Revista Brasileira de Farmacognosia 28 (2018) 294–297

Brazilian Journal of Pharmacognosy
REVISTA BRASILEIRA DE FARMACOGNOSIA
www.elsevier.com/locate/bjp

Original Article

A new glucosidic iridoid from *Isodon rubescens*

Soumia Belaabed[a], Marinella De Leo[b,*], Salvatore Velotto[c], Nicola Malafronte[d], Massimiliano D'Ambola[d]

[a] *Department of Chemistry, Research Unit, Development of Natural Resources, Bioactive Molecules, Physiochemical and Biological Analysis, University Mentouri Constantine, Constantine, Algeria*
[b] *Dipartimento di Farmacia, Università di Pisa, Pisa, Italy*
[c] *Dipartimento di Medicina Veterinaria e Produzione Animale, Università di Napoli Federico II, Napoli, Italy*
[d] *Dipartimento di Farmacia, Università di Salerno, Fisciano, Salerno, Italy*

ARTICLE INFO

Article history:
Received 26 January 2018
Accepted 7 March 2018
Available online 24 May 2018

Keywords:
Rabdosia
Lamiaceae
Iridoid
NMR

ABSTRACT

One new glucosidic iridoid, 6-*O*-veratroylbarlerin, was isolated from the chloroform/methanol extract of *Isodon rubescens* (Hemsl.) H.Hara, Lamiaceae aerial parts, along with the known compounds apigenin and caffeic acid. The structure of the new compound was elucidated on the basis of 1D and 2D NMR experiments and ESI-MS technique.

Introduction

Isodon (formerly named *Rabdosia*), an important genus of Lamiaceae family, comprised roughly 150 species worldwide, mainly distributed throughout the tropical and subtropical Asia and southwestern China (Sun et al., 2006). Several species of the genus *Isodon* have been used in traditional Chinese medicine for the treatment of different diseases (Park, 2011). Among them, *Isodon rubescens* (Hemsl.) H.Hara, a perennial herb widely used in China against inflammation, bacterial infections, respiratory and gastrointestinal diseases and cancer (Ding et al., 2013), is the most popular species. Previous phytochemical investigations of this plant resulted in the isolation of several *ent*-kaurane and *ent*-abietane diterpenoids, that attracted considerable attention due to their diverse structures and interesting biological properties (Gao et al., 2011; Luo et al., 2017; Zhang et al., 2017), together with alkaloids, diterpenes (Liu et al., 2015), and phenolic compounds (Du et al., 2010a). To the best of our knowledge, while there have been numerous reports focused on the presence of diterpenoids in the *Isodon* genus, there are no papers concerning iridoids. The present study reports for the first time the isolation and the structure elucidation of a glucosidic iridoid (**1**) from *I. rubescens* aerial parts, along with three known compounds.

Materials and methods

General experimental procedure

Briefly, NMR experiments were recorded on a Bruker DRX-600 spectrometer (Bruker BioSpin, Rheinstetten, Germany) equipped with a Bruker 5 mm TCI CryoProbe, acquiring the spectra in methanol-d_4 (Milella et al., 2016). ESI-MS (positive mode) were obtained from a Finningan LC-Q Advantage Termoquest spectrometer (ThermoFinnigan, USA). Thin Layer Chromatographies (TLC) were performed on precoated Kieselgel 60 F_{254} plates (Merck, Darmstadt, Germany) and compounds were detected by cerium disulfate/sulfuric acid (Sigma-Aldrich, Milan, Italy). Column chromatographies were performed over Sephadex LH-20 (40–70 μm, Amersham Pharmacia Biotech AB, Uppsala, Sweden) and over silica gel 60 (Merck, Darmstadt, Germany), followed by reverse phase-high performance liquid chromatography (RP-HPLC) performed on Shimadzu LC-8A series pumping system with Shimadzu RID-10A refractive index detector, C_{18} μ-Bondapak column (30 cm × 7.8 mm, 10 μm, Waters, Milford, MA, USA), using mixtures of methanol/water at flow 2.0 ml/min) (Bisio et al., 2017). All solvents used for extraction and separation processes were purchased from Sigma-Aldrich (Milan, Italy).

* Corresponding author.
E-mail: marinella.deleo@unipi.it (M. De Leo).

https://doi.org/10.1016/j.bjp.2018.03.009

Plant material

Dried aerial parts of *Isodon rubescens* (Hemsl.) H.Hara, Lamiaceae, were purchased in November 2008 from Yee Po International Company (Hong Kong) and authenticated by Dr. Fabiano Camangi (Scuola Superiore Sant'Anna, Pisa, Italy). A sample number was YP08-139.

Extraction and isolation

Dried aerial parts (700 g) were extracted using increasing polarity solvent hexane, chloroform, chloroform/methanol (9:1, v/v) and methanol by extensive maceration (3 times × 2 l) (De Leo et al., 2017). The solvent was evaporated under vacuum system obtaining the following yields 8.10, 17.29, 5.67 and 27.73 g, respectively. Briefly, part of the chloroform/methanol (9:1) extract (2.8 g) was separated by Sephadex LH- 20 with methanol as eluent. Fractions of 10 ml were collected, analyzed by TLC and grouped into seventeen fractions (A–Q) (Bisio et al., 2016). Fractions L and O were isolated as pure apigenin (39.5 mg) and caffeic acid (4 mg), respectively. Fractions C, D, E, and F (1548 mg) were regrouped and separated by silica gel CC eluting with chloroform followed by increasing concentrations of methanol (between 1% and 100%). Fractions of 5 ml were collected, analyzed by TLC and grouped into 21 fractions (A1-U1). Fraction J1 was isolated as pure oridonin (31.7 mg). Fraction H1 (100.1 mg) was subjected to RP-HPLC with methanol/water (35:65) as eluent and regrouped in fifteen fractions (A2-P2). Fractions C3 was isolated as a pure caffeic acid (1.5 mg, t_R 6 min). Fraction N2 (70.5 mg) was separated by RP-HPLC with methanol/water (45:55) as eluent to give pure compound **1** (1 mg, t_R 40 min).

Compound **1**: brownish amorphous solid; $[\alpha]^{25}_D$: −7 (*c* 0.1, MeOH); ^{1}H and ^{13}C NMR (CD_3OD, 600 MHz), see Table 1; ESIMS *m/z* 613 $[M+H]^+$, 451 $[M+H-162]^+$; HRESIMS *m/z* 613.2120 $[M+H]^+$ (calcd 613.2132 for $C_{28}H_{37}O_{15}$).

Table 1
^{1}H- and ^{13}C-NMR data of compound **1** in CD_3OD, δ ppm, *J* (Hz).[a]

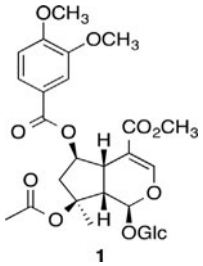
Position	1	
	δ_H	δ_C
1	5.95 d (2.8)	95.2
3	7.56 s	153.4
4		107.0
5	3.45 m	39.7
6	5.52 br d (5.0)	79.0
7a	2.26 dd (14.0, 5.0)	44.5
7b	2.50 br d (14.0)	
8		89.0
9	3.11 dd (3.5, 8.5)	50.2
10	1.62 s	21.4
11		168.0
12	3.69 s	51.6
Glc-1′	4.71 d (8.0)	100.1
2′	3.23 dd (8.0, 9.0)	74.2
3′	3.37 t (9.0)	78.0
4′	3.30 t (9.0)	71.3
5′	3.39 m	77.7
6′	3.70 o	62.8
	3.54 dd (12.0, 3.5)	
Vrt-7′		167.0
1″	7.58 d (1.5)	123.5
2″		113.3
3″	7.09 d (8.3)	149.9
4″	7.70 dd (8.3, 1.5)	154.6
5″	3.93 s	111.6
6″	3.91 s	124.9
OCH_3-3″		56.2
OCH_3-4″	1.91 s	56.0
$O\underline{C}O\underline{C}H_3$		172.3
$OCO\underline{CH_3}$		21.2

[a] Data assignments were confirmed by DQF-COSY, HSQC and HMBC experiments. Glc, glucose; Vrt, veratroyl; o, overlapped.

Results and discussion

The phytochemical study of the chloroform/methanol (9:1) extract from *I. rubescens* aerial parts, by means of different chromatographic techniques, led to the isolation of four compounds, of which a new iridoid glucoside (**1**).

Compound **1** was isolated as brownish amorphous solid and was assigned the molecular formula $C_{28}H_{36}O_{15}$ as deduced from the HRESIMS (*m/z* 613.2120 $[M+H]^+$) and ^{13}C NMR analyses. Spectral data indicated the presence of 11 degree of unsaturation. The ESIMS/MS fragmentation pattern showed an ion fragment at *m/z* 451 due to the loss of a hexose unit $[M+H-162]^+$. Analysis of ^{1}H NMR data (Table 1) evidenced the presence of a double bond at δ 7.56 (1H, s), characteristic for a 4-substituted enol-ether system, typical of iridoid skeleton. According to an iridoid structure, one acetal proton (δ 5.95, d, *J* = 2.8 Hz), one hydroxylated methine (δ 5.52, br d, *J* = 5.0 Hz), two methines (δ 3.45, m; δ 3.11, dd, *J* = 3.5, 8.5 Hz), one methylene (δ 2.26, dd, *J* = 14.0, 5.0 Hz); δ 2.50, br d, *J* = 14.0 Hz), and one methyl (δ 1.62, s) were observed. Furthermore, protons ascribable to a monosaccharide portion were present, with anomeric proton at δ 4.71 (1H, d, *J* = 8.0). In addition, the ^{1}H NMR spectrum of **1** exhibited characteristic signals of the veratroyl group at δ 7.09 (1H, d, *J* = 8.3 Hz), 7.58 (1H, d, *J* = 1.5 Hz), and 7.70 (1H, dd, *J* = 8.3, 1.5 Hz). The ^{13}C NMR spectrum confirmed ^{1}H-NMR data, showing 28 signals (Table 1), of which ten attributable to an iridoidal aglycon moiety, while the remaining eighteen signals were ascribable to a hexose residue, a veratroyl group, and an acetyl function. Thus, the aglycon was identified as shanzhigenin methyl ester (Guo et al., 2001). The downfield shift of 10.0 ppm for C-8 (δ 89.0), compared with a hydroxy-substituted carbon, led to establish the location of the acetyl group at the same carbon (Damtoft et al., 1981). The location of the veratroyl substituent at C-6 was deduced from the downfield shift of 1.47 ppm for H-6 (δ 5.52) (Kato et al., 2012). The monosaccharide portion was established to be a glucose on the basis of literature data (Kato et al., 2012). HMBC correlations between H-1′–C-1 and H-1–C-1′ confirmed the position at C-1 of the glucopyranosyl portion. The other substituent sites were derived from the HSQC and HMBC correlations which also allowed the assignments of all the resonances of ^{13}C NMR spectrum. The correlations between H-3–C-1, H-3–C-4, H-3–C-5, and H-3–C-11 substantiated the location of the double bond. The presence of methoxy group at C-11 was confirmed by HMBC correlation between H-12–C-11, while the position of methyl group at C-10 was deduced by correlations between H-10–C-7, H-10–C-8, and H-10–C-9. Finally, correlations between H-7–C-5, H-7–C-6, H-7–C-8, H-7–C-9, and H-7–C-10 were consistent with the established aglycon structure. Thus, compound **1** was identified as 6-*O*-veratroylbarlerin.



1

Together with the new iridoid glucoside, oridonin (Lu et al., 2006), caffeic acid (Chang et al., 2009), and apigenin (Alwahsh et al., 2015) were isolated and characterized by comparison of ^{1}H and ^{13}C NMR spectra and MS data with those reported in the literature. *I.*

Table 2
Occurrence of caffeic acid and apigenin/apigenin derivatives in the *Isodon*/*Rabdosia* genera.

Plant species	Caffeic acid	Apigenin	Apigenin glycosides	References
I. eriocalyx var. *laxiflora*	+			Niu et al. (2003)
I. japonicus	+			Hong et al. (2009)
I. lophanthoides	+			Feng et al. (2013)
I. lophanthoides var. *gerardianus*	+		+	Tang et al. (2015); Feng et al. (2016)
I. lophathoides var. *graciliflorus*	+		+	Zhou et al. (2014); Tang et al. (2015)
I. nervosa	+			Du et al. (2010b)
I. oresbius		+		Hao et al. (1996)
I. rubescens	+			Du et al. (2010a)
I. sculponeata	+			Jiang et al. (2002)
I. serra	+		+	Liu et al. (2010); Tang et al. (2015)
I. sorra	+		+	Chen et al. (2013); Tang et al. (2015)
I. striatus	+		+	Tang et al. (2015)
I. ternifolius		+		Na et al. (2002)
I. xerophilus	+			Hou et al. (2011)
R. excisa	+			Tang et al. (2014)
R. japonica		+		Shen et al. (2009); Liu et al. (2013)
R. japonica var. *glaucocalyx*	+	+	+	Zhang et al. (2006); Yao et al. (2013)
R. lophanthoides	+		+	Kuang et al. (2014); Lu (2015)
R. lophanthoides var *gerardiana*	+			Lu et al. (2013)
R. rubescens	+			Tang et al. (2011); Guo et al. (2017)
R. flexicaulis	+			Li et al. (2015)
R. serra	+			Zhu et al. (2013)

rubescens is known as one of the best source of oridonin (Harris et al., 2012). The occurrence of caffeic acid and apigenin with its derivatives in *Isodon*/*Rabdosia* genera is illustrated in Table 2. In conclusion, this is the first report about the isolation of a glucosidic iridoid from *Isodon* genus.

Author's contribution

MD and NM planned the experiments. SB carried out the extraction and purification of compounds. NM performed the NMR experiments. SV and MDL contributed to the interpretation of results. MDL and MD wrote the first draft of the manuscript. All authors contributed to the critical revision of the manuscript.

Conflicts of interest

The authors declare no conflicts of interest.

References

Alwahsh, M.A.A., Khairuddean, M., Chong, W.K., 2015. Chemical constituents and antioxidant activity of *Teucrium barbeyanum* Aschers. Rec. Nat. Prod. 9, 159–163.

Bisio, A., Fraternale, D., Schito, A.M., Parricchi, A., Dal Piaz, F., Ricci, D., Giacomini, M., Ruffoni, B., De Tommasi, N., 2016. Establishment and analysis of *in vitro* biomass from *Salvia corrugata* Vahl. and evaluation of antimicrobial activity. Phytochemistry 122, 276–285.

Bisio, A., De Mieri, M., Milella, L., Schito, A.M., Parricchi, A., Russo, D., Alfei, S., Lapillo, M., Tuccinardi, T., Hamburger, M., 2017. Antibacterial and hypoglycemic diterpenoids from *Salvia chamaedryoides*. J. Nat. Prod. 80, 503–514.

Chang, S.W., Kim, K.H., Lee, I.K., Choi, S.U., Ryu, S.Y., Lee, K.R., 2009. Phytochemical constituents of *Bistorta manshuriensis*. Nat. Prod. Sci. 15, 234–240.

Chen, X.-D., Zhu, D.-Q., Zhang, G.-D., He, W.-J., Liu, F.-J., Wei, M., 2013. Determination of caffeic acid, vitexin and rosmarinic acid contents in *Isodon sorra* formula granule by HPLC. Zhongyaocai 36, 1530–1532.

Damtoft, S., Rosendal, S., Nielsen, B.J., 1981. ^{13}C and ^{1}H NMR spectroscopy as a tool in the configurational analysis of iridoid glucosides. Phytochemistry 20, 2717–2732.

De Leo, M., Peruzzi, L., Granchi, C., Tuccinardi, T., Minutolo, F., De Tommasi, N., Braca, A., 2017. Constituents of *Polygala flavescens* ssp. *flavescens* and their activity as inhibitors of human lactate dehydrogenase. J. Nat. Prod. 80, 2077–2087.

Ding, C., Zhang, Y., Chen, H., Yang, Z., Wild, C., Chu, L., Liu, H., Shen, Q., Zhou, J., 2013. Novel nitrogen-enriched oridonin analogues with thiazole-fused A-ring: protecting group-free synthesis, enhanced anticancer profile, and improved aqueous solubility. J. Med. Chem. 56, 5048–5058.

Du, Y., Liu, P., Yuan, Z., Jin, Y., Zhang, X., Sheng, X., Shi, X., Wang, Q., Zhang, L., 2010a. Simultaneous qualitative and quantitative analysis of 28 components in *Isodon rubescens* by HPLC-ESI-MS/MS. J. Sep. Sci. 33, 545–557.

Du, Y., Jin, Y., Liu, P., Zhang, X., Sheng, X., Shi, X., Wang, Q., Zhang, L., 2010b. Rapid method for simultaneous determination of 20 components in *Isodon nervosa* by HPLCaphy-electrospray ionization tandem mass spectrometry. Phytochem. Anal. 21, 416–427.

Feng, H.R., Zhu, D.Q., Huang, S., Lin, J., Lai, X.P., Chen, L.L., Lu, Q.F., 2013. Effects of different harvest times and different processing methods on contents of caffeic acid and rosmarinic acid in *Isodon lophanthoides*. Zhongguo Shiyan Fangjixue Zazhi 19, 71–73.

Feng, C.P., Tang, H.M., Huang, S., Hou, S.Z., Liang, J., Huang, W., Lai, X.P., 2016. Evaluation of the effects of the water-soluble total flavonoids from *Isodon lophanthoides* var. *gerardianus* (Benth.) H.Hara on apoptosis in HepG2 cell: investigation of the most relevant mechanisms. J. Ethnopharmacol. 188, 70–79.

Gao, X.-M., Luo, X., Pu, J.-X., Wu, Y.-L., Zhao, Y., Yang, L.B., He, F., Li, X.N., Xiao, W.-L., Chen, G.-Q., 2011. Antiproliferative diterpenoids from the leaves of *Isodon rubescens*. Planta Med 77, 169–174.

Guo, S.-J., Gao, L.-M., Cheng, D.-L., 2001. Iridoids from *Phlomis umbrosa*. Die Pharm. 56, 178–180.

Guo, S., Cui, X., Jiang, M., Bai, L., Tian, X., Guo, T., Liu, Q., Zhang, L., Ho, C.T., Bai, N., 2017. Simultaneous characterization and quantification of 17 main compounds in *Rabdosia rubescens* by high performance liquid chromatography. J. Food Drug Anal. 25, 417–424.

Harris, E.S., Cao, S., Schoville, S.D., Dong, C., Wang, W., Jian, Z., Zhao, Z., Eisenberg, D.M., Clardy, J., 2012. Selection for high oridonin yield in the Chinese medicinal plant *Isodon* (Lamiaceae) using a combined phylogenetics and population genetics approach. PLoS ONE 7, e50753.

Hao, H., Handong, S., Shouxun, Z., 1996. Flavonoids from *Isodon oresbius*. Phytochemistry 42, 1247–1248.

Hong, S.-S., Lee, C., Lee, C.-H., Park, M., Lee, M.-S., Hong, J.-T., Lee, H., Lee, M.-K., Hwang, B.-Y., 2009. A new furofuran lignan from *Isodon japonicus*. Arch. Pharm. Res. 32, 501–504.

Hou, A.-J., Yang, H., Liu, Y.-Z., Zhao, Q.-S., Lin, Z.-W., Sun, H.-D., 2011. Novel *ent*-kaurane diterpenoids from *Isodon xerophilus*. Chin. J. Chem. 19, 365–370.

Jiang, B., Hou, A.-J., Li, M.-L., Li, S.-H., Han, Q.-B., Wang, S.-J., Lin, Z.-W., Sun, H.-D., 2002. Cytotoxic *ent*-kaurane diterpenoids from *Isodon sculponeata*. Planta Med. 68, 921–925.

Kato, L., de Oliveira, C.M., Melo, M.P., Freitas, C.S., Schuquel, I.T., Delprete, P.G., 2012. Glucosidic iridoids from *Molopanthera paniculata* Turcz. (Rubiaceae, Posoquerieae). Phytochem. Lett. 5, 155–157.

Kuang, Y.-H., Lin, Q., Liang, S., Yao, X.-H., Wang, Z.-M., Li, C.-Y., 2014. Water-soluble chemical constituents from *Rabsodia lophanthoides*. Zhongguo Shiyan Fangjixue Zazhi 20, 110–112.

Li, L.-J., Yu, L.-J., Wu, Z.-Z., Liu, X., 2015. Chemical constituents in ethyl acetate extract from *Rabdosia flexicaulis*. Zhongcaoyao 46, 339–343.

Liu, P., Du, Y., Zhang, X., Sheng, X., Shi, X., Zhao, C., Zhu, H., Wang, N., Wang, Q., Zhang, L., 2010. Rapid analysis of 27 components of *Isodon serra* by LC-ESI-MS-MS. Chromatographia 72, 265–273.

Liu, H.-C., Jin, Y.-S., Chen, H.-S., 2013. Study on triterpenoid and flavonoid contents of *Rabdosia japonica*. Dier Junyi Daxue Xuebao 34, 1121–1124.

Liu, X., Yang, J., Wang, W.-G., Li, Y., Wu, J.-Z., Pu, J.-X., Sun, H.-D., 2015. Diterpene alkaloids with an aza-*ent*-kaurane skeleton from *Isodon rubescens*. J. Nat. Prod. 78, 196–201.

Lu, Y., Sun, C., Pan, Y., 2006. Isolation and purification of oridonin from *Rabdosia rubescens* using upright counter-current chromatography. J. Sep. Sci. 29, 314–318.

Lu, Q.-F., Tang, H.-M., Chen, L.-L., Feng, H.-R., Huang, S., 2013. Identification and determination of caffeic acid and rosmarinic acid in *Rabdosia lophanthoides* var *gerardiana* by TLC and HPLC. Zhongguo Shiyan Fangjixue Zazhi 19, 114–116.

Lu, Q., 2015. Study on the content dynamic changes of caffeic acid, vicenin-2 and isoschaftoside in *Rabdosia lophanthoides*. Zhongguo Yaofang 26, 4271–4273.
Luo, G.-Y., Deng, R., Zhang, J.-J., Ye, J.-H., Pan, L.-T., 2017. Two cytotoxic 6,7-*seco*-*spiro*-lacton-*ent*-kauranoids from *Isodon rubescens*. J. Asian Nat. Prod. Res., 1–7.
Milella, L., Milazzo, S., De Leo, M., Vera Saltos, M.B., Faraone, I., Tuccinardi, T., Lapillo, M., De Tommasi, N., Braca, A., 2016. α-Glucosidase and α-amylase inhibitors from *Arcytophyllum thymifolium*. J. Nat. Prod. 79, 2104–2112.
Na, Z., Xiang, W., Zhao, Q., Mei, S., Li, C., Lin, Z., Sun, H., 2002. New *ent*-kauranoid from *Isodon ternifolius*. Yunnan Zhiwu Yanjiu 24, 267–272.
Niu, X., Li, S., Na, Z., Mei, S., Zhao, Q., Sun, H., 2003. Studies on chemical constituents of *Isodon eriocalyx* var. *laxiflora*. Zhongcaoyao 34, 300–303.
Park, S., 2011. Research on *Isodon* species: still going strong. Arch. Pharm. Res. 34, 1999–2001.
Shen, X., Wang, B., Liu, C., Zhang, J., 2009. Chemical composition of *Rabdosia japonica*. Zhongcaoyao 40, 1883–1885.
Sun, H.-D., Huang, S.-X., Han, Q.-B., 2006. Diterpenoids from *Isodon* species and their biological activities. Nat. Prod. Rep. 23, 673–698.
Tang, J., Zhao, M., Wang, Y., Kang, G., Wu, J., Zheng, M., Peng, S., 2011. J. Chromatogr. B Analyt. Technol. Biomed. Life Sci. 879, 2783–2793.
Tang, J., Ma, R.-L., Liu, H.-C., Ouyang, Z., Chen, H.S., 2014. Tianran Chanwu Yanjiu Yu Kaifa 26, 215–217.
Tang, H.-M., Chen, J.-N., Zhang, Y., Lai, X.-P., Huang, S., 2015. Simultaneous determination of eight water-soluble compositions in *Isodon serra* from different origins by HPLC. Yaowu Fenxi Zazhi 35, 228–234.
Yao, S., Xu, N.-Y., Chu, C.-J., Zhang, J., Chen, D.-F., 2013. Chemical constituents of *Rabdosia japonica* var. *glaucocalyx* and their anti-complement activity. Zhongguo Zhongyao Zazhi 8, 199–203.
Zhang, J., Wang, B., Zhang, N., 2006. Flavonoid components of *Rabdosia japonica* var. *glaucocalyx* (Maxin.) Hara. Zhongcaoyao 37, 1142–1144.
Zhang, Y.-Y., Jiang, H.-Y., Liu, M., Hu, K., Wang, W.-G., Du, X., Li, X.-N., Pu, J.-X., Sun, H.-D., 2017. Bioactive *ent*-kaurane diterpenoids from *Isodon rubescens*. Phytochemistry 143, 199–207.
Zhou, W., Xie, H., Xu, X., Liang, Y., Wei, X., 2014. Phenolic constituents from *Isodon lophanthoides* var. *graciliflorus* and their antioxidant and antibacterial activities. J. Funct. Foods 6, 492–498.
Zhu, D.-Q., Huang, S., Chen, J.-N., Tan, Y.-L., Qu, Y.-Y., Zhuang, Y.-J., 2013. Determination of caffeic acid and rosmarinic acid in *Rabdosia serra* from different species and different habitats. Zhongguo Shiyan Fangjixue Zazhi 19, 114–117.