6
27	1.14 s	24.9	1.23 s	26.2	–	178.8
28	1.01 s	22.7	1.14 s	25.5	1.19	31.9
29	1.12 s	21.4	1.07 s	22.2	1.30 s	25.0
30	–	ND	–	180.7		
$(\underline{CH_3})_2C$–			1.32 s	26.8	–	
$(\underline{CH_3})_2C$–			1.40 s	28.5		
$(CH_3)_2\underline{C}$–			–	106.3		

[a] Overlapped signals within a column.
[b] Recorded in CD_3OD.
[c] Recorded in $CDCl_3$.
[d] Recorded in $CDCl_3$–CD_3OD.

HMBC cross-peak observed between H_3-23 (δ_H 0.90) and C-3 (δ_C 72.8). Moreover, the four-bond long-range correlation observed in the HMBC spectrum between H_3-29 and the carbonyl at δ_C 178.8 (C-27), as well as the downfield shift of the oxygenated quaternary carbon C-20 (δ_C 84.5) supported lactonization between C-27 and C-20. The relative configuration of **3** was established on the basis of ROESY experiment. Observed ROESY correlations on one hand of H-3/H-4, H-4/H-10, and H-10/H-8 indicated the α-orientation of these protons. On the other hand, correlations of H-18 with Me-26, Me-28 and Me-29, and correlations of Me-29 with H-21 implied their β–orientation. Thus **3** was elucidated as 3β,21α-dihydroxy-27-oxo-30-nor-(D:A)-friedo-oleane-27,20α-lactone, and given the name as glaucalactone B.

The inhibition of 11β-hydroxysteroid dehydrogenase type 1 (11β-HSD1) can improve components of metabolic syndrome such as insulin resistance and dyslipidaemia (Boyle, 2008). The inhibitory effects of compounds **1**–**3** on mouse and human 11β-HSD1 and 11β-HSD2 were evaluated. All assays were carried out in duplicate with glycyrrhizinic acid as positive control. Only compound **1** showed important inhibitory activities against mouse

Table 2
Inhibitory activities of **1** against isozymes of 11β-hydroxysteroid dehydrogenases.

Compounds	Mouse 11β-HSD1 (IC_{50})	Mouse 11β-HSD2 (IC_{50})	Mouse HSD2/HSD1	Human 11β-HSD1 (IC_{50})	Human 11β-HSD2 (IC_{50})	Human HSD2/HSD1
1	102.90 nM	>100 μM	>971.82	519.85 nM	3.12 μM	6.01
Glycyrrhizinic acid[a]	3.04 nM	–	–	5.95 nM	0.41 nM	0.07

[a] Positive control.

and human 11β-HSD1 (EC_{50} = 102.9 and 519.8 nM, respectively). It is noteworthy that compound **1** exhibited a better selectivity on mouse enzymes (HSD2/HSD1 > 971.8) (Table 2).

3. Experimental

3.1. General experimental procedures

Melting points were measured on a X-4 micro melting point apparatus and are uncorrected. A Bruker Tensor 27 spectrophotometer was used for scanning IR spectra with KBr pellets. MS and HRMS were carried out on an API Qstar time-of-flight spectrometer in positive ionization mode. Optical rotations were obtained with a JASCO P-1020 digital polarimeter. 1D NMR spectra (^1H, ^{13}C NMR and DEPT) were recorded on a Bruker AV-400 spectrometer, while 2D NMR spectra (HSQC, HMBC, ^1H–^1H COSY and ROESY) were recorded on a Bruker DRX-500 instrument. All chemical shifts (δ) were given in ppm units with reference to the residual solvent signal (TMS) and coupling constants (J) were calculated in Hz. Column chromatography was performed using Merck silica gel 60 (100–200 and 300–400 mesh) and Sephadex LH-20 (40–70 μm). MPLC was performed on Büchi Sepacore System, and columns packed with Chromatorex C-18 (40–75 μm) and MCI gel CHP-20P (75–150 μm). TLC was carried out on precoated silica gel 60 F_{254} aluminum plates and detection accomplished by heating after dipping into a 10% ethanolic H_2SO_4 solution. Solvents were distilled prior to use.

3.2. Plant material

The leaves of *C. glauca* were collected in Bangang-Wabane village, South-west Region of Cameroon, in May 2009. The plant material was authenticated at the National Herbarium of Cameroon (Yaoundé, Cameroon), where a voucher specimen was deposited under the reference number 55064/HNC.

3.3. Extraction and isolation

Air-dried and powdered leaves of *C. glauca* (2 kg) were extracted three times, each for 72 h, with MeOH (3 L) at room temperature. After filtration and removal of the solvent under vacuum, 200 g of a crude extract was obtained. This extract was defatted using *n*-hexane and the insoluble portion (150 g) was fractionated over a silica gel column. Elution with gradients of petroleum ether–EtOAc (from 90:10 to 20:80) and EtOAc–MeOH (from 100:0 to 0:100) gave five main fractions, A–E (Mpetga et al., 2012b). Fraction D (6 g) was successively subjected to MPLC on MCI and over RP-18 eluted with MeOH–H_2O (from 50:50 to 100:0). Then, repeated separation on silica gel columns followed by purification over Sephadex LH-20 ($CHCl_3$–MeOH, 1:1) afforded compounds **1** (8 mg), **2** (10 mg) and **3** (8 mg).

3.4. Caloncobic acid C (*1*)

White powder; mp 123–125 °C; $[\alpha]_D^{23}$ −30.0 (*c* 0.1, MeOH); IR (KBr) ν_{max} 3431, 3038, 2969, 1705, 1560, 1383, 1078 cm^{-1}; ^1H (400 MHz, CD_3OD) and ^{13}C (100 MHz, CD_3OD) NMR data, see Table 1; positive ESIMS: *m/z* 469 $[M-2H_2O+H]^+$, 505 $[M+H]^+$, 527 $[M+Na]^+$; HRESIMS *m/z* 504.3442 $[M]^+$ (calcd for $C_{30}H_{48}O_6$, 504.3451).

3.5. Caloncobalactone C (*2*)

White powder; mp 171–173 °C; $[\alpha]_D^{23}$ +17.3 (*c* 0.1, $CHCl_3$); IR (KBr) ν_{max} 3431, 2970, 2958, 1758, 1702, 1377, 1204, 1014 cm^{-1}; ^1H (400 MHz, $CDCl_3$) and ^{13}C (100 MHz, $CDCl_3$) NMR data, see Table 1; positive ESIMS: *m/z* 455 $[M-(CH_3)_2CO_2+H]^+$, 528 $[M]^+$, 551 $[M+Na]^+$; HRESIMS *m/z* 528.3792 $[M]^+$ (calcd for $C_{33}H_{52}O_5$, 528.3815).

3.6. Glaucalactone B (*3*)

White powder; mp 227–229 °C; $[\alpha]_D^{23}$ +42.9 (*c* 0.067, $CHCl_3$–MeOH, 2:1); IR (KBr) ν_{max} 3413, 2946, 2925, 1709, 1633, 1451, 1094 cm^{-1}; ^1H (400 MHz, $CDCl_3$–CD_3OD) and ^{13}C (100 MHz, $CDCl_3$–CD_3OD) NMR data, see Table 1; EIMS: *m/z* 443 $[M-CH_3]^+$, 458 $[M]^+$, 459 $[M+H]^+$; HREIMS *m/z* 458.3395 $[M]^+$ (calcd for $C_{29}H_{46}O_4$, 458.3396).

3.7. Bioassay

The inhibitory activities of the compounds on human and mouse 11β-HSD1 and 11β-HSD2 were determined using a scintillation proximity assay (SPA) with microsomes containing 11β-HSD1 or 11β-HSD2 as described in previous studies (Yang et al., 2008). Briefly, the full-length cDNAs of human or murine 11β-HSD1 and 11β-HSD2 were isolated from the cDNA libraries provided by the NIH Mammalian Gene Collection and cloned into a pcDNA3 expression vector. HEK-293 cells were transfected with the pcDNA3-derived expression plasmid and selected after cultivation in the presence of 700 μg/mL of G418. The microsomal fraction overexpressing 11β-HSD1 or 11β-HSD2 was prepared from the HEK-293 cells stably transfected with either 11β-HSD1 or 11β-HSD2 and used as the enzyme source for Scintillation Proximity Assay (SPA). Microsomes containing human or mouse 11β-HSD1 were incubated with NADPH and [^{3}H]cortisone, and then the product [3H]cortisol was specifically captured by a monoclonal antibody coupled to protein A-coated SPA beads. 11β-HSD2 screening was performed by incubating 11β-HSD2 microsomes with [^{3}H]cortisol and NAD^+ and monitoring substrate disappearance. IC_{50} ($X \pm$ S.D., $n = 2$) values were calculated using Prism Version 4 (GraphPad Software) with glycyrrhizinic acid as a positive control.

Acknowledgements

We are grateful to the Chinese Academy of Sciences (CAS) and the Academy of Sciences for the Developing World (TWAS) for their financial support through the CAS-TWAS Postgraduate Fellowship (FR number: 3240223251). The authors are also grateful to the analytical group of the State Key Laboratory of Phytochemistry and Plant Resources in West China, Kunming Institute of Botany, Chinese Academy of Sciences for recording the spectra.

References

Boyle, C.D., 2008. Recent advances in the discovery of 11 beta-HSD1 inhibitors. Curr. Opin. Drug Discov. Dev. 11, 495–511.

Choi, Y.-H., Kim, N.G., Lee, I.R., 1996. A novel cycloartane glycoside from *Thalictrum uchiyamai*. Arch. Pharm. Res. 19, 429–431.

Grougnet, R., Magiatis, P., Mitaku, S., Loizou, S., Moutsatsou, P., Terzis, A., Cabalion, P., Tillequin, F., Michel, S., 2006. *Seco*-cycloartane triterpenes from *Gardenia aubryi*. J. Nat. Prod. 69, 1711–1714.

Gutierrez-Lugo, M.-T., Singh, M.P., Maiese, W.M., Timmermann, B.N., 2002. New antimicrobial cycloartane triterpenes from *Acalypha communis*. J. Nat. Prod. 65, 872–875.

Horo, I., Bedir, E., Perrone, A., Özgökçe, F., Piacente, S., Alankuş-Çalişkan, Ö., 2010. Triterpene glycosides from *Astragalus icmadophilus*. Phytochemistry 71, 956–963.

Iskenderov, D.A., Isaev, I.M., Isaev, M.I., 2009a. Triterpene glycosides from *Astragalus* and their genins, LXXX. Cyclomacroside D, a new bisdesmoside. Chem. Nat. Compd. 45, 55–58.

Iskenderov, D.A., Isaev, I.M., Isaev, M.I., 2009b. Triterpene glycosides from *Astragalus* and their genins, LXXXIII. Structure of cyclomacroside A. Chem. Nat. Compd. 45, 656–659.

Kim, J.S., Yean, M.-H., Lee, E.-J., Jung, H.S., Lee, J.Y., Kim, Y.J., Kang, S.S., 2008. Two new cycloartane saponins from the roots of *Astragalus membranaceus*. Chem. Pharm. Bull. 56, 105–108.

Kodai, T., Horiuchi, Y., Nishioka, Y., Noda, N., 2010. Novel cycloartane-type triterpenoid from the fruits of *Nandina domestica*. J. Nat. Med. 64, 216–218.

Linnek, J., Mitaine-Offer, A.-C., Miyamoto, T., Tanaka, C., Paululat, T., Avunduk, S., Alankuş-Çalişkan, Ö., Lacaille-Dubois, M.-A., 2011. Cycloartane glycosides from three species of *Astragalus* (Fabaceae). Helv. Chim. Acta 94, 230–237.

Mahato, S.B., Kundu, A.P., 1994. ^{13}C NMR spectra of pentacyclic triterpenoids – a compilation and some salient features. Phytochemistry 37, 1517–1575.

Mpetga, S.D.J., Tene, M., Wabo, H.K., Li, S.-F., Kong, L.-M., He, H.-P., Hao, X.-J., Tane, P., 2012a. Cytotoxic cycloartanes from the fruits of *Caloncoba glauca*. Phytochem. Lett. 5, 183–187.

Mpetga, S.D.J., Shen, Y., Tane, P., Li, S.-F., He, H.-P., Wabo, H.K., Tene, M., Leng, Y., Hao, X.-J., 2012b. Cycloartane and friedelane triterpenoids from the leaves of *Caloncoba glauca* and their evaluation for inhibition of 11β-hydroxysteroid dehydrogenases. J. Nat. Prod. 75, 599–604.

Nian, Y., Zhang, Y.-L., Chen, J.-C., Lu, L., Qiu, M.-H., Qing, C., 2010. Cytotoxic chemical constituents from the roots of *Cimicifuga fetida*. J. Nat. Prod. 73, 93–98.

Polat, E., Caliskan-Alankus, O., Perrone, A., Piacente, S., Bedir, E., 2009. Cycloartane-type glycosides from *Astragalus amblolepis*. Phytochemistry 70, 628–634.

Sun, R., Song, H.-C., Wang, C.-R., Shen, K.-Z., Xu, Y.-B., Gao, Y.-X., Chen, Y.-G., Dong, J.-Y., 2011. Compounds from *Kadsura angustifolia* with anti-HIV activity. Bioorg. Med. Chem. Lett. 21, 961–965.

Yang, H., Dou, W., Lou, J., Leng, Y., Shen, J., 2008. Discovery of novel inhibitors of 11β-hydroxysteroid dehydrogenase type 1 by docking and pharmacophore modeling. Bioorg. Med. Chem. Lett. 18, 1340–1345.