Preprint Title	Undescribed triterpenoids obtained from *Dictamnus dasycarpus* Turcz and their anti-proliferation activities
Authors	ye sun, yan liu, siyi wang, xu yang, jiatong wu, juan pan, zhichao hao, wei guan, zhenpeng xu, yuanyuan zhou, shaowa lv, haixue kuang and Bingyou yang
Publication Date	01 Nov 2023
Article Type	Full Research Paper
Supporting Information File 1	Supporting information.docx; 1.3 MB
ORCID® iDs	Bingyou yang - https://orcid.org/0000-0002-2310-2750

Undescribed triterpenoids obtained from *Dictamnus dasycarpus* Turcz and their anti-proliferation activities

Ye Sun[1], Yan Liu[1], Si-Yi Wang, Xu Yang, Jia-Tong Wu, Juan Pan, Zhi-Chao Hao, Wei Guan, Zhen-Peng Xu, Yuan-Yuan Zhou, Shao-Wa Lv, Hai-Xue Kuang* and Bing-You Yang*

Key Laboratory of Basic and Application Research of Beiyao (Heilongjiang University of Chinese Medicine), Ministry of Education, Harbin 150040, People's Republic of China

Corresponding Author:

*Haixue Kuang, Email: hxkuang@yahoo.com, Tel.: +86-0451-87267188;

*Bingyou Yang, Email: ybywater@163.com, Tel.: +86-0451-87267038

ABSTRACT

Three new triterpenoids, named dictamtriterpenol B-D (**1-3**), along with ten known compounds (**4-13**), were isolated from *Dictamnus dasycarpus* Turcz. The structures of all compounds were characterized by spectroscopic methods, including IR, HR-ESI-MS, 1D and 2D NMR. Furthermore, HepG2 and A549 cell lines were used to evaluate their anti-proliferation activities. And compounds **1**, **5**, and **8** (IC_{50} values in the range of 1.84±0.03 to 14.98±0.39 μM) displayed significant anti-proliferation activity against HepG2 cells. As well as compounds **1**, **4**, **9**, **10**, and **13** (IC_{50} values in the range of 1.63±0.04 to 8.56±1.46 μM) displayed significant anti-proliferation activity against A549 cells.

Keywords

Dictamnus dasycarpus Turcz; Triterpenoids; Anti-proliferation

Introduction

Dictamnus dasycarpus Turcz was widely distributed in the Heilongjiang Province of China. As a traditional Chinese medicine “Baixianpi”, the root bark of *D. dasycarpus* was used for the treatment of cancer, infection, eczema, and so on [1]. As well as *D. dasycarpus* showed a variety of significant anti-inflammatory, anti-cancer, and antioxidant activities [2-4]. Meanwhile, the phytochemical studies of *D. dasycarpus* have revealed the presence of limonoids, alkaloids, sesquiterpenes, flavonoids, and triterpenoids [5-7]. Thus, to discover the bioactive constituents of *D. dasycarpus*, a systematic and in-depth phytochemical study was carried out.

Three new triterpenoids (**1**-**3**) and ten (**4**-**13**) known compounds were obtained and identified in this study. The structures of the above compounds were determined by the results of many spectroscopic techniques. Meanwhile, all compounds were tested the anti-proliferation activities against HepG2 and A549 cancer cell lines by CCK-8 assay.

Results and Discussion

The root bark of *D. dasycarpus* was extracted with 70% EtOH. The extract was partitioned with EtOAc. And the EtOAc layer was separated by several methods, such as silicagel column, ODS, and preparative HPLC purification, to obtain pure compounds. Including three new triterpenoids (**1**-**3**) and ten known compounds were obtained. The known compounds were identified as 3-O-*α*-L-arabinopyranosyl pomolic acid (**4**) [8], 24-epi-24-O-acetyl-7,8-didehydrohydroshengmanol3-O-*β*-D-xylopyranoside (**5**) [9], 24(*S*),7,8-didehydrocimigenol-3-O-*β*-D-xylopyranoside (**6**) [9], 24-epi-7,8-didehydrocimigenol-3-xyloside (**7**) [10], chisopanin G (**8**) [11], 21-O-methyltoosendanpentol (**9**) [12], agladupol A-c (**10**) [12], agladupol A-b (**11**) [12], dictamtriterpenol A (**12**) [13], and polystanin E (**13**) [14] (Fig. 1). Their ^{13}C NMR data were summarised in Tab. S1.

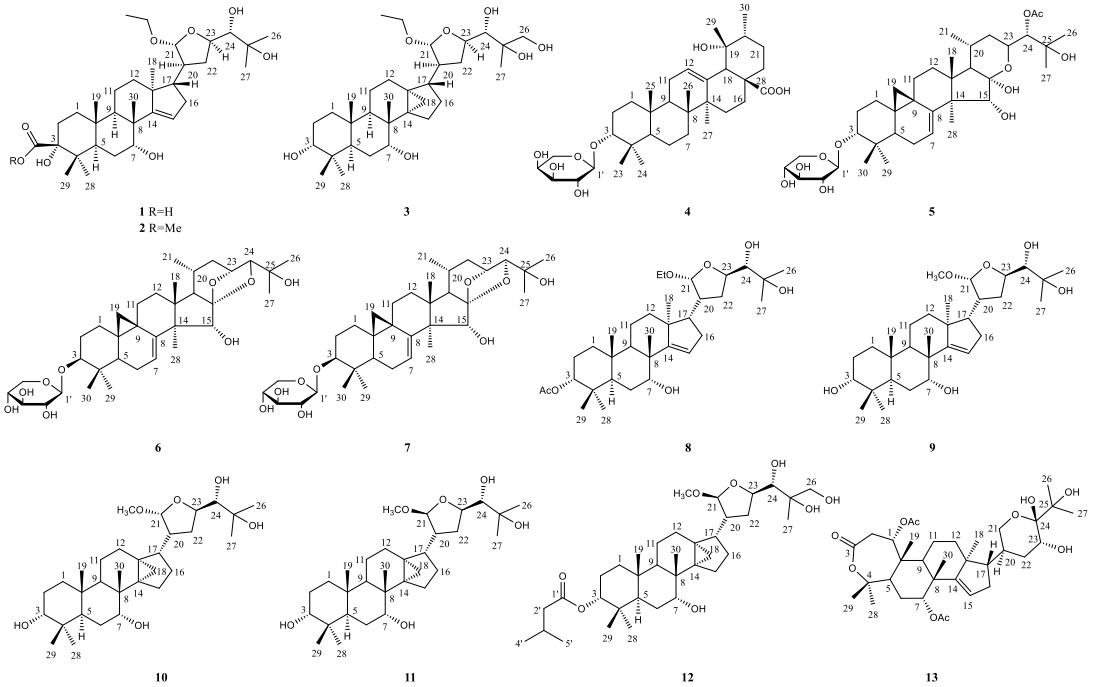

Fig. 1. The structures of compounds **1-13**

Compound **1** was extracted as a white amorphous powder. The HR-ESI-MS (Fig. S1-8) gave an obvious $[M+Na]^+$ ion peak at *m/z* 601.3705 (calcd for 601.3711). Its molecular formula was predicted to be $C_{33}H_{54}O_8$. The ^1H NMR data (Tab.1) of compound **1** exhibited signals for seven methyl singlets at δ_H 1.27/1.25/1.25/1.20/1.09/1.08/1.07, one ethoxyl at δ_H 3.74/3.46 (each 1H, m),

and 1.20 (3H, s), four oxymethines at δ_H 4.92 (1H, d, *J* = 3.8 Hz, H-21), 4.26 (1H, m, H-23), 3.87 (1H, br.s, H-7), 3.22 (1H, br.s, H-24), as well as an olefinic proton at δ_H 5.40 (1H, br.s, H-15). In the ^{13}C NMR data (Tab. 1) and DEPT-135 (Fig. S1-3), compound **1** displayed 33 carbons, including eight methyls, eight methylenes, ten methines, and seven quaternary carbons. All the data above indicated that compound **1** was a triterpenoid. And the structure was similar to toonasinensin A [15]. The difference was the C-3 of compound **1** was replaced by a carboxyl group. The long-range correlations from H-2 to the -COOH in the HMBC spectrum (Fig. S1-6) further confirmed the above structure of compound **1** (Fig. 2).

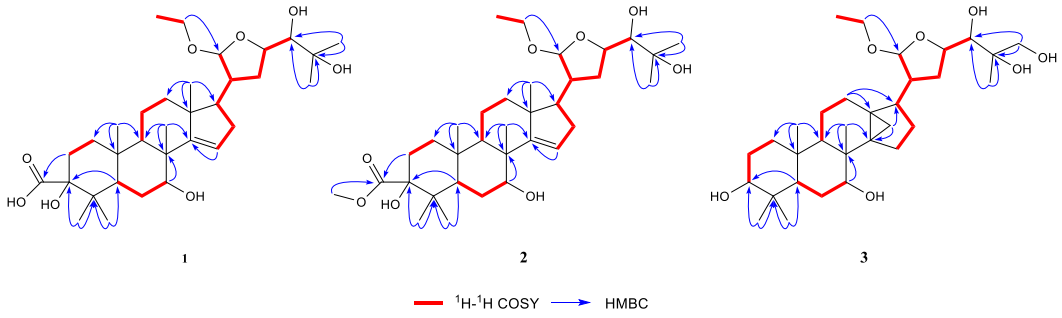

Fig. 2. Key HMBC and ^{1}H-^{1}H COSY correlations of compounds **1**-**3**.

The relative configurations of compound **1** were established by the analysis of NOESY spectrum (Fig. S1-7). The correlations (Fig. 3) of H-6*β*/H_3-29, H-6*β*/H_3-19, H-6*β*/H_3-30, H_3-30/H-7, H_3-30/H-12*β*, and H-12*β*/H-17, assigned the *β*-oriented H-7, H-17, H_3-19, H_3-29, and H_3-30. The correlations between H-5/H_3-28, H-5/H-9, and H-9/H_3-18 concluded the *α*-oriented H-5, H-9, and H_3-18. Its negative specific rotation [$[\alpha]_D^{20}$= -79.1, (c = 0.1, MeOH)] and NMR data were similar to those of (3*α*,7*α*,13*α*,17*α*,20*S*,21*R*,23*R*,24*S*)-3-(3-methylbutanoate)-21,23-epoxy-21-methoxy-13,30-cyclodammarane-3,7,24,25-tetrol [16]. Then, the structure of dictamtriterpenol B (**1**) was elucidated.

Table 1 ^{1}H and ^{13}C-NMR Data of **1-3** (600 MHz in ^{1}H NMR and 150MHz in ^{13}C NMR, in CD_3OD)

No	1		2		3	
	δ_C	δ_H (*J* in Hz)	δ_C	δ_H (*J* in Hz)	δ_C	δ_H (*J* in Hz)
1	35.7	2.35 (1H, *m*)	35.6	2.36 (1H, *m*)	34.4	1.31 (2H, *m*)
		1.62 (1H, *m*)		1.61 (1H, *m*)		
2	30.1	2.57 (1H, *m*)	29.8	2.61 (1H, *m*)	27.5	1.63 (1H, *m*)
		2.12 (1H, *m*)		2.14 (1H, *m*)		0.96 (1H, *m*)
3	76.1		76.0		77.0	3.32 (1H, *br.s*)
4	44.7		44.7		37.8	
5	44.6	2.00 (1H, *m*)	44.7	1.98 (1H, *m*)	41.1	1.96 (1H, *m*)
6	29.0	1.90 (1H, *m*)	29.0	1.89 (1H, *m*)	26.0	1.64 (1H, *m*)
		1.76 (1H, *m*)		1.75 (1H, *m*)		1.56 (1H, *m*)
7	73.5	3.87 (1H, *br.s*)	73.5	3.87 (1H, *br.s*)	75.8	3.70 (1H, *br.s*)
8	44.7		44.7		40.4	
9	34.8	2.16 (1H, *m*)	34.9	2.14 (1H, *m*)	45.4	1.39 (1H, *m*)
10	42.6		42.6		38.1	
11	17.3	1.65 (1H, *m*)	17.3	1.62 (1H, *m*)	17.5	1.33 (2H, *m*)
		1.58 (1H, *m*)		1.58 (1H, *m*)		
12	34.7	1.87 (1H, *m*)	34.7	1.86 (1H, *m*)	26.8	1.88 (1H, *m*)
		1.49 (1H, *m*)		1.49 (1H, *m*)		1.57 (1H, *m*)
13	48.0		48.0		29.6	
14	162.6		162.5		38.5	
15	120.0	5.40 (1H, *br.s*)	120.0	5.40 (1H, *br.s*)	27.2	1.85 (2H, *m*)
16	36.0	2.16 (1H, *m*)	36.0	2.16 (1H, *m*)	26.2	1.96 (1H, *m*)
		1.64 (1H, *m*)		1.64 (1H, *m*)		1.51 (1H, *m*)
17	59.3	1.71 (1H, *m*)	59.3	1.71 (1H, *m*)	49.9	1.97 (1H, *m*)
18	19.5	1.08 (3H, *s*)	19.5	1.06 (3H, *s*)	15.0	0.72 (1H, *d*, *J*=5.5)
						0.50 (1H, *d*, *J*=5.5)
19	20.5	1.07 (3H, *s*)	20.5	1.06 (3H, *s*)	16.3	0.91 (3H, *s*)
20	47.5	2.33 (1H, *m*)	47.5	2.32 (1H, *m*)	50.5	2.05 (1H, *m*)
21	109.7	4.92 (1H, *d*, *J*=3.8)	109.7	4.92 (1H, *d*, *J*=3.8)	109.5	4.98 (1H, *d*, *J*=4.1)
22	36.1	1.94 (1H, *m*)	36.1	1.93 (1H, *m*)	34.3	1.89 (1H, *m*)
		1.66 (1H, *m*)		1.65 (1H, *m*)		1.68 (1H, *m*)
23	77.2	4.26 (1H, *m*)	77.2	4.26 (1H, *m*)	77.2	4.28 (1H, *m*)
24	78.5	3.22 (1H, *br.s*)	78.5	3.22 (1H, *br.s*)	75.2	3.44 (1H, *br.s*)
25	73.9		73.9		75.6	
26	27.5	1.25 (3H, *s*)	27.5	1.25 (3H, *s*)	68.9	3.56 (1H, *d*, *J*=11.1)
						3.47 (1H, *d*, *J*=11.1)
27	25.3	1.20 (3H, *s*)	25.3	1.20 (3H, *s*)	20.0	1.16 (3H, *s*)
28	28.3	1.25 (3H, *s*)	28.3	1.24 (3H, *s*)	28.8	0.90 (3H, *s*)
29	32.9	1.27 (3H, *s*)	33.0	1.26 (3H, *s*)	22.8	0.83 (3H, *s*)
30	28.0	1.09 (3H, *s*)	28.0	1.08 (3H, *s*)	20.3	1.04 (3H, *s*)
3-COOH	179.2		177.2			
$COOCH_3$			52.1	3.64 (3H, *s*)		
OEt	64.8	3.74 (1H, *m*)	64.8	3.75 (1H, *m*)	64.9	3.74 (1H, *m*)
		3.46 (1H, *m*)		3.46 (1H, *m*)		3.45 (1H, *m*)
OEt	15.8	1.20 (3H, *s*)	15.8	1.20 (3H, *s*)	15.7	1.19 (3H, *t*, *J*=7.1)

Compound **2** was extracted as a white amorphous powder. The HR-ESI-MS (Fig. S2-8) gave an obvious $[M+NH_4]^+$ ion peak at *m/z* 610.4318 (calcd for 610.4313), and its molecular formula was predicted to be $C_{34}H_{56}O_8$. The ^1H NMR and ^{13}C NMR data were similar to compound **1**. The only difference was the -$COOCH_3$ group on C-2. The long-range correlations from δ_H 3.64 (3H, s) to the δ_C 177.2 in the HMBC spectrum (Fig. S2-6) further confirmed the above structure of compound **2** (Fig. 2). As well as the configurations of compound **2** were similar to compound **1**. Then, the structure of dictamtriterpenol C (**2**) was elucidated.

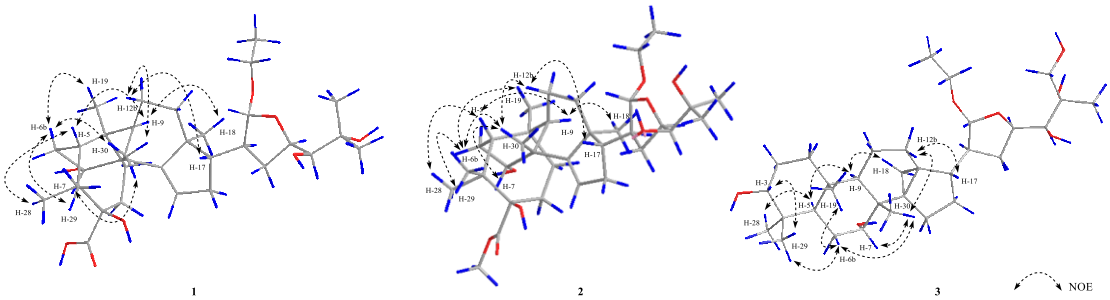

Fig. 3. Key NOESY correlations of compounds **1**-**3**.

Compound **3** was extracted as a white amorphous powder. The HR-ESI-MS (Fig. S3-8) gave an obvious $[M+K]^+$ ion peak at *m/z* 589.3522 (calcd for 589.3507), and its molecular formula was predicted to be $C_{32}H_{54}O_7$. The ^1H NMR data (Tab.1) of compound **3** exhibited signals for five methyl singlets at δ_H 1.16/1.04/0.91/0.90/0.83, one ethoxyl at δ_H 3.74/3.45 (each 1H, m), and 1.19 (3H, t, *J* =7.1), five oxymethines at δ_H 4.98 (1H, d, *J* = 4.1 Hz, H-21), 4.28 (1H, m, H-23), 3.70 (1H, br.s, H-7), 3.44 (1H, br.s, H-24), 3.32 (1H, br.s, H-3). In the ^{13}C NMR data (Tab. 1) and DEPT-135 (Fig. S3-3), compound **3** displayed 32 carbons, including six methyls, eleven methylenes, nine methines, and six quaternary carbons. The structure of compound **3** was similar to dictamtriterpenol A [4]. The difference was the substituent of C-2 of compound **3** was a hydroxyl group, and there was an ethoxyl group on C-25. The long-range correlations from H-26

to C-25 in the HMBC spectrum (Fig. S3-6), and correlations of H-2/H-3 in the ^{1}H-^{1}H COSY (Fig. S3-5) further confirmed the above structure of compound **3** (Fig. 2).

The relative configurations of compound **3** were established by the analysis of NOESY spectrum (Fig. S3-7). The correlations (Fig. 3) of H-3/H_3-29, H-6β/H_3-29, H-6β/H_3-19, H-6β/H_3-30, H_3-30/H-7, H_3-30/H-12β, and H-12β/H-17, assigned the β-oriented H-3, H-7, H-17, H_3-19, H_3-29, and H_3-30. The correlations between H-5/H_3-28, H-5/H-9, and H-9/H_2-18 concluded the α-oriented H-5, H-9, and H_3-18. Its negative specific rotation [$[\alpha]_D^{20}$= -121.6, (c = 0.1, MeOH)] and NMR data were similar to those of (3α,7α,13α,17α,20*S*,21*R*,23*R*,24*S*)-3-(3-methylbutanoate)-21,23-epoxy-21-methoxy-13,30-cyclodammarane-3,7,24,25-tetrol [16]. Then, the structure of dictamtriterpenol D (**3**) was elucidated.

Furthermore, the anti-proliferation activities of the isolated compounds on HepG2 and A549 cell lines were used to evaluate the anti-proliferation activities. And compounds **1**, **5**, and **8** (IC_{50} values in the range of 1.84±0.03 to 14.98±0.39 μM) displayed significant anti-proliferation activity against HepG2 cells. Meanwhile, compounds **1**, **4**, **9**, **10**, and **13** (IC_{50} values in the range of 1.63±0.04 to 8.56±1.46 μM) displayed significant anti-proliferation activity against A549 cells. The data were summarised in Tab. S2.

Conclusion

In conclusion, three new triterpenoids (**1-3**) and ten known ones (**4-13**) were isolated from the root bark of *D. dasycarpus*, and evaluated for anti-proliferation activities against HepG2 and A549 cell lines. Interestingly, compounds **1**, **5**, and **8** displayed significant anti-proliferation activity against HepG2 cells. And compounds **1**, **4**, **9**, **10**, and **13** displayed significant anti-proliferation activity against A549 cells. Above all can be concluded that the carbonyl, carboxyl, and glycosyl groups may be the anti-proliferation activity group against the above two human cancer cell lines. Therefore, this study can enrich the variety of sesquiterpenoids and

provide the scientific basis for future research on *D. dasycarpus*.

Experimental

General experimental procedures

1D and 2D NMR spectra were acquired on a Bruker DPX-600 spectrometer. HRESIMS data of the new compounds were obtained using an AB SCIEX Triple TOF 5600 mass spectrometer. Preparative HPLC (LC-20AR, Shimadzu) was performed on Shim-pack (5 μm, 20×250 mm, Shimadzu) with a RID-20 A detector with flow rate 5 mL/min. Optical rotation measurements were conducted on a JASCO P-2000 instrument.

Plant material

The root bark of *D. dasycarpus* was collected from Heilongjiang Province in August 2021, and identified by Professor Rui-Feng Fan of Heilongjiang University of Chinese Medicine, and its voucher specimen (NO. 20210826) has been deposited at Heilongjiang University of Chinese Medicine.

Extraction and Isolation

The root bark of *D. dasycarpus* (75 kg) was extracted with 70% EtOH. The extract was partitioned with EtOAc, and the EtOAc layer (402.3 g) was separated by silica gel CC (CH_2Cl_2-CH_3OH gradient, from 100:1 to 0:1) to yield seven fractions (Fr. A-G). Fr. B (18.7 g) was purified by ODS chromatography and afforded nine fractions Fr. B 1-9. Fr. B 5 (325.1 mg) was purified by preparative HPLC (MeOH/H_2O 80%) to afford compounds **1** (6.3 mg), **8** (12.2 mg), and **11** (7.6 mg). Fr. B 9 (117.3 mg) was purified by preparative HPLC (MeOH/H_2O 83%) to afford compounds **2** (11.7 mg), **9** (32.6 mg), and **10** (7.5 mg). Fr. F (42.2 g) was purified by ODS chromatography and afforded fifteen fractions Fr. F 1-15. Fr. F 2 (423.8 mg) was purified by

preparative HPLC (MeOH/H_2O 70%) to afford compounds **4** (11.9 mg) and **7** (9.1 mg). F 12 (236.8 mg) was purified by preparative HPLC (MeOH/H_2O 85%) to afford compounds **3** (6.3 mg), **12** (12.2 mg), and **13** (7.6 mg). Fr. G (13.5 g) was purified by ODS chromatography and afforded fifteen eight Fr. G 1-8. Fr. G 4 (273.9 mg) was purified by preparative HPLC (MeOH/H_2O 75%) to afford compounds **5** (23.7 mg) and **6** (3.8 mg).

Compound characterization data

Dictamtriterpenol B (**1**): white amorphous powder; $[\alpha]_D^{20}$ = -79.1, (c = 0.1, MeOH); HR-ESI-MS: *m/z* 601.3705 $[M+Na]^+$ (calcd for 601.3711); IR (KBr): ν_{max} 3405, 2928, 1716, 1604, 1389, 1033 cm^{-1}; ^1H and ^{13}C NMR (CD_3OD, 600, 150 MHz) data, see Tab. 1.

Dictamtriterpenol C (**2**): white amorphous powder; $[\alpha]_D^{20}$ = -63.7, (c = 0.1, MeOH); HR-ESI-MS: *m/z* 610.4318 $[M+NH_4]^+$ (calcd for 610.4313); IR (KBr): ν_{max} 3422, 2971, 1603, 1386, 1034 cm^{-1}; ^1H and ^{13}C NMR (CD_3OD, 600, 150 MHz) data, see Tab. 1.

Dictamtriterpenol D (**3**): white amorphous powder; $[\alpha]_D^{20}$ = -121.6, (c = 0.1, MeOH); HR-ESI-MS: *m/z* 589.3522 $[M+K]^+$ (calcd for 589.3507); IR (KBr): ν_{max} 3406, 2937, 1603, 1386, 1032 cm^{-1}; ^1H and ^{13}C NMR (CD_3OD, 600, 150 MHz) data, see Tab. 1.

Cell culture

HepG2 and A549 cells (Stem Cell Bank, Chinese Academy of Sciences) were maintained in DMEM (Gibco), supplemented with 10% fetal bovine serum (FBS, Sigma), 1% penicillin-streptomycin (Thermo) at 37 °C in the presence of 5% CO_2.

CCK-8 assay

Cell viability was measured with the CCK-8 (APExBIO) assay. The HepG2 cells were seeded at a density of 5×10^3 cells/well into 96-well plates overnight, the A549 cells were seeded

at a density of 1×10^4 cells/well into 96-well plates overnight, then compounds **1**-**13** were added at various concentrations (0.15625, 0.3125, 0.625, 1.25, 2.5, 5, 10 and 20 μM). After 24 h incubation, 10 μL CCK-8 solution was appended to each well, and the optical density (OD) value in each well was measured at 450 nm using a microplate reader (BioTeK, USA).

Conflict of interest

Ye Sun and Yan Liu contributed equally to this study.

No potential conflict of interest was reported by the authors.

Funding

This work was financially supported by the National Natural Science Foundation of China (U22A20370), Key Research and Development Projects of Heilongjiang Province (GA21D008), Heilongjiang Touyan Innovation Team Program ([2019]5), and Heilongjiang Province "Double First Class" Discipline Collaborative Innovation Achievement Construction Project (LJGXCG2022-096).

Supporting Information

MS, IR, and NMR spectra of compounds **1-3**; half inhibitory concentrations (IC_{50}) for two cancer cell linesl of compounds **1-13**; ^{13}C NMR data of compounds **4-13**.

References

1. Lv, M.-Y.; Xu, P.; Tian, Y.; Liang, J.-Y.; Gao, Y.-Q.; Xu, F.-G.; Zhang, Z.-J.; Sun, J.-B. Medicinal uses, phytochemistry and pharmacology of the genus *Dictamnus*(Rutaceae). J. Ethnopharmacol. **2015,** 171, 247-263.

doi:10.1016/j.jep.2015.06.011

2. Kotamballi, N.; Chidambara, M.; Guddadarangavvanahally, K. Apoptosis mediated cytotoxicity of citrus obacunone in human pancreatic cancer cells. Toxicology. In. Vitro. **2011,** 25, 859-867.

doi: 10.1016/j.tiv.2011.02.006

3. Jung, H.-J.; Sok, D.-E.; Kim, Y.-H. Potentiating effect of obacunone from *Dictamnus dasycarpus* on cytotoxicity of microtubule inhibitors, vincristine, vinblastine and taxol. Planta. Medica. **2000,** 66, 74-76.

doi:10.1055/s-0029-1243113

4. Zheng, D.-D.; Sun, F.; Wang, H.-M. Isoprenoids obtained from *Cortex Dictamni* and their nitric oxide inhibitory activities. Fitoterapia. **2019,** 139, 104358.

doi:10.1016/j.fitote.2019.104358

5. Wang, L.-L.; Jiang, C.-S.; Fu, Y.; Chen, F.-F.; Lan, L.-F. Two new limonoids from the root bark of chinese medicinal plant *Dictamnus dasycarpus*. Helv. Chim. Acta. **2014,** 97, 1301-1306.

doi:10.1002/hlca.201400027

6. Tian, M.-Y.; Bao, J.; Li, X.; Zhang, Q.-R.; Wang, S.-J. Antimicrobial alkaloids from the root bark of *Dictamnus dasycarpus*. J. Asian. Nat. Prod. Res. **2021,** 1-7.

doi:10.1080/10286020.2021.1939311

7. Bai, Y.; Jin, X.; Jia, X.; Tang, W.; Wang, X.; Zhao, Y. Two new apotirucallane-type isomeric triterpenoids from the root bark of *Dictamnus dasycarpus* with their anti-proliferative activity. Phytochem. Lett. **2014,** 10, 118-122.

doi:10.1016/j.phytol.2014.06.017

8. Reher, G.; BudĚÍnsky, M. Triterpenoids from plants of the *sanguisorbeae*. Phytochemistry. **1992,** 31, 3909-3914.

doi:10.1016/S0031-9422(00)97552-6

9. Honda, Y.-M.; Murata, K.; Anraku, T. Suppression of release of matrix metalloprotease-1 from human gingival fibroblasts by *cimicifuga rhizome* extract and a novel cimigenol xyloside as an active constituent. Nat. Prod. Comm. **2018,** 13, 230-237.

doi:10.1177/1934578X1801301006

10. Li T.-T.; Meng Q.-H.; Erbing, H. Study on the cyclic triterpenoid components and their biological activities of xing'an *Cimicifuga*. Chin. J. Pharm. Chem. **2021,** 031-007.

11. Yang, M.-H.; Wang, J.-S.; Luo, J.-G. Chisopanins A-K, 11 new protolimonoids from *Chisocheton paniculatus* and their anti-inflammatory activities. Bio. Med. Chem. **2011,** 19, 1409-1417.

doi:10.1016/j.bmc.2011.01.007

12. Xie, B.-J.; Yang, S.-P.; Chen, H.-D. Agladupols A-E, triterpenoids from *Aglaia duperreana*. J. Nat. Prod. **2007,** 70, 1532-1535.

doi:10.1021/np0702842

13. Mitsui, K.; Maejima, M.; Saito, H. Triterpenoids from *Cedrela sinensis*. Tetrahedron. **2005,** 61, 10569-10582.

doi:10.1016/j.tet.2005.08.044

14. Zhang, Y.; Wang, J.-S.; Wei, D.-D. Bioactive terpenoids from the fruits of *Aphanamixis grandifolia*. J. Nat. Prod. **2013,** 76, 1191-5.

doi: 10.1021/np400126q

15. Liu, D.; Wang, R.-S.; Xuan, L.-L.; Wang, X.-H.; Li, W.-Z. Two new apotirucallane-type triterpenoids from the pericarp of *Toona sinensis* and their ability to reduce oxidative stress in rat glomerular mesangial cells cultured under high-glucose conditions. Molecules. **2020,** 25, 801.

doi: 10.3390/molecules25040801

16. Wang, P.; Xie, C.; An, L.; Yang, X.-Y.; Xi, Y.-S.; Zhang, C.; Tuerhong, M.; Jin, D.-Q.; Lee, D.; Zhang, J.; Ohizumi, Y.; Xu, J.; Guo, Y. Bioactive diterpenoids from the stems of *Euphorbia royleana*. J. Nat. Prod. **2019,** 82, 183-193.

doi:10.1021/acs.jnatprod.8b00493