Biochemical Systematics and Ecology 101 (2022) 104393

Contents lists available at ScienceDirect

Biochemical Systematics and Ecology

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

Resveratrol oligomers from roots of *Ampelocissus martini* Planch.

Sariyarach Thanasansurapong [a], Sakchai Hongthong [b], Amporn Saekee [a], Threeraphat Chutimasakul [c], Amnuay Wattanakornsiri [d], Naowarat Kongkum [e,*]

[a] Department of Chemistry, and Center of Excellence for Innovation in Chemistry (PERCH-CIC), Faculty of Science, Mahidol University, Bangkok, 10400, Thailand
[b] Division of Chemistry, Faculty of Science and Technology, Rajabhat Rajanagarindra University, Chachoengsao, 24000, Thailand
[c] Thailand Institute of Nuclear Technology (Public Organization), Nakhon Nayok, 26120, Thailand
[d] Program of Environmental Science, Faculty of Science and Technology, Surindra Rajabhat University, Surin, 32000, Thailand
[e] Program of Chemistry, Faculty of Science and Technology, Surindra Rajabhat University, Surin, 32000, Thailand

ARTICLE INFO

Keywords:
Resveratrol oligomers
Ampelocissus martini
Vitaceae
Chemotaxonomy

ABSTRACT

Phytochemical investigation of roots of *Ampelocissus martini* Planch. (Vitaceae family) led to the isolation of five resveratrol oligomers comprising (−)-ampelopsin F (**1**), (+)-hopeaphenol (**2**), (−)-α-viniferin (**3**), (−)-wilsonol A (**4**) and (−)-stenophyllol B (**5**). The structure elucidation was performed using their spectroscopic data as well as comparison with those of literature data. All the isolated compounds were submitted to anti-HIV-1 activities employing the syncytium inhibition assay, using the $^{\Delta Tat/Rev}$MC99 virus and 1A2 cell line system, and the reverse transcriptase (RT) assay. The results revealed that the enzymatic inhibition of tested compounds except compound **1** exhibited the potential inhibition in anti-HIV 1-RT assay with IC_{50} in the range of 1.68–5.85 μM better than the positive control, navirapin (IC_{50} at 7.77 μM). Based on the results, their activities displayed the RT enzymatic inhibition better than the positive control. In addition, the chemical isolation of *A. martini* was studied for the first time herein. All known secondary metabolites except compound **2** were firstly reported from *Ampelocissus* genus. Furthermore, the chemotaxonomic significance of the isolates was discussed.

1. Subject and source

The genus *Ampelocissus* (Vitaceae family) consists of 115 species widespread in the tropical and subtropical regions (Wen et al., 2018). More than 12 species widely distribute in various parts of Thailand (Trias-Blasi et al., 2015). *Ampelocissus martini* Planch., synonym of *A. martinii* or *Vitis martini* (Planch.) Ridl. (Govaerts et al., 2021), was locally known as wild-grape or Som-Kung in Thai. This plant has been usually found in deciduous forest with bamboo and dipterocarp plants. In general, its morphology is similar to cultivated grapes (*Vitis* genus) including stem and fruit (Jirum et al., 2013; Siripipatthana et al., 2021). Thai people, especially in northern and northeastern regions, consume its fruits and use its various parts as folk medicine. For example, its ground-roots are normally used for antipyretic. In Thai ethnobotanical utilities and traditional medicine, *A. martini* roots have been used as an active ingredient for mild laxative and cough remedy (Vittaya et al., 2019). To our knowledge, chemical constituents along with their biological activities on this plant, *A. martini*, especially its roots have never been previously studied. Thus, we investigate the chemical and biological constituents of *A. martini* roots. In this study, *A. martini* was collected from Sang-Kha District, Surin Province, Thailand and identified by S.H. (RRU-SH-010).

2. Previous work

The crude extracts in different solvents from various parts of *Ampelocissus martini* such as seeds (Simchuer et al., 2018; Siripipatthana et al., 2020), fruits (Jirum et al., 2013), and roots (Srihanam et al., 2019; Siripipatthana et al., 2021) were studied for total phenolic content (TPC), total flavonoid content (TFC), total proanthocyanidin content (TPAC), total triterpenoid content (TTC), total sterol content (TSC), as well as their biological activities. For example, the methanol extracts of stems and roots of *A. martini* collected from Chumphon Province, Thailand provided a good activity against radical scavenging and antimicrobial assays (Vittaya et al., 2019). From our best searching for the studies of phytochemicals and biological activities of *A. martini*, the isolation of secondary metabolites from various parts of *A. martini* has not been reported.

* Corresponding author.
E-mail address: Naowarat_k@srru.ac.th (N. Kongkum).

https://doi.org/10.1016/j.bse.2022.104393
Received 11 October 2021; Received in revised form 27 January 2022; Accepted 29 January 2022

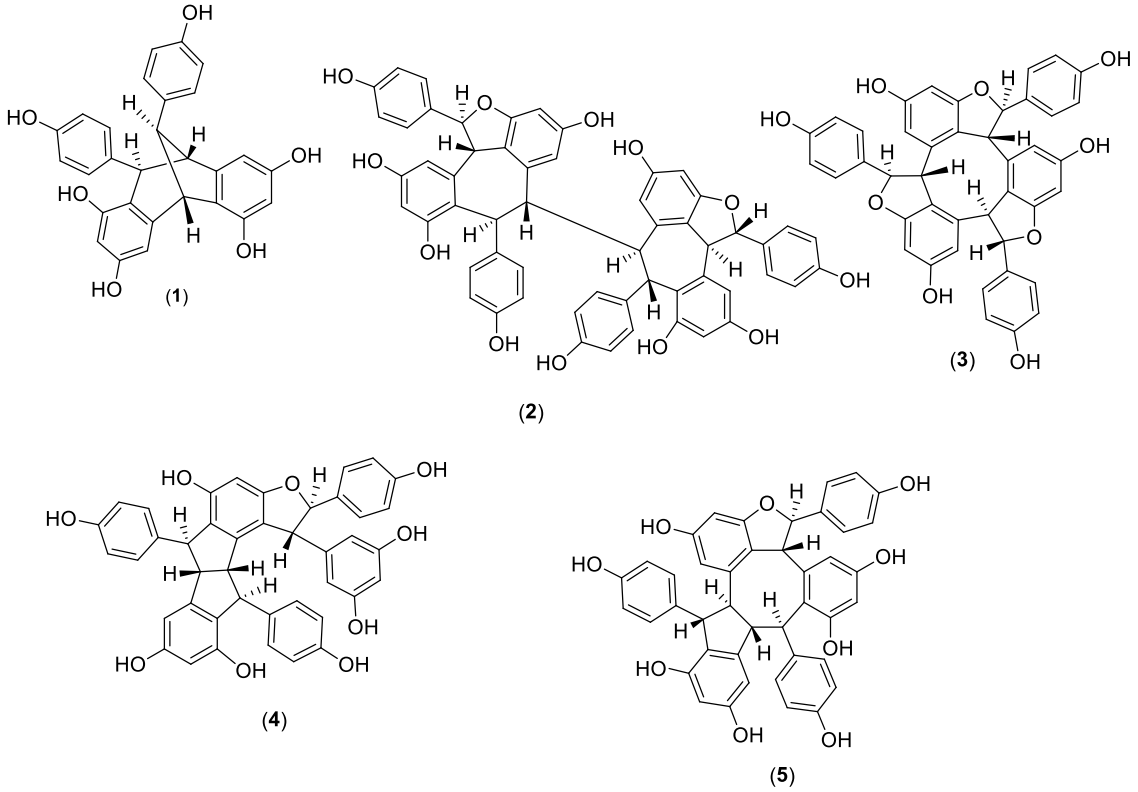

Fig. 1. Isolated compounds **1**–**5** from *A. martini* roots.

3. Present study

3.1. General experimental procedures

Melting points (uncorrected) were measured in degree Celsius (°C) on a digital Electrothermal apparatus. Optical rotations were measured on a digital JASCO DIP 370 polarimeter, using a 50 mm microcell (1 mL). UV spectra were recorded in MeOH on a Perkin-Elmer Lambda 365 spectrophotometer. FT-IR spectra were acquired on Bruker Alpha FT-IR spectrometer. 1D and 2D NMR spectra were recorded on Bruker Ascend™ 400 in deuterated solvent, using residual non-deuterated solvent peaks as an internal reference. HR-TOF-MS were determined on a Micromass VQ-TOF-2 model. Vacuum liquid column chromatography (VLC) and column chromatography (CC) were performed using silica gel (Si-gel) 60G (5–40 μm, E. Merck) and Si-gel 60H (63–200 μm, E. Merck), respectively. Gel filtration was conducted by Sephadex LH-20 (Amersham Biosciences). Pre-coated TLC aluminium sheets of silica gel 60 F_{254} (TLC plates, 20 × 20 cm, E. Merck) were used for analytical purposes. Spots on TLC plates were visualized either by ultraviolet light or by anisaldehyde spraying reagent. All solvents used for extraction and isolation were distilled at their boiling point ranges prior to use.

3.2. Extraction and isolation

Air dried and finely powdered roots of *Ampelocissus martini* (320 g) were extracted by maceration method with MeOH (1 L x 3 times) at room temperature. After filtration and removal of solvent under reduced pressure, the crude MeOH extract (19.04 g) was obtained. The crude MeOH extract was fractionated on silica gel by VLC technique, using hexanes, CH_2Cl_2, EtOAc and MeOH as eluents to provide four fractions (A1–A4). The EtOAc fraction (5.62 g) was isolated on Sephadex LH-20 CC using MeOH as eluent to provide subfractions B1–B6. Subfraction B5 (877.7 mg) was subjected on Si-gel CC eluted by 40% acetone-hexanes to afford subfractions C1–C10. Subfraction C5 (174.3 mg) was purified on Sephadex LH-20 CC using MeOH as eluent to provide compound **1** (60.2 mg). After recrystallization of subfraction C7 (282.3 mg), compound **2** (189.0 mg) was obtained. Subfraction B6 (2.39 g) was fractionated by Si-gel CC eluted by 60% EtOAc-hexanes to afford subfractions D1–D11. Subfraction D4 (736.9 mg) was separated by Sephadex LH-20 CC using 70% MeOH–CH_2Cl_2 as eluent to yield compound **3** (528.2 mg). Subfraction D6 (404.2 mg) was isolated by Sephadex LH-20 CC using MeOH as eluent to provide subfractions E1–E5. Compounds **4** (96.9 mg) and **5** (104.1 mg) were obtained after purification of subfractions E2 (113.8 mg) and E4 (143.2 mg) on Si-gel CC eluted with MeOH:acetone:CH_2Cl_2 (1:1.5:1.75), respectively.

Chemical structures of the isolated compounds were elucidated on the basis of their spectroscopic data (NMR, MS, UV, IR and OR) as well as comparison with those of previous literature as (−)-ampelopsin F (**1**) (Luo et al., 2001; Ito et al., 2013; Indriani et al., 2017), (+)-hopeaphenol (**2**) (Guebailia et al., 2006; Sasikumar et al., 2016), (−)-α-viniferin (**3**) (Mattivi et al., 2011; Rohaiza et al., 2012; Sasikumar et al., 2019), (−)-wilsonol A (**4**) (Jiang et al., 2012) and (−)-stenophyllol B (**5**) (Ohyama et al., 1998). Additionally, the NOESY experiment and optical rotation were operated to support their relative configurations. Their chemical structures are displayed in Fig. 1 (for ^{1}H, ^{13}C NMR and spectroscopic data were summarized and shown in Supplementary data).

3.3. Anti-HIV-1 assay

Some natural resveratrol oligomers have been shown to have antiviral activities. For example, two resveratrol oligomers, dibalanocarpol and balanocarpol, isolated from *Hopea malibato* Foxw. exhibited HIV-inhibitory activity of EC_{50} 46 and 20 μg/mL, respectively (Dai et al., 1998). In addition, (−)-hopeaphenol and shoreaketone showed antiviral activity against influenza A virus as well as herpes simplex virus type 1 (HSV-1) and type 2 (HSV-2) (Ito et al., 2018). Interestingly, (−)-hopeaphenol was claimed to be a potent HIV inhibitor without concomitant cytotoxicity (Tietjen et al., 2019). In this study, all isolated compounds

Table 1
Anti-HIV-1 activities of isolated compounds **1–5**.

Compound	Cytotoxic and Syncytium Reduction Assays[a]				Reverse Transcriptase Assay[b]		
	IC_{50} (μM)	EC_{50} (μM)	SI	Activity	% inhibition at 200 μg/mL	Activity	IC_{50} (μM)
1	47.36	63.85	0.74	I	96.61	VA	33.27
2	8.87	7.83	1.13	A	100.00	VA	4.34
3	<5.75	<5.75	–	T	100.00	VA	4.19
4	55.43	25.71	2.16	A	97.37	VA	5.85
5	18.21	22.12	0.82	I	100.00	VA	1.68
AZT	–	6.02×10^{-9}	–	–	–	–	–
Navirapine	–	–	–	–	–	–	7.77

AZT, azidothymidine, and Navirapine were positive control for syncytium reduction and reverse transcriptase assays, respectively.

[a] Syncytium reduction assay: EC_{50} = dose of compound reducing 50% syncytium formation by $^{\Delta Tat/Rev}$MC99 virus in 1A2 cells. IC_{50} = dose of compound inhibiting 50% metabolic activity of uninfected 1A2 cells. SI, selective index: IC_{50}/EC_{50}. Activity: A, active (SI > 1); I, inactive; T, Toxic (IC_{50} is less than the lowest concentration tested).

[b] RT assay: compounds were prescreened at 200 μg/mL. Activity; VA = very active (>70% inhibition).

were submitted for anti-HIV-1 activities employing the syncytium inhibition assay using the $^{\Delta Tat/Rev}$MC99 virus (Nara et al., 1987; Kiser et al., 1996) and 1A2 cell line system, as well as the reverse transcriptase (RT) assay (Tan et al., 1991). Table 1 shows that compounds **2** and **4** were active in the syncytium reduction assay, while compound **3** was toxic to $^{\Delta Tat/Rev}$MC99 virus and 1A2 cell line. All the tested compounds exhibited significant inhibition activity in the HIV-1 RT assay (>90% at 200 μg/mL). All the compounds except compound **1** had activity with IC_{50} in the range of 1.68–5.85 μM compared to the positive control, nevirapine (IC_{50} 7.77 μM). Compound **5** was the most active with an IC_{50} of 1.68 μM.

4. Chemotaxonomic significance

Resveratrol oligomers are major phytochemical constituents in the Vitaceae family. Nine genera (*Ampelocissus, Ampelopsis, Cayratia*, *Cissus*, *Cyphostemma*, *Muscadinia*, *Parthenocissus*, *Rhoicissusu* and *Vitis*) of the 16 genera in Vitaceae family have been reported to contain resveratrol derivatives (Riviere et al., 2012; Keylor et al., 2015; Wen et al., 2018). Thus, resveratrol oligomers were claimed to be chemotaxonomic significance in plants from Vitaceae family. Based on the searching for chemical constituents, no isolation and structure identification of chemical components from *Ampelocissus martini* were reported. After systematic isolation of the MeOH extract of *A. martini* roots by using various chromatographic techniques, five resveratrol oligomers **1**–**5** were obtained. (−)-Ampelopsin F (**1**) was isolated from plants in various families comprising *Caragana sinica* (Buc'hoz) Rehder in Fabaceae family (Luo et al., 2001): *Dipterocarpus grandiflorus* Blanco, *Vateria indica* L., *Shorea cordifolia* (Thw.) P. S. Ashton (Ito et al., 2004, 2010, 2013), *Vatica umbonata* Burck (Atun et al., 2004), *V. mangachapoi* Blanco (Wu et al., 2019) and *Dryobalanops oblongifolia* Dyer (Indriani et al., 2017) in Dipterocarpaceae family. In contrary, (+)-ampelopsin F, an enantiomer of **1**, was found in *Ampelopsis* genus: *A. brevipedunculata* var. *hancei* (Planch.) Rehder (Oshima et al., 1993), and in *Vitis* genus: *V. amurensis* Rupr. (Ha et al., 2009) and *V. coignetiae* Pulliat ex Planchon (Oshima et al., 1995). Furthermore, (−)-α-viniferin (**3**) was found in *Vitis vinifera* L. (Mattivi et al., 2011; Giovannelli et al., 2014) and reported in several species of Dipterocarpaceae family consisting of *Shorea seminis* (De Vriese) v. Slooten (Aminah et al., 2002), *S. gibbosa* Brandis (Saroyobudiono et al., 2008), *S. faguetiana* Heim. (Rohaiza et al., 2012), *Dipterocarpus hasseltii* Bl. (Muhtadi et al., 2006) and *Hopea ponga* (Dennst.) D. J. Mabberley (Sasikumar et al., 2019), whereas (+)-α-viniferin, an enantiomer of **3**, was separated from various genus in Vitaceae family such as *Vitis riparia* Michx. (Langcake., 1981), *V. heyneana* Roem. & Schult (Ha et al., 2018), *Cayratia trifolia* (L.) Domin (Roat et al., 2008) and *Parthenocissus tricuspidata* (Siebold & Zucc.) Planchon (Kim et al., 2005). (−)-Wilsonol A (**4**) and (−)-stenophyllol B (**5**) were previously isolated from *Vitis wilsonae* Veitch (Jiang et al., 2012) and *V. thunbergii* var. *taiwaniana* Lu (Hu et al., 2016), respectively. (+)-Hopeaphenol (**2**) has been reported in plant of *Ampelocissus* genus: *Ampelocissus indica* (L.) Planch. (Sasikumar et al., 2016). In addition, it was reported on the related genera in Vitaceae plants including *Vitis* genus: *V. amurensis* (Huang et al., 2001), *V. thunbergii* var. *taiwaniana* (Lin et al., 2015) and *V. chunganensis* Hu (He et al., 2009) as well as *Ampelopsis* genus: *A. brevipedunculata* var. *hancei* (Su et al., 2015; Chang et al., 2017). Therefore, (+)-hopeaphenol (**2**) was regarded to be the chemotaxonomic marker from *Ampelocissus* plants and all isolated compounds except compound **1** were remarkable as chemotaxonomy significance for Vitaceae family. Interestingly, this is the first report for (−)-α-viniferin (**3**), (−)-wilsonol A (**4**) and (−)-stenophyllol B (**5**) in *Ampelocissus* genus and (−)-ampelopsin F (**1**) in Vitaceae family. Data from this study on *A. martini* shows that it contains resveratrol oligomers that have anti-viral activity which could be research further.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This study was partially supported by Thailand Institute of Nuclear Technology (Public Organization) under TINT to University project. The authors also thank Faculty of Science and Technology, Surindra Rajabhat University and the Center of Excellence for Innovation in Chemistry (PERCH-CIC), the Office of the Higher Education Commission, Mahidol University under the National Research Universities (NRU) for laboratory equipment and spectroscopic measurements, respectively.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bse.2022.104393.

References

Aminah, N.S., Achmad, S.A., Aimi, N., Ghisalberti, E.L., Hakim, E.H., Kitajima, M., Syah, Y.M., Takayama, H., 2002. Diptoindonesin A, a new *C*-glucoside of ε-viniferin from *Shorea seminis* (Dipterocarpaceae). Fitoterapia 73 (6), 501–507.

Atun, S., Achmad, S.A., Ghisalberti, E.L., Hakim, E.H., Makmur, L., Syah, Y.M., 2004. Oligostilbenoids from *Vatica umbonata* (Dipterocarpaceae). Biochem. Systemat. Ecol. 32 (11), 1051–1053.

Chang, C.I., Chien, W.C., Huang, K.X., Hsu, J.L., 2017. Anti-inflammatory effects of vitisinol A and four other oligostilbenes from *Ampelopsis brevipedunculata var.* hancei. Molecules 22 (7), 1195.

Dai, J.R., Hallock, Y.F., Cardellina, J.H., Boyd, M.R., 1998. HIV-inhibitory and cytotoxic oligostilbenes from the leaves of *Hopea malibato*. J. Nat. Prod. 61 (3), 351–353.

Giovannelli, L., Innocenti, M., Santamaria, A.R., Bigagli, E., Pasqua, G., Mulinacci, N., 2014. Antitumoural activity of viniferin-enriched extracts from *Vitis vinifera* L. cell Cultures. Nat. Prod. Res. 28 (22), 2006–2016.

Govaerts, R., Lughadha, E.N., Black, N., Turner, R., Paton, A., 2021. The world checklist of vascular plants, a continuously updated resource for exploring. Sci. Data 8, 215–224.

Guebailia, H.A., Chira, K., Richard, T., Mabrouk, T., Furiga, A., Vitrac, X., Monti, J.P., Delaunay, J.C., Merillon, J.M., 2006. Hopeaphenol: the first resveratrol tetramer in wines from North Africa. J. Agric. Food Chem. 54 (25), 9559–9564.

Ha, D.T., Chen, Q.C., Hung, T.M., Youn, U.J., Ngoc, T.M., Thuong, P.T., Kim, H.J., Seong, Y.H., Min, B.S., Bae, K.H., 2009. Stilbenes and oligostilbenes from leaf and stem of *Vitis amurensis* and their cytotoxic activity. Arch. Pharm. Res. (Seoul) 32 (2), 177–183.

Ha, D.T., Long, P.T., Hien, T.T., Tuan, D.T., An, N.T.T., Khoi, N.M., Oanh, H.V., Hung, T. M., 2018. Anti-infammatory effect of oligostilbenoids from *Vitis heyneana* in LPS-stimulated RAW 264.7 macrophages via suppressing the NF-κB activation. Chem. Cent. J. 12, 14–22.

He, S., Jiang, L., Wu, B., Li, C., Pan, Y., 2009. Chunganenol: an unusual antioxidative resveratrol hexamer from *Vitis chunganensis*. J. Org. Chem. 74, 7966–7969.

Hu, J., Lin, T., Xu, J., Ding, R., Wang, G., Shen, R., Zhang, Y., Chen, H., 2016. Polyphenols isolated from leaves of *Vitis thunbergii* var. *taiwaniana* regulate APP related pathway. Bioorg. Med. Chem. Lett 26 (2), 505–511.

Huang, K.S., Lin, M., Cheng, G.F., 2001. Anti-inflammatory tetramers of resveratrol from the roots of *Vitis amurensis* and the conformations of the seven-membered ring in some oligostilbenes. Phytochemistry 58 (2), 357–362.

Indriani, Takaya, Y., Puspaningsih, N.N.T., Aminah, N.S., 2017. (-)-Ampelopsin F, dimerstilbene compound from *Dryobalanops oblongifolia* and antimalarial activity test. Chem. Nat. Compd. 53 (3), 559–561.

Ito, T., Tanaka, T., Iinuma, M., Nakaya, K., Takahashi, Y., Sawa, R., Murata, J., Darnaedi, D., 2004. Two new resveratrol (=5-[(1E)-2-(4-hydroxyphenyl)ethenyl]-benzene-1,3-diol) tetramers with a tetrahydrofuran ring from *Dipterocarpus grandiflorus*. Helv. Chim. Acta 87 (2), 479–495.

Ito, T., Masuda, Y., Abe, N., Oyama, M., Sawa, R., Takahashi, Y., Chelladurai, V., Iinuma, M., 2010. Chemical constituents in the leaves of *Vateria indica*. Chem. Pharm. Bull. 58 (10), 1369–1378.

Ito, T., Nishiya, K., Oyama, M., Tanaka, T., Murata, J., Darnaedi, D., Iinuma, M., 2013. Novel isolation of resveratrol dimer *O*-glucosides with enantiomeric aglycones from the leaves of *Shorea cordifolia*. Phytochem. Lett. 6 (4), 667–670.

Ito, T., Hayashi, K., Nishiguchi, M., Hayashi, T., Iinum, M., 2018. Resveratrol oligomer *C*-glucosides and anti-viral resveratrol tetramers isolated from the stem bark of *Shorea uliginosa*. Phytochem. Lett. 28, 1–7.

Jiang, L., He, S., Sun, C., Pan, Y., 2012. Selective O_2 quenchers, oligostilbenes, from *Vitis wilsonae*: structural identification and biogenetic relationship. Phytochemistry 77, 294–303.

Jirum, J., Sangdee, A., Srihanam, P., 2013. Phytochemical and biological activities in fresh juice extracts of wild grape (*Ampelocissus martini* Planch.) fruits. Int. J. Res. Ayurveda Pharm. 4 (3), 337–341.

Keylor, M.S., Matsuura, B.S., Stephenson, C.R.J., 2015. Chemistry and biology of resveratrol-derived natural products. Chem. Rev. 115, 8976–9027.

Kim, H.J., Saleem, M., Seo, S.H., Jin, C., Lee, Y.S., 2005. Two new antioxidant stilbene dimers, parthenostilbenins A and B from *Parthenocissus tricuspidata*. Planta Med. 71 (10), 973–976.

Kiser, R., Makovsky, S., Terpening, S.J., Laing, N., Clanton, D.J.J., 1996. Assessment of a cytoprotection assay for the discovery and evaluation of antihuman immunodeficiency virus compounds utilizing a genetically-impaired virus. J. Virol. Methods 58, 99–109.

Langcake, P., 1981. Disease resistance of Vitis spp. and the production of the stress metabolites resveratrol, ε-viniferin α-viniferin and pterostilbene. Physiol. Plant Pathol. 18 (2), 213–226.

Lin, Y.S., Chen, C.R., Wu, W.H., Wen, C.L., Chang, C.I., Hou, W.C., 2015. Anti-α-glucosidase and anti-dipeptidyl peptidase-IV activities of extracts and purified compounds from *Vitis thunbergii* var. *taiwaniana*. J. Agric. Food Chem. 63 (28), 6393–6401.

Luo, H.F., Zhang, L.P., Hu, C.Q., 2001. Five novel oligostilbenes from the roots of *Caragana sinica*. Tetrahedron 57 (23), 4849–4854.

Mattivi, F., Vrhovsek, U., Malacarne, G., Masuero, D., Zulini, L., Stefanini, M., Moser, C., Velasco, R., Guella, G., 2011. Profiling of resveratrol oligomers, important stress metabolites, accumulating in the leaves of hybrid *Vitis vinifera* (Merzling × Teroldego) genotypes infected with *Plasmopara viticola*. J. Agric. Food Chem. 59 (10), 5364–5375.

Muhtadi, Hakim, E.H., Juliawaty, L.D., Syah, Y.M., Achmad, S.A., Latip, J., Ghisalberti, E.L., 2006. Cytotoxic resveratrol oligomers from the tree bark of *Dipterocarpus hasseltii*. Fitoterapia 77 (7–8), 550–555.

Nara, P.L., Hatch, W.C., Dunlop, N.M., Robey, W.G., Arthur, L.O., Gonda, M.A., Fischinger, P.J., 1987. Simple, rapid, quantitative, syncytium-forming microassay for the detection of human immunodeficiency virus neutralizing antibody. AIDS Res. Hum. Retrovir. 3, 283–302.

Ohyama, M., Tanaka, T., Iinuma, M., Burandt, C.L.J., 1998. Phenolic compounds isolated from the roots of *Sophora stenophylla*. Chem. Pharm. Bull. 46 (4), 663–668.

Oshima, Y., Ueno, Y., Hisamichi, K., Takeshita, M., 1993. Ampelopsins F and G, novel bridged plant oligostilbenes from *Ampelopsis brevipedunculata* var. *hancei* roots (Vitaceae). Tetrahedron 49 (26), 5801–5804.

Oshima, Y., Namao, K., Kamijou, A., Matsuoka, S., Nakano, M., Terao, K., Ohizumi, Y., 1995. Powerful hepatoprotective and hepatotoxic plant oligostilbenes, isolated from the oriental medicinal plant *Vitis coignetiae* (Vitaceae). Experientia 51 (1), 63–66.

Riviere, C., Pawlus, A.D., Merillon, J.M., 2012. Natural stilbenoids: distribution in the plant kingdom and chemotaxonomic interest in Vitaceae. Nat. Prod. Rep. 29, 1317–1333.

Roat, C., Kumar, N., Ramawat, K.G., 2008. Occurrence of stilbenes in unorganized cultures of *Cayratia trifolia* (L.) Domin. J. Herb. Med. Toxicol. 2 (1), 11–15.

Rohaiza, S., Yaacob, W.A., Din, L.B., Nazlina, I., 2012. Chemical constituents of stem bark of *Shorea faguetiana*. Sains Malays. 41 (12), 1571–1577.

Saroyobudiono, H., Juliawaty, L.D., Syah, Y.M., Achmad, S.A., Hakim, E.H., Latip, J., Said, I.M., 2008. Oligostilbenoids from *Shorea gibbosa* and their cytotoxic properties against P-388 cells. J. Nat. Med. 62 (2), 195–198.

Sasikumar, P., Prabha, B., Reshmitha, T.R., Veluthoor, S., Pradeep, A.K., Rohit, K.R., Dhanya, B.P., Sivan, V.V., Jithin, M.M., Kumar, N.A., Shibi, I.G., Nisha, P., Radhakrishnan, K.V., 2016. Comparison of antidiabetic potential of (+) and (−)-hopeaphenol, a pair of enantiomers isolated from *Ampelocissus indica* (L.) and *Vateria indica* Linn., with respect to inhibition of digestive enzymes and induction of glucose uptake in L6 myotubes. RSC Adv. 6 (80), 77075–77082.

Sasikumar, P., Lekshmy, K., Sini, S., Prabha, B., Kumar, N.A., Sivan, V.V., Jithin, M.M., Jayamurthy, P., Shibi, I.G., Radhakrishnan, K.V., 2019. Isolation and characterization of resveratrol oligomers from the stem bark of *Hopea ponga* (Dennst.) Mabb. and their antidiabetic effect by modulation of digestive enzymes, protein glycation and glucose uptake in L6 myocytes. J. Ethnopharmacol. 236, 196–204.

Simchuer, W., Srihanam, P., 2018. Phytosterol screening of skin and seed extracts of wild grape *Ampelocissus martinii* Planch. Orient. J. Chem. 34 (2), 875–880.

Siripipatthana, P., Srihanam, P., 2020. Fractionation and identification of phytochemicals and antioxidant activity of wild grape (*Ampelocissus martinii* Planch.) seed extracts. Asian J. Chem. 32 (7), 1703–1707.

Siripipatthana, P., Srihanam, P., Sangdee, A., 2021. Natural phytochemicals and biological activities of wild grape (*Ampelocissus martinii* Planch.) root extract. Asian J. Chem. 33 (3), 545–550.

Srihanam, P., Siripipatthan, P., 2019. Phytochemical content and antioxidant activity in *Ampelocissus martini* Planch. root extracts. Orient. J. Chem. 35 (6), 1690–1694.

Su, P.S., Doerksen, R.J., Chen, S.H., Sung, W.C., Juan, C.C., Rawendra, R.D.S., Chen, C. R., Li, J.W., Aisha, Huang, T.C., Liao, M.H., Chang, C.I., Hsu, J.L., 2015. Screening and profiling stilbene-type natural products with angiotensin-converting enzyme inhibitory activity from *Ampelopsis brevipedunculata* var. *hancei* (Planch.) Rehder. J. Pharm. Biomed. 108, 70–77.

Tan, G.T., Pezzuto, J.M., Kinghorn, A.D., 1991. Evaluation of natural products as inhibitors of human immunodeficiency virus type 1 (HIV−1) reverse transcriptase. J. Nat. Prod. 54, 143–154.

Tietjen, I., Haq, Z., Naidu, M., Rivera-Ortiz, J., Cai, Y., Beattie, K., Rali, T., Brumme, Z., Montaner, L., Davis, R., 2019. Persistent HIV reservoir suppression by (−)-hopeaphenol, a plant-derived stilbenoid. J. Virus Erad. 5 (3), 44.

Trias-Blasi, A., Watson, M.F., Chayamarit, K., Parnell, J.A.N., 2015. Typification of two newly recorded species of *Ampelocissus* (Vitaceae) for Thailand. Phytotaxa 212 (2), 149–156.

Vittaya, L., Aiamyang, S., Ui-eng, J., Khongsai, S., Leesakul, N., 2019. Effect of solvent extraction on phytochemical component and antioxidant activity of vine and rhizome *Ampelocissus martini*. Sci. Technol. Asia 24, 17–26.

Wen, J., Lu, L.M., Nie, Z.L., Liu, X.Q., Zhang, N., Ickert-Bond, S., Gerrath, J., Manchester, S.R., Boggan, J., Chen, Z.D., 2018. A new phylogenetic tribal classification of the grape family (Vitaceae). J. Systemat. Evol. 56 (44), 262–272.

Wu, S.Y., Fu, Y.H., Zhou, Q., Bai, M., Chen, G.Y., Han, C.R., Song, X.P., 2019. Biologically active oligostilbenes from the stems of *Vatica mangachapoi* and chemotaxonomic significance. Nat. Prod. Res. 33 (16), 2300–2307.