ISSN 1859 - 4735

JOURNAL OF MEDICINAL MATERIALS

No. 5 - Vol. 31
9/2026

NATIONAL INSTITUTE OF MEDICINAL MATERIALS

3B QUANG TRUNG - CUA NAM - HANOI - VIETNAM
TEL: (+84-24) 38247058 FAX: (+84-24) 39348740
Email: tapchiduoclieu@nimm.org.vn; tapchiduoclieu@gmail.com

JOURNAL OF MEDICINAL MATERIALS (Print and Electronic Journals)

EDITORIAL BOARD (Term 2025-2030)

(Attached to Decision No. 666/QD-VDL dated April 24, 2025 signed by the Director of Vietnam National Institute of Medicinal Materials)

EDITOR-IN-CHIEF

Assoc. Prof. PhD. Do Thi Ha

I. Subcommittee of Pharmacognosy - Traditional Medicine

- **Assoc. Prof. Dr. Sci. Nguyen Minh Khoi - Head of Subcommittee**
- Assoc. Prof. PhD. Nguyen Thuong Dong - Member
- Prof. PhD. Nguyen Minh Duc - Member
- Prof. PhD. Tran Cong Luan - Member
- Prof. PhD. Won Keun Oh - Member
- Assoc. Prof. PhD. Tran Hung - Member
- Assoc. Prof. PhD. Nguyen Thi Bich Thu - Member
- Assoc. Prof. PhD. Phuong Thien Thuong - Member
- Assoc. Prof. PhD. Phan Minh Giang - Member
- Assoc. Prof. PhD. Le Nguyen Thanh - Member
- Assoc. Prof. PhD. Le Viet Dung - Member
- Assoc. Prof. PhD. Nguyen Quoc Huy - Member
- Assoc. Prof. PhD. Nguyen Thu Hang - Member
- PhD. Tran Minh Ngoc - Member
- PhD. Nguyen Van Tai - Member
- Assoc. Prof. PhD. Le Dinh Chi - Member
- PhD. Nguyen Tuan Hiep - Member.

II. Subcommittee of Pharmacology - Clinical Pharmacy

- **Assoc. Prof. PhD. Pham Thi Nguyet Hang - Head of Subcommittee**
- Assoc. Prof. Dr.Sci. Do Trung Dam - Member
- Assoc. Prof. PhD. Nguyen Thi Thu Huong - Member
- Assoc. PhD. William R. Folk - Member
- Assoc. Prof. PhD. Pham Thi Van Anh - Member
- Assoc. Prof. PhD. Nguyen Thuy Duong - Member
- Assoc. Prof. PhD. Le Van Minh - Member
- PhD. Tran Thi Hien - Member.

III. Subcommittee of Agriculture - Biology

- **PhD. Nguyen Van Khiem - Head of Subcommittee**
- PhD. Phan Thuy Hien - Member
- Assoc. Prof. PhD. Nguyen Van Tap - Member
- Assoc. Prof. PhD. Pham Thanh Huyen - Member
- Prof. PhD. Tran The Bach - Member.

IV. Subcommittee of Secretariat Administration

- **Assoc. Prof. PhD. Le Nguyen Thanh - Head of Subcommittee**
- PhD. Le Thi Xoan - Academic Secretary
- BSc. Nguyen Thi Minh Loc - Administrative Secretary.

CONTENTS VOL. 31(5), 2026
(Pages 355 - 450)

Page	SCIENTIFIC RESEARCH
357	**Saponins from the Leaves of *Panax vietnamensis* var. *fuscidiscus* Collected in Lai Chau Province, Vietnam -** *Vu Thi Diep, Do Thi Ha, Le Thi Xoan, Tran Minh Ngoc, Nguyen Thi Thanh Thanh, Nguyen Le Thuy Duong,*
365	**Benzyl, Flavonoid, and Iridoid Constituents from the Leaves of *Psychotria serpens* with Nitric Oxide Inhibitory Activity** - *Pham The Chinh, Vu Quang Tung, Pham Thi Tham, Phan Van Kiem, Nguyen Phuong Thao*
375	**Benzyl and Megastigmane Glucosides from the Leaves of *Zanthoxylum rhetsa* (Roxb.) DC. and their Inhibitory Effects on Nitric Oxide Production -** *Bui Thi Mai Anh, Nguyen Thi Mai, Nguyen Phuong Thao*
383	**Investigation of Flavonoid Constituents and Antioxidant Activity of Leaf Extracts from *Coccoloba uvifera* (L.) L.** - *Nguyen Thu Anh, Pham Van Son, Huynh Loi, Vo Van Leo*
391	**Triterpenoids and Acylglucosylsterol from *Galphimia glauca* Cav. Collected in Vietnam** - *Nguyen Thi Hue, Nguyen Thi Thu Trang, Tran Minh Ngoc, Nguyen Thi Hue, Do Thi Ha, Nguyen Van Tai*
398	**Phytochemical Constituents of the Branches and Leaves of *Alangium salviifolium* (L.f.) Wangerin Collected in Quang Ngai, Vietnam** - *Phan Thi Trang, Tran Minh Ngoc, Pham Van Cong, Dang Viet Hau, Do Thi Ha, Nguyen Van Tai*
405	**Chemical Constituents of *Bauhinia bracteata* Benth. Leaves and Their Antioxidant Activity -** *Nguyen Thi Trang, Le Minh Tuan, Pham Thi Thuy Trang, Tran Thanh Ha, Pham Thi Nguyet Hang*
412	**Isolation and Cytotoxic Evaluation of Compounds from the Twigs of *Millettia leptobotrya* Dunn** - *Ngo Van Cuong, Trinh Thi Thanh Van, Phi Thi Dao, Le Tran Nguyen Vu, Pham Van Cuong, Nguyen Thuy Linh, Doan Thi Mai Huong*
419	**Chemical Composition Analysis and Quantification of Perillaldehyde in *Perilla frutescens* Leaf Essential Oil Collected in Vietnam** - *Pham Thi Hien, Nguyen Thi Hai Yen, Do Thi Xinh, Nguyen Thi Thu, Phan Van Truong, Nguyen Thi Hang, Do Thi Ha, Tran Minh Ngoc, Nguyen Minh Khoi, Nguyen Thi Ha Ly*
428	**Preliminary Research on Establishing the Quality Standards for Wine-Processed *Radix Angelicae sinensis* -** *Do Thi Thuy Linh, Nguyen Thi Ha Ly, Phan Thanh Thuy, Nguyen Phu Quang, Pham Anh Minh, Tran Huu Khanh Tan, Bui Ngoc Tan, Nguyen Tuan Hiep*
438	***In vitro* Screening of Cytotoxic Activity of Vietnamese Medicinal Plants -** *Nguyen Thi Thu, Nguyen Tra My, Do Thi Ha, Vu Thi Diep, Nguyen Thi Hang, Tran Thi Hien, Hoang Thi Dieu Huong, Tran Thuy Giang*
446	**Evaluation of Biocompatibility and Preliminary Hemostatic Efficacy of a Chitosan-Based Hemostatic Sponge (Field Hemostatic Sponge) in Experimental Models -** *Vu Quang Thai, Le Thi Xoan, Nguyen Hoang Ngan, Do Thi Thuy Trang*

Journal of Medicinal Materials, 2026, Vol. 31, No. 5 (365 - 374)

BENZYL, FLAVONOID, AND IRIDOID CONSTITUENTS FROM THE LEAVES OF *PSYCHOTRIA SERPENS* WITH NITRIC OXIDE INHIBITORY ACTIVITY

Pham The Chinh[1], Vu Quang Tung[1,*], Pham Thi Tham[2], Phan Van Kiem[3], Nguyen Phuong Thao[3,*]

[1]*Thai Nguyen University of Sciences, Thai Nguyen, Vietnam;*

[2]*Faculty of Chemical Technology, Hanoi University of Industry, Hanoi, Vietnam;*

[3]*Institute of Chemistry, Vietnam Academy of Science and Technology (VAST), Hanoi, Vietnam*

*Corresponding author: tungvq@tnus.edu.vn; thaonp@ich.vast.vn

Received June 10th, 2026 Accepted August 24th, 2026

Summary

Six metabolites (**1**–**6**) were isolated from the leaves of *Psychotria serpens* L. through extensive chromatographic separation. Their structures were elucidated as fisetinidol 3-*O*-*β*-D-glucoside (**1**), camelliaside B (**2**), potalioside A (**3**), benzyl gentiobioside (**4**), 10-*O*-*β*-D-glucosylborreriagenin (**5**), and borreriagenin (**6**) by comprehensive spectroscopic analyses, including 1D and 2D NMR and HRESIMS data, together with comparisons to reported literature values. The absolute configuration of compound **1** was established by an experimental ECD spectrum. Remarkably, compound **1** is reported here for the first time as a naturally occurring metabolite, and its complete NMR spectroscopic data are described for the first time. Evaluation of their anti-inflammatory activity revealed that compounds **1**, **5**, and **6** effectively suppressed LPS-induced nitric oxide (NO) production in RAW264.7 macrophages, displaying IC_{50} values of 53.37, 60.82, and 50.97 μM, respectively, compared with dexamethasone (IC_{50} = 13.12 μM). Furthermore, the taxonomic occurrence of these metabolites was comprehensively examined and discussed in the context of phylogenetic relationships, providing further insight into their potential chemotaxonomic significance.

Keywords: *Psychotria serpens;* Rubiaceae*; Benzyl; Flavonoid; Iridoid; NO inhibitory activity.*

1. Introduction

The family Rubiaceae Juss. comprises more than 16,859 species in approximately 611 genera and is widely distributed throughout tropical and subtropical ecosystems [1]. Several members of this family are known to be toxic, affecting cardiac function and causing the death of farm animals [2]. Among them, the genus *Psychotria* L. is one of the largest within Rubiaceae, comprising approximately 1,857 accepted species, many of which are used in traditional medicine for the treatment of various ailments [1],[3]. Species of *Psychotria* have traditionally been employed for the treatment of rheumatic diseases, pain, muscle disorders, circulatory conditions, earache, and abdominal ailments, as well as in medicinal preparations [3]. Reliable data on the exact number of *Psychotria* species occurring in Vietnam are currently unavailable. However, published studies have reported the presence of 27–35 species and one variety of the genus in the country [4],[5],[6],[7].

Psychotria serpens L. (syn. *P. scandens*, *P. serpens* var. *latifolia*, *Grumilea serpens*, and *Uragoga serpens*) is distributed in Cambodia, China, Japan, Laos, Malaya, Taiwan, Thailand, and Vietnam [1]. In Vietnam, this species occurs in various regions of the country and has traditionally been used to treat rheumatism, sciatica, body aches, back and lumbar pain, post-traumatic dysfunction, carbuncles, and boils [8]. Previous phytochemical studies of *P. serpens* have led to the identification of several classes of secondary metabolites, including flavonoids [9],[10], iridoids [11], glycosylsphingolipids [12], and triterpenoids [9],[13]. Biological evaluations of some of these constituents have revealed anti-inflammatory [11] and cytotoxic [12] activities, suggesting that *P. serpens* represents a potential source of bioactive natural products.

As part of our ongoing phytochemical studies on the genus *Psychotria* [11], the chemical constituents of the leaves of *P. serpens* were investigated, resulting in the isolation of six compounds (**1**–**6**, Fig. 1). Herein, we report their isolation and structural elucidation, together with an evaluation of their inhibitory effects on nitric oxide (NO) production.

2. Materials and Methods

2.1. Chemicals and equipment

Optical rotations were recorded on a JASCO P-2000 polarimeter. ECD spectrum was recorded on a Chirascan spectrometer (Applied Photophysics, Surrey, UK). The NMR spectra

were recorded on a Bruker AVANCE NEO 600 FT-NMR spectrometer with TMS as an internal standard. The HRESIMS was taken on an Agilent 6530 Accurate Mass Q-TOF LC/MS. Column chromatography (CC) was conducted on *silica gel*, Diaion HP-20, Sephadex LH-20, and RP-18. Preparative HPLC was performed using an Agilent 1100, J'sphere ODS H-80 column (4 μm, 250 × 20 mm), a flow rate of 6 mL/min, and a DAD at wavelengths of 205, 230, 254, and 280 nm. An isocratic mobile phase with a flow rate of 3.0 mL/min was used in pre-HPLC. Analytical thin-layer chromatography (TLC) was performed on precoated *silica gel* 60 F_{254} and RP-18 $F_{254}S$ plates, and compounds were visualized by spraying with 10% H_2SO_4 in water and then heating for 1.5–2 minutes.

2.2. Plant material

The leaves of *Psychotria serpens* L. were collected in Vinh Linh, Quang Tri Province, Vietnam, in October 2024 and taxonomically identified by Dr. Le Tuan Anh, Institute of Advanced Technology in Central Vietnam (IATC), VAST. A voucher specimen (TN185) has been deposited at the Thai Nguyen University of Sciences, Thai Nguyen University.

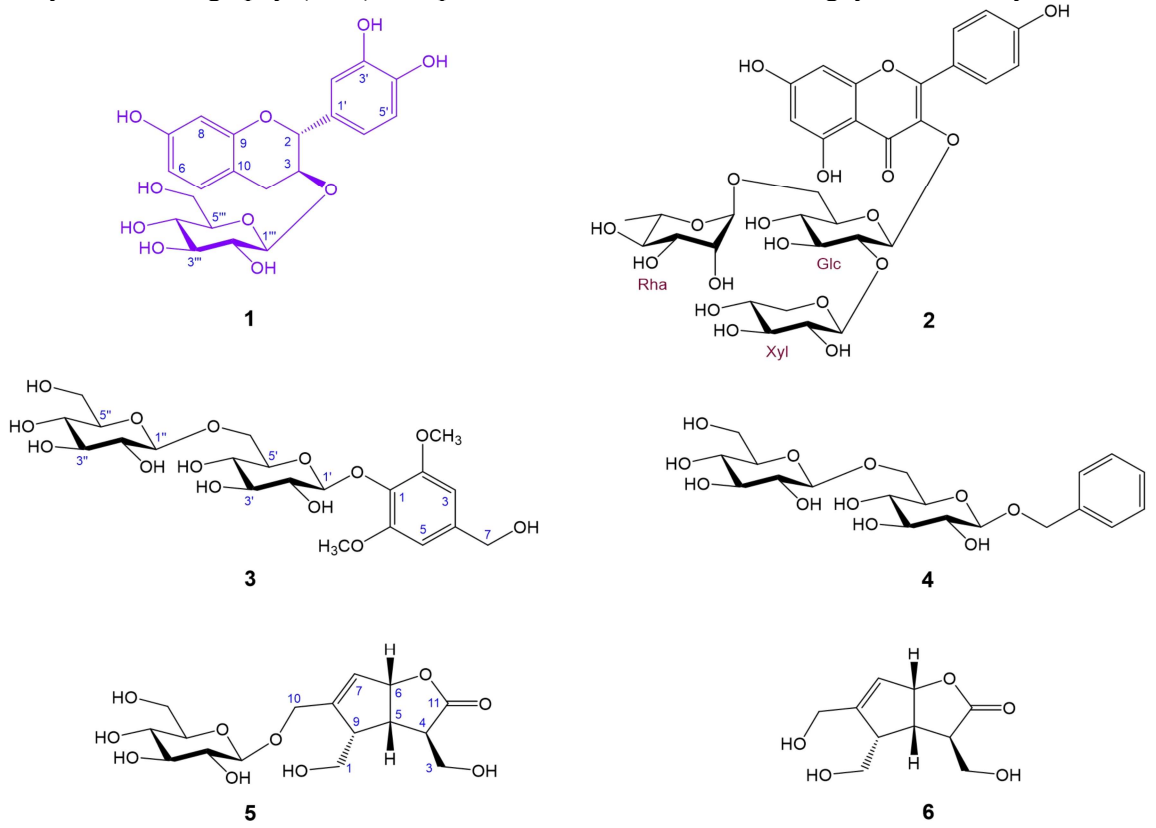


Fig. 1. Chemical structures of compounds **1**–**6**

2.3. Extraction and isolation

The dried powdered leaves of *P. serpens* (6.8 kg) were ultrasonically extracted with MeOH (3 × 15 L, 2 h each), yielding 337 g of extract. The MeOH extract was suspended in water and successively partitioned with *n*-hexane, CH_2Cl_2, and EtOAc to give the corresponding fractions: *n*-hexane (PSH, 34.0 g), CH_2Cl_2 (PSD, 43.0 g), EtOAc (PSE, 18.0 g), and the water layer (PSW). The PSW layer was subjected to Diaion HP-20 column and eluted with MeOH-H_2O (1:4, 1:2, 1:1, and 100% MeOH, each 3L), yielding three fractions: PSW1 (11.0 g), PSW2 (25.0 g), and PSW3 (41.0 g). Fraction PSW1 was further separated on an RP-18 column using MeOH-H_2O (1:1, v/v) as the mobile phase to afford eight fractions (PSW1A–PSW1H). Fraction PSW1A (0.2 g) was chromatographed on a *silica gel* column eluted with CH_2Cl_2-MeOH-H_2O (9:1:0.1, v/v/v) to yield four subfractions (PSW1A1–PSW1A4). Subfraction PSW1A1 (125 mg) was purified by semi-preparative HPLC using 9.8% MeOH, 3 mL/min, to afford compound **6** (8.1 mg, t_R = 41.9 min). Similarly, subfraction PSW1A2

(148 mg) was purified by semi-preparative HPLC using 25% ACN, yielding compounds **1** (6.5 mg, t_R = 56.8 min) and **4** (5.9 mg, t_R = 46.5 min). Subfraction PSW1A4 (0.8 g) was further fractionated by *silica gel* CC using CH_2Cl_2-MeOH (6:1, v/v) as the eluent to obtain four subfractions (PSW1A4a–PSW1A4d). Subfraction PSW1A4c (105 mg) was purified by semi-preparative HPLC using 27% ACN in H_2O to afford compounds **2** (9.4 mg, t_R = 46.3 min) and **3** (7.5 mg, t_R = 53.9 min). Finally, subfraction PSW1A4d (89 mg) was purified by semi-preparative HPLC using 25% ACN in H_2O to yield compound **5** (8.7 mg, t_R = 39.2 min).

Fisetinidol 3-O-β-D-glucoside (1): White amorphous powder; $[\alpha]_D^{24}$ –89.6 (*c* 0.15, MeOH); UV (MeOH) λ_{max} (log ε) 282 (3.98), 254 (3.54); ECD (MeOH) nm ([θ]) 216 (–25 000), 240 (+3600), 288 (–6000); ^{1}H (600 MHz, CD_3OD) and ^{13}C NMR (150 MHz, CD_3OD) spectroscopic data, see Table 1; HRESIMS *m/z* 435.1298 $[M – H]^–$ (calcd. for $[C_{21}H_{23}O_{10}]^–$, 435.1297).

Camelliaside B (2): Yellow amorphous; $[\alpha]_D^{24}$ –60.3 (*c* 0.15, MeOH); ^{1}H NMR (600 MHz, CD_3OD) δ (ppm): 6.20 (1H, br s, H-6), 6.39 (1H, br s, H-8), 8.07 (2H, d, *J* = 8.4 Hz, H-2'/H-6'), 6.91 (2H, d, *J* = 8.4 Hz, H-3'/H-5'), 5.42 (1H, d, *J* = 7.8 Hz, H-1"), 3.68 (1H, dd, *J* = 9.0, 7.8 Hz, H-2"), 3.62 (1H, dd, *J* = 9.0, 9.0 Hz, H-3"), 3.29 (1H, overlapped signal, H-4"), 3.42 (1H, m, H-5"), 3.38 (1H, overlapped signal, H_a-6"), 3.83 (1H, overlapped signal, H_b-6"), 4.52 (1H, br s, H-1'"), 3.62 (1H, m, H-2'"), 3.50 (1H, dd, *J* = 9.0, 3.0 Hz, H-3'"), 3.27 (1H, m, H-4'"), 3.45 (1H, m, H-5'"), 1.11 (3H, d, *J* = 6.0 Hz, H-6'"), 4.80 (1H, d, *J* = 7.0 Hz, H-1""), 3.42 (1H, m, H-2""), 3.36 (1H, overlapped signal, H-3""), 3.54 (1H, m, H-4""), 3.27 (1H, m, H_a-5""), and 3.85 (1H, m, H_b-5""); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 158.5 (C-2), 138.5 (C-3), 179.1 (C-4), 161.1 (C-5), 100.7 (C-6), 162.5 (C-7), 94.9 (C-8), 158.5 (C-9), 105.1 (C-10), 122.9 (C-1'), 132.3 (C-2'/C-6'), 116.3 (C-3'/C-5'), 161.3 (C-4'), 100.8 (C-1"), 81.9 (C-2"), 78.2 (C-3"), 71.4 (C-4"), 76.8 (C-5"), 68.1 (C-6"), 102.1 (C-1'"), 72.1 (C-2'"), 72.3 (C-3'"), 73.9 (C-4'"), 69.7 (C-5'"), 17.8 (C-6'"), 105.1 (C-1""), 74.6 (C-2""), 77.0 (C-3""), 71.0 (C-4""), and 66.5 (C-5""); ESIMS *m/z* 725.1 $[M – H]^–$.

Potalioside A (3): White amorphous powder; $[\alpha]_D^{24}$ –39.7 (*c* 0.15, MeOH); ^{1}H (600 MHz, CD_3OD) and ^{13}C NMR (150 MHz, CD_3OD) spectroscopic data, see Table 1; HRESIMS *m/z* 531.1674 $[M + Na]^+$ (calcd. for $[C_{21}H_{32}NaO_{14}]^+$, 531.1684).

Benzyl gentiobioside (4): White amorphous powder; $[\alpha]_D^{24}$ –119.4 (*c* 0.15, MeOH); ^{1}H NMR (600 MHz, CD_3OD) δ (ppm): 7.45 (2H, dd, *J* = 8.4, 1.8 Hz, H-2/H-6), 7.35 (2H, dd, *J* = 8.4, 1.8 Hz, H-3/H-5), 7.29 (1H, t, *J* = 8.4 Hz, H-4), 4.68 (1H, d, *J* = 12.0 Hz, H_a-7), 4.94 (1H, d, *J* = 12.0 Hz, H_b-7), 4.39 (1H, d, *J* = 7.8 Hz, H-1'), 3.26 (1H, dd, *J* = 9.0, 7.8 Hz, H-2'), 3.32-3.40 (6H, overlapped signals, H-3'/H-4'/H-5'/H-3"/H-4"/H-5"), 3.84 (1H, dd, *J* = 12.0, 5.4 Hz, H_a-6'), 4.20 (1H, dd, *J* = 12.0, 2.4 Hz, H_b-6'), 4.44 (1H, d, *J* = 7.8 Hz, H-1"), 3.26 (1H, dd, *J* = 9.0, 7.8 Hz, H-2"), 3.70 (1H, dd, *J* = 12.0, 5.4 Hz, H_a-6"), and 3.90 (1H, dd, *J* = 12.0, 1.8 Hz, H_b-6"); ^{13}C NMR (150 MHz, CD_3OD) δ (ppm): 139.1 (C-1), 129.3 (C-2/C-6), 129.2 (C-3/C-5), 128.7 (C-4), 72.0 (C-7), 103.5 (C-1'), 75.1 (C-2'), 78.1 (C-3'), 71.6 (C-4'), 77.2 (C-5'), 69.8 (C-6'), 104.9 (C-1"), 75.1 (C-2"), 78.0 (C-3"), 71.6 (C-4"), 78.0 (C-5"), and 62.8 (C-6"); ESIMS *m/z* 433.2 $[M + H]^+$.

10-O-β-D-Glucosylborreriagenin (5): White amorphous powder; $[\alpha]_D^{24}$ +47.9 (*c* 0.15 MeOH); ^{1}H (600 MHz, CD_3OD) and ^{13}C NMR (150 MHz, CD_3OD) spectroscopic data, see Table 2; HRESIMS *m/z* 411.1063 $[M + {}^{35}Cl]^–$ (calcd. for $[C_{16}H_{24}{}^{35}ClO_{10}]^+$, 411.1063).

Borreriagenin (6): White amorphous powder; $[\alpha]_D^{24}$ –11.0 (*c* 0.15, MeOH); ^{1}H (600 MHz, CD_3OD) and ^{13}C NMR (150 MHz, CD_3OD) spectroscopic data, see Table 2; HRESIMS *m/z* HRESIMS *m/z* 237.0726 $[M + Na]^+$ (calcd. for $[C_{10}H_{14}NaO_5]^+$, 237.0739).

*2.4. Acid hydrolysis of compounds **1**, **3**, and **5***

The acid hydrolysis of compounds **1**, **3**, and **5** was carried out following previously reported procedures [14],[15]. Compounds **1**, **3**, and **5** (each 4.0 mg) were separately dissolved in 1.0 M HCl (dioxane-H_2O, 1:1, v/v, 1.0 mL) and heated to 80°C in a water bath for 3.5 h. The acidic solution was neutralized with silver carbonate, the precipitated silver chloride was removed, and the solution was concentrated thoroughly under a nitrogen atmosphere. The residue was re-dissolved in 1.0 mL of water and extracted with chloroform (three times, each 1 mL). The aqueous layer was concentrated to dryness using

nitrogen gas, and monosaccharides were purified by preparative TLC (pre-coated *silica gel* 60 F_{254}, MeCOEt-isoPrOH-Me_2CO-H_2O (20:10:7:6). The specific rotations $[\alpha]_D^{25}$ of sugars were determined after dissolving in H_2O.

For compound **1**: glucose (0.6 mg, R_f = 0.48, and $[\alpha]_D^{24}$ +47.1) [14],[15].

For compound **3**: glucose (0.8 mg, R_f = 0.47, and $[\alpha]_D^{24}$ +46.5) [14],[15].

For compound **5**: glucose (0.5 mg, R_f = 0.48, and $[\alpha]_D^{24}$ +47.6) [14],[15].

2.5. NO inhibitory assay

Nitric oxide assay was performed as previously described [16],[17]. In brief, RAW264.7 cells, originally sourced from the American Type Culture Collection (ATCC, Manassas, VA, USA), were maintained in Dulbecco's Modified Eagle's Medium (DMEM; Gibco-BRL, St. Louis, MO, USA) supplemented with 5% heat-inactivated fetal bovine serum, along with 100 U/mL penicillin and 100 μg/mL streptomycin. The cultures were incubated under control conditions at 37°C in a humidified atmosphere containing 5% CO_2. Cells were seeded in 96-well plates at a density of 2×10^5 cells per well and allowed to adhere for 6 h. The cells were then treated with the tested compounds (10–100 μM) or vehicle for 24 h, followed by stimulation with LPS (1 μg/mL) for an additional 2 h. To assess cell viability, the remaining adherent cells were subjected to the MTT assay using 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) reagent (Sigma Chemical Co., St. Louis, MO, USA), and absorbance was measured at 570 nm. Culture medium (100 μL) was mixed with an equal volume of Griess reagent and incubated at room temperature for 10 minutes. Absorbance was measured at 540 nm on a microplate reader. Nitrite concentration, as an indicator of NO production, was determined using a standard curve that was built from $NaNO_2$ serial diluted solutions. Experiments were performed in triplicate. The IC_{50} values were generated by TableCurve 2Dv4 software.

3. Results and Discussion

Compound **1** was purified as a white amorphous powder. Its molecular formula was determined to be $C_{21}H_{24}O_{10}$, corresponding to 10 double-bond equivalents, based on its deprotonated molecular ion at *m/z* 435.1298 $[M - H]^-$ (calcd. for $[C_{21}H_{23}O_{10}]^-$, 435.1297) observed in the HRESIMS spectrum and ^{13}C NMR data. The ^1H NMR spectrum displayed six aromatic proton signals in the downfield region, comprising two ABX-spin systems characteristic of two 1,3,4-trisubstituted aromatic rings [δ_H 6.84 (1H, d, J = 7.8 Hz, H-5), 6.34 (1H, dd, J = 7.8, 2.4 Hz, H-6), 6.30 (1H, d, J = 2.4 Hz, H-8) and δ_H 6.81 (1H, d, J = 1.8 Hz, H-2'), 6.74 (1H, d, J = 7.8 Hz, H-5'), 6.70 (1H, dd, J = 7.8, 1.8 Hz, H-6')]. In addition, signals attributable to one methylene [δ_H 2.83 (1H, dd, J = 16.2, 6.0 Hz, H_a-4) and 2.90 (1H, dd, J = 16.2, 6.6 Hz, H_b-4)] and two oxygenated methines [δ_H 4.97 (1H, d, J = 6.0 Hz, H-2) and 4.25 (1H, m, H-3)] were observed. The ^1H NMR spectrum also showed an anomeric proton signal [δ_H 4.19 (1H, d, J = 7.8 Hz, H-1")]. Together with the characteristic resonances of the remaining oxygenated methine and methylene protons between δ_H 3.09 and 3.85, as well as the observed NOESY correlations, these data suggested the presence of a β-linked glucopyranosyl unit [18]. In the ^{13}C NMR spectrum, 21 carbon signals were observed, which could be divided into 12 aromatic carbons (six protonated carbons, three quaternary carbons, and three oxygenated quaternary carbons), two oxymethines (δ_C 80.2 and 76.1), one methylene (δ_C 31.2), and a glucopyranosyl unit (δ_C 103.8, 75.1, 77.8, 71.6, 78.0, and 62.8) (Table 1). The substitution pattern of ring A was established from the HMBC correlations of H-5 (δ_H 6.84) to C-7 (δ_C 157.9), and C-9 (δ_C 155.9); H-6 (δ_H 6.34) to C-8 (δ_C 103.6), and C-10 (δ_C 112.5); and H-8 (δ_H 6.30) to C-6 (δ_C 109.5) and C-10, indicating the presence of an oxygenated substituent at C-7. The HMBC correlations of H-2' (δ_H 6.81) and H-6' (δ_H 6.70) to C-2, together with those of H-2 to C-1' (δ_C 132.3), C-2' (δ_C 114.7), and C-6' (δ_C 119.5), established the connection of ring B to ring C through C-2 (Fig. 2). The substituted moieties of the B-ring were determined to both hydroxy groups due to the presence of the unassigned electronegative non-protonated aromatic carbons C-3' and C-4' (δ_C 146.4 and 146.3, respectively), with proton signals not detectable due to hydrogen-deuterium exchange with the solvent (CD_3OD). In addition, the oxygenated proton signal [δ_H 4.25 (H-3)] was correlated with the next oxygenated proton signal

[δ_H 4.97 (H-2)] and aliphatic proton signals [δ_H 2.83 (H_a-4) and 2.90 (H_b-4)] in the ^1H–^1H COSY spectrum. These data, together with the key HMBC correlations from H-2 to C-2', C-6' and from H_2-4 to C-5, C-9, and C-10, supported the assignment of a fisetinidol-type aglycone [20]. Overall, the NMR spectroscopic features were consistent with a flavan-3-ol glycoside [18],[21], and the remaining 2D NMR correlations of the aglycone moiety were in good agreement with those reported for fisetinidol [20].

Comparison of the NMR data of **1** with those reported for fisetinidol 3'-*O*-*β*-D-glucopyranoside [18] revealed closely related structural features, with the most notable differences occurring for the chemical shifts of C-2 to C-4 (Table 1) [18]. These differences suggested that the glucopyranosyl moiety in **1** was attached to C-3 rather than to the position observed in the reported analog. This assignment was further supported by the characteristic ^{13}C NMR chemical shifts and unambiguously established by the reciprocal HMBC correlations between H-3 and C-1" and between H-1" and C-3 (Fig. 2). Acid hydrolysis of **1** afforded glucose, which was identified as D-glucose by comparison with an authentic D-glucose standard (Sigma-Aldrich) using TLC. Its positive optical rotation, in agreement with reported data, further supported the D-configuration of the released sugar [14].

The relative configuration at C-2 and C-3 was deduced from the coupling constant and NOESY data. The *trans* relationship between H-2 and H-3 was supported by the observed coupling constant ($J_{2,3}$ = 6.0 Hz) [18],[21] and the NOESY correlations of H-3 and H_a-4, H-2', and H-6' (Fig. 2). The absolute configuration was subsequently supported by the experimental ECD spectrum, which exhibited a positive Cotton effect around 240 nm and a negative Cotton effect around 288 nm, consistent with the 2*R*,3*S* configuration previously reported for related flavan-3-ol derivatives [22]. Based on these data, compound **1** was identified as fisetinidol 3-*O*-*β*-D-glucoside. To the best of our knowledge, although the structure of this compound has previously been disclosed in a World Intellectual Property Organization patent [23], detailed NMR spectroscopic data have not been reported. Thus, the present study provides the first comprehensive NMR characterization of fisetinidol 3-*O*-*β*-D-glucoside.

Compound **3** was isolated as a white amorphous powder. Its UV spectrum showed absorption bands at 210 and 260 nm, consistent with the presence of an aromatic chromophore. The molecular formula was established as $C_{21}H_{32}O_{14}$ from the sodium-adduct ion observed in the HRESIMS spectrum at *m/z* 531.1674 (calcd. for $[C_{21}H_{32}NaO_{14}]^+$, 531.1684), in conjunction with its ^{13}C NMR data. Analysis of the ^1H and ^{13}C NMR spectroscopic data (Table 1) revealed signals attributable to a 1,2,4,6-tetrasubstituted aromatic ring [δ_C 134.8 (C-1), 154.4 (C-2 and C-6), 105.7 (C-3 and C-5)/δ_H 6.72 (2H, s, H-3 and H-5), and 139.6 (C-4)], an oxygenated sp^3 methylene group [δ_C 65.2 (C-7)/δ_H 4.59 (2H, s, H-7)], two methoxy groups [δ_C 56.9 (2,6-O<u>C</u>H$_3$)/δ_H 3.88 (6H, s, 2,6-OC<u>H</u>$_3$)], and two hexosyl units [δ_C 104.3 (C-1'), 75.7 (C-2'), 78.4 (C-3'), 71.5 (C-4'), 77.6 (C-5'), 68.9 (C-6') and 103.9 (C-1"), 75.1 (C-2"), 77.7 (C-3"), 71.6 (C-4"), 77.9 (C-5"), 62.7 (C-6")]. The two glucose residues were further characterized by the presence of two anomeric protons [δ_H 4.99 (1H, d, J = 7.8 Hz, H-1') and 4.23 (1H, d, J = 7.8 Hz, H-1")], together with two oxygenated methylene groups [δ_H 3.82 (1H, dd, J = 12.0, 5.4 Hz, H_a-6')/4.03 (1H, dd, J = 12.0, 1.8 Hz, H_b-6') and δ_H 3.64 (1H, dd, J = 12.0, 5.4 Hz, H_a-6")/3.83 (1H, br d, J = 12.0 Hz, H_b-6")]. The relatively large coupling constants of the two anomeric protons (^3J = 7.8 Hz) indicated *β*-configurations for both glycosidic linkages. The overall NMR features suggested a syringyl-type benzyl alcohol aglycone substituted with a disaccharide moiety, consistent with a gentiobioside-type structure [19]. The positions of the two methoxy groups were assigned from the HMBC correlations of the methoxy proton signal at δ_H 3.88 to C-2 and C-6 (each δ_C 154.4). The connectivity of the sugar residues was subsequently determined from the HMBC data. The correlation from H-1' (δ_H 4.99) to C-1 (δ_C 134.8) supported the attachment of the inner glucosyl unit to the aromatic moiety through an *O*-glycosidic linkage. Furthermore, the oxygenated methylene proton signals of the *β*-glucopyranose unit (H-6') were observed at a relatively low magnetic field (δ_H 3.82 and 4.03), which is commonly detected around δ_H 3.60-3.80. This deshielding effect is consistent with an

esterification effect and indicates that the oxygenated methylene carbon (C-6') of the first glucose unit is linked to the hemiacetal carbon of a second glucose residue. This assignment was further supported by HMBC correlations between H-1" (δ_H 4.23) and C-6' (δ_C 68.9), as well as between H_2-6' and C-1" (δ_C 103.9), thereby establishing a *β*-D-glc-(1→6)-*β*-D-glc disaccharide unit (Fig. 2). The identities and D-configuration of the two glucose residues were determined as described above. Based on the combined spectroscopic evidence and comparison of its NMR data with those reported in the literature, compound **3** was identified as potalioside A, previously reported from *Potalia amara* [19].

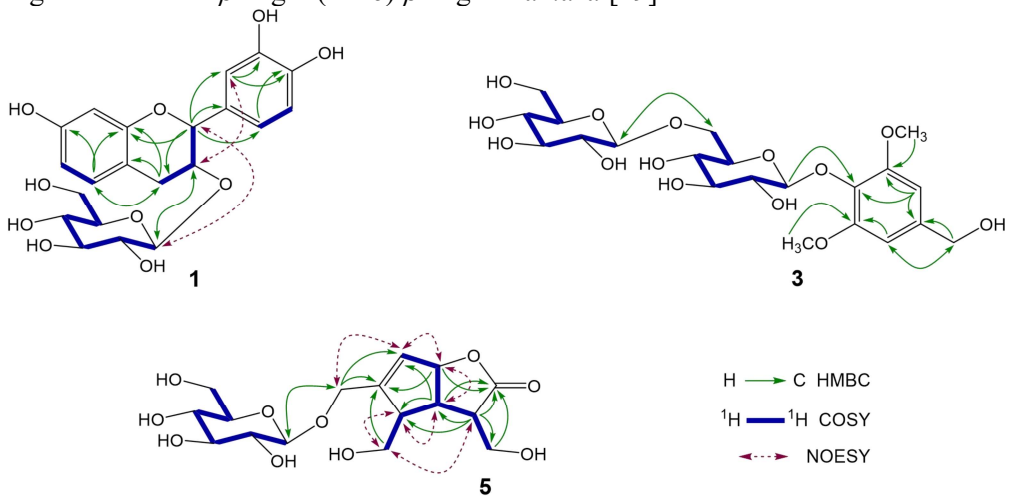


Fig. 2. Key 2D NMR correlations of compounds **1**, **3**, and **5**.

Table 1. ^{1}H and ^{13}C NMR spectroscopic data of compounds **1** and **3** and the reference compounds.

No.	$^{\#}\delta_C$[a]	**1**		$^{\$}\delta_C$[a]	**3**	
		δ_C[a,b]	δ_H[a,c] mult. (*J* in Hz)		δ_C[a,b]	δ_H[a,c] mult. (*J* in Hz)
1				133.9	134.8	-
2	83.1	80.2	4.97 d (6.0)	154.0	154.4	-
3	68.7	76.1	4.25 m	105.1	105.7	6.72 s
4	33.4	31.0	2.83 dd (16.2, 6.0) 2.90 dd (16.2, 6.6)	139.6	139.6	-
5	131.4	131.3	6.84 d (7.8)	105.1	105.7	6.72 s
6	109.6	109.5	6.34 dd (7.8, 2.4)	154.0	154.4	-
7	158.0	157.9	-	64.5	65.2	4.59 s
8	103.7	103.6	6.30 d (2.4)			
9	156.2	155.9	-			
10	112.7	112.5	-			
1'	132.4	132.3	-	103.4	104.3	4.99 d (7.8)
2'	117.3	114.7	6.81 d (1.8)	75.9	75.7	3.51 dd (9.0, 7.8)
3'	146.6	146.4	-	78.4	78.4	3.42 dd (9.0, 9.0)
4'	148.2	146.3	-	71.4	71.5	3.38 t (9.0)
5'	116.9	116.2	6.74 d (7.8)	79.0	77.6	3.03 m
6'	123.7	119.5	6.70 dd (7.8, 1.8)	68.3	68.9	3.82 dd (12.0, 5.4) 4.03 dd (12.0, 1.8)
1"	103.9	103.8	4.19 d (7.8)	103.8	103.9	4.23 d (7.8)
2"	74.9	75.1	3.09 dd (9.0, 7.8)	75.3	75.1	3.10 dd (9.0, 7.8)
3"	77.7	77.8	3.22 t (9.0)	77.8	77.7	3.20 dd (9.0, 9.0)
4"	71.2	71.6	3.21*	71.4	71.6	3.23 t (9.0)
5"	78.3	78.0	3.19 m	77.7	77.9	3.41 m
6"	62.4	62.8	3.65 dd (12.0, 6.0) 3.85 dd (12.0, 2.4)	62.6	62.7	3.64 dd (12.0, 5.4) 3.83 br d (12.0)
2,6-OCH_3				56.4	56.9	3.88 s

Recorded in [a]CD_3OD, [b]150 MHz, and [c]600 MHz. *Overlapped signal, $^{\#}\delta_C$ of fisetinidol 3'-*O*-*β*-D-glucopyranoside [18], and $^{\$}\delta_C$ of potalioside A [19].

Compound **5** was also obtained as an amorphous powder. The ^{13}C NMR spectroscopic data, together with the sodium adduct ion at *m/z* 411.1063 $[M + {}^{35}Cl]^+$ in the HRESIMS, established the molecular formula $C_{16}H_{24}O_{10}$ (calcd. for $[C_{16}H_{24}{}^{35}ClO_{10}]^+$, 411.1063). Careful examination of the ^1H and ^{13}C NMR data, in conjunction with the HSQC spectrum revealed the presence of an internal *γ*-lactone moiety [δ_C 46.0 (C-4)/δ_H 3.00 (1H, m, H-4), 44.0 (C-5)/δ_H 3.34 (1H, m, H-5), 88.3 (C-6)/δ_H 5.42 (1H, br d, *J* = 7.8 Hz, H-6), and 181.0 (C-11)], three *O*-bearing methylene groups [δ_C 60.7 (C-1)/δ_H 3.79, 3.82 (each 1H, dd, *J* = 11.0, 6.0 Hz, H_2-1), 62.9 (C-3)/δ_H 3.86, 3.91 (each (1H, dd, *J* = 10.8, 4.8 Hz, H-2), and 67.4 (C-10)/δ_H 4.53, 4.29 (each 1H, dd, *J* = 13.8, 1.2 Hz, H-10)], one methine [δ_C 50.5 (C-9)/δ_H 3.16 (1H, m, H-9)], and a trisubstituted double bond [δ_C 127.3 (C-7)/δ_H 5.99 (1H, m, H-7) and 149.7 (C-8)]. In addition, the remaining NMR signals were attributable to a hexose unit, including a hemiacetal [δ_C 103.9 (C-1')], four oxygenated methines [δ_C 75.1 (C-2'), 78.1 (C-3'), 71.7 (C-4'), and 78.1 (C-5')], and one oxygenated methylene [δ_C 62.8 (C-6')]. These data, together with the coupling constant of the anomeric proton [δ_H 4.33 (1H, d, *J* = 7.8 Hz, H-1')], were consistent with a *β*-glucopyranosyl unit [24]. The attachment of the glucosyl moiety at C-10 was established by the HMBC correlations from H-1' (δ_H 4.33) to C-10 (δ_C 67.4) and from H_2-10 (δ_H 4.53/4.29) to C-1' (δ_C 103.9). Analysis of the ^1H–^1H COSY spectrum of **5** confirmed three proton spin-systems corresponding to the H-1–H-9–H-5, H-3–H-7, and the glucosyl fragment from H-1'–H-6' (Fig. 2). The remaining connectivities were established from the HMBC spectrum. In particular, the correlations from H-4 (δ_H 3.00) to C-3 (δ_C 62.9), C-5 (δ_C 44.0), C-9 (δ_C 50.5), and C-11 (δ_C 181.1); from H-5 (δ_H 3.34) to C-7 (δ_C 127.3), C-8 (δ_C 149.7), and C-11; from H-6 (δ_H 5.42) to C-8 and C-11; and from H_2-10 to C-7 and C-8 established the planar structure of the aglycone. Taken together, the ^1H–^1H COSY and HMBC data enabled the complete assignment of the ^1H and ^{13}C NMR resonances (Table 2) and indicated an iridoid glucoside framework [24].

By analyzing the coupling constants (*J*) observed in the ^1H NMR spectrum of **5** and comparing them with reported structures, the configuration of the four chiral centers (C-4, C-5, C-6, and C-9) was assigned. The coupling constants, including the long-range couplings, of the hydrogens attached to the ring containing these carbons were highly similar to those for related iridoids (Table 2). Moreover, the majority of naturally occurring iridoids possess these configurations, with only a few known exceptions, none of which have been reported in the Rubiaceae family. With the *R**-configuration for C-5 fixed, C-6 should have the *S**-configuration, with H-6 in the *β*-position because the fusion of the *γ*-lactone ring can occur only in a *cis*-fashion. Additional support for the assigned configurations at C-4, C-5, C-6, and C-9 was obtained through comparison with the spectroscopic data of borreriagenin (**6**), previously isolated from *Morinda citrifolia* [25] and *Borreria verticillata* [26]. Additional support was provided by the NOESY spectrum (Fig. 2). The correlations of H-9 (δ_H 3.16) with H_b-1, H-5, and H-6 indicated that these protons were located on the same face of the molecule and were tentatively assigned a *β*-orientation. In contrast, the correlation between H_a-1 and H-4 supported their common *α*-orientation. The absence of a NOESY correlation between H-5 and H-3, together with the observed correlations and comparison with the reported data for **6**, was consistent with the proposed relative configuration of the fused ring system [25]. The assignment was further supported by the characteristic *cis*-fusion of the *γ*-lactone ring and by comparison of the complete NMR spectroscopic data with those reported for related naturally occurring iridoids. The identity of the glucose residue and its D-configuration were determined as described above. Accordingly, compound **5** was identified as 10-*O*-*β*-D-glucosylborreriagenin.

Table 2. ^{1}H and ^{13}C NMR spectroscopic data of compounds **5** and **6** and the reference compounds.

No.	$^{@}\delta_C$[a]	**5**		$^{\&}\delta_C$[a]	**6**	
		δ_C[a,b]	δ_H[a,c] mult. (*J* in Hz)		δ_C[a,b]	δ_H[a,c] mult. (*J* in Hz)
1	59.3	60.7	3.79 dd (11.0, 6.0) 3.82 dd (11.0, 6.0)	59.4	60.8	3.74 dd (10.8, 5.4) 3.80 dd (10.8, 5.4)
3	61.5	62.9	3.86 dd (10.8, 4.8) 3.91 dd (10.8, 4.8)	61.5	62.8	3.87 dd (10.8, 4.8) 3.93 dd (10.8, 4.8)
4	44.7	46.0	3.00 m	44.5	45.9	2.98 m
5	42.5	44.0	3.34 m	42.6	44.0	3.36 m
6	87.0	88.3	5.42 br d (7.8)	86.9	88.3	5.42 br d (7.8)
7	125.8	127.3	5.99 m	127.7	125.1	5.86 m
8	148.4	149.7	-	152.0	153.4	-
9	49.0	50.5	3.16 m	48.6	50.0	3.13 m
10	66.0	67.4	4.53 dd (13.8, 1.2) 4.29 dd (13.8, 1.2)	59.2	60.6	4.24 dd (10.8, 1.8) 4.18 dd (10.8, 1.8)
11	179.7	181.0	-	179.6	180.9	-
1'	102.4	103.9	4.33 d (7.8)			
2'	73.6	75.1	3.22 dd (9.0, 7.8)			
3'	76.6	78.1	3.26 dd (9.0, 9.0)			
4'	70.2	71.7	3.28 t (9.0)			
5'	76.5	78.1	3.37 ddd (9.0, 5.4, 1.8)			
6'	61.4	62.8	3.68 dd (12.0, 5.4) 3.89 dd (12.0, 1.8)			

Measured in [a]CD_3OD, [b]150 MHz, and [c]600 MHz. $^{@}\delta_C$ of 10-*O*-*β*-D-glucosylborreriagenin [24] and $^{\&}\delta_C$ of borreriagenin [25].

The three remaining compounds were determined to be camelliaside B (**2**) [27], benzyl gentiobioside (**4**) [28], and borreriagenin (**6**) [25] by comparing their physical and spectroscopic data with published reference data.

Flavonoids are characterized by a distinctive C6–C3–C6 skeleton, in which two phenyl rings are linked by a three-carbon unit. This unit typically cyclizes to form a heterocyclic pyran ring, providing the core scaffold for the diverse flavonoid derivatives widely distributed throughout the plant kingdom. According to the SciFinder database, compound **1** is reported here for the first time as a natural product. In addition, the isolation of the flavonoid glycoside **2** represents its first occurrence in the Rubiaceae family. Previously, compound **2** was identified from *Camellia sinensis* [27] of the Theaceae family. The occurrence of these flavonoids **1** and **2** in the investigated plant may provide additional phytochemical information supporting the characterization of the collected material. However, because flavonoids are widely distributed in nature, their chemotaxonomic significance should be regarded as limited. Based on available literature, compound **3** has previously been reported from *Potalia amara* (Gentianaceae) [19] and *Scleropyrum pentandrum* (Santalaceae) [29]. To the best of our knowledge, this study marks the first isolation of compound **3** in the Rubiaceae family. Similarly, compound **4** has been identified in *Lycopersicon esculentum* (syn. *Solanum lycopersicum*, Solanaceae) [28], *Polygonatum sibiricum* (Asparagaceae) [30], and several other species. However, its occurrence in the present study constitutes the first report of this compound from the genus *Psychotria*.

Iridoid aglycones are relatively rare natural products and have been reported from representatives of several plant families, including Apocynaceae, Bignoniaceae, Loganiaceae, Scrophulariaceae, and Verbenaceae. Although iridoid glucoside **5** has been identified in several species of the Rubiaceae family, including *Anthospermum emirnense* [24], *Morinda citrifolia* [25], and *Borreria verticillata* [26], its isolation from the genus *Psychotria* is documented here for the first time. In contrast, compound **6** appears to have a more restricted distribution. As a deglucosylated derivative of compound **5**, it appears to be rare within the genus, unlike the widespread occurrence of its glucosylated form [3]. Based on available literature, compound **6** has previously been reported only in *Borreria verticillata* [26], *Morinda citrifolia* [25], and *Psychotria succulenta* [31]. Accordingly, the present study provides the first report of compound **6** from *P. serpens* and, to the best of our knowledge, only the second record of this constituent within the genus *Psychotria*.

Table 3. Inhibitory effects of the isolated compounds on NO production induced by LPS in RAW264.7 cells.

Compound	IC_{50} (μM)[a]	Compound	IC_{50} (μM)
1	53.37 ± 2.83	**5**	60.82 ± 4.69
2	>80	**6**	50.97 ± 3.14
3	>80	Dexamethasone[b]	13.12 ± 1.12
4	>80		

[a]Values were presented as means ± SD (n=3). [b]Dexamethasone was used as a positive control.

Inflammation is a physiological response to injury, infection, or internal stress and is characterized by redness, swelling, heat, and often pain. When persistent, inflammation can increase the risk of developing chronic diseases. NO is a key pro-inflammatory mediator; its excessive production under pathological conditions contributes to the inflammatory process. Therefore, the *in vitro* anti-inflammatory activities of the isolated compounds were screened by evaluating their ability to inhibit NO production in LPS-stimulated RAW264.7 macrophages, with dexamethasone used as the positive control. Cells were treated with isolated compounds at concentrations of 10, 20, 40, 50, 80, and 100 μM. None of the tested compounds showed any obvious cytotoxicity at concentrations effective for NO inhibition (cell viability over 90%). Among the isolated compounds, compounds **1**, **5**, and **6** dose-dependently suppressed NO production in LPS-stimulated RAW264.7 cells without any apparent toxicity, with IC_{50} values of 53.37, 60.82, and 50.97 μM, respectively, compared to dexamethasone (IC_{50} = 13.12 μM). The remaining metabolites displayed no significant inhibitory activity against NO production (IC_{50} > 80 μM, Table 3).

4. Conclusions

The chemical constituents of *P. serpens* leaves were investigated in the present study, leading to the isolation of six compounds: fisetinidol 3-*O*-*β*-D-glucoside (**1**), camelliaside B (**2**), potalioside A (**3**), benzyl gentiobioside (**4**), 10-*O*-*β*-D-glucosylborreriagenin (**5**), and borreriagenin (**6**). The structures of these compounds were elucidated on the basis of comprehensive NMR spectroscopic analyses and by comparison with previously reported data. Among the compounds tested, compounds **1**, **5**, and **6** showed inhibitory effects on NO production in LPS-induced RAW264.7 macrophages, with IC_{50} values of 50.97–60.82 μM. To the best of our knowledge, compound **1** is reported here for the first time as a natural product, and its complete NMR spectroscopic assignments are presented. Compounds **2** and **3** are reported for the first time from the Rubiaceae family, whereas compounds **4** and **5** are documented here for the first time from the genus *Psychotria*. Although the occurrence of these compounds alone does not allow definitive conclusions regarding their biosynthetic or chemotaxonomic significance, the present findings expand the current knowledge of the phytochemical diversity of *P. serpens* and provide useful information for future studies on the chemical characteristics and potential chemotaxonomic relationships within the genus *Psychotria*.

Acknowledgments: *This research is funded by the Vietnam National Foundation for Science and Technology Development (NAFOSTED) under grant number 104.01-2023.06.*

References

1. POWO (2026), Plants of the World Online, Facilitated by the Royal Botanic Gardens, Kew. *Published on the Internet (accessed 31/5/2026)*, https://powo.science.kew.org/results?f=accepted _names&q=Rubiaceae.

2. Flávia A. O. B., Emily R. A., José J. L. B., Antonio F. M. O., Antonio F. M. O. (2025), Poisoning in ruminants by *Palicourea* Aubl. species (Rubiaceae) in Brazil: a review. *Veterinary Sciences*, 12, e540.

3. Yang H. M., Zhang H. M., Yang C. Q., Chen Y. (2016), Chemical constituents of plants from the genus *Psychotria. Chemistry & Biodiversity*, 13(7), 1–14.

4. Nguyen Q. B. (2025), *Taxonomy of the genus Psychotria* L. *(*Rubiaceae*) in Vietnam.* Doctoral Dissertation in Biology (Field of Botany), 1–137.

5. Nguyen T. B. (1997), *Handbook for reference and identification of the families of Angiospermae plants in Vietnam.* Agricultural Publishing House, Vol. 3, 40–60.
6. Pham H. H. (2000), *An illustrated flora of Vietnam.* Tre Publishing House, Vol. 3, 1–201.
7. Tran N. N. (2005), Rubiaceae *family, Handbook for reference and identification of the families of Angiospermae plants in Vietnam.* Agricultural Publishing House, Vol. 3, 1–146.
8. Vo V. C. (2018), *Dictionary of Vietnamese medicinal plants.* Medical Publishing House, Ha Noi, Vol. 1, 1307–1308.
9. Zhou B. D., Zhang X. L., Niu H. Y., Guan C. Y., Liu Y. P., Fu Y. H. (2018), Chemical constituents from stems and leaves of *Psychotria serpens. China Journal of Chinese Materia Medica*, 43(24), 4878–4883.
10. Lin C. Z., Wu A. Z., Zhong Y., Wang Y. M., Peng G. T., Su X. J., Liu B. X., Deng Y., Zhu C. C., Zhang C. X. (2015), Flavonoids from *Psychotria serpens* L., a herbal medicine with anti-cancer activity. *Journal of Cancer Research Updates*, 4(2), 60–64.
11. Pham T. C., Pham T. T., Vo Q. T., Nguyen T. T. T., Dang T. V., Vu T. K., Cao T. H., Phan T. T. H., Bui H. T., Phan V. K. (2026), Psychoserpens A and B: two new iridoids from the leaves of *Psychotria serpens* L. that inhibit nitric oxide production. *Chemistry & Biodiversity*, 23, e03452.
12. Wang Y. M., Wu A. Z., Zhong Y., Peng G. T., Fan Q., Zhu C., Zhang C. X. (2020), New glycosylsphingolipids from *Psychotria serpens* L. *Natural Product Research*, 34(14), 2095–2100.
13. Lee K. H., Lin Y. M., Wu T. S., Zhang D. C., Yamagishi T., Hayashi T., Hall I. H., Chang J. J., Wu R. Y., Yang T. H. (1988), The cytotoxic principles of *Prunella vulgaris*, *Psychotria serpens*, and *Hyptis capitata*: ursolic acid and related derivatives. *Planta Medica*, 54(4), 308–311.
14. Nazabadioko L. V., Gevrenova R., Borie N., Harakat D., Sayagh C., Weng A., Thakur M., Zaharieva M., Henry M. (2013), Triterpenoid saponins from the roots of *Gypsophila trichotoma* Wender. *Phytochemistry*, 90, 114–127.
15. Tran T. T. H., Duong T. D., Bui H. T., Phan V. K. (2023), Polypunctosides E–K: seven new steroidal saponins from *Polygonatum punctatum* Royle ex Kunth and their nitric oxide production inhibitory activities. *Journal of Natural Medicines*, 77(1), 238–249.
16. Nguyen A. B., Duong T. H. Y., Dan T. T. H., Pham H. H. Y., Nguyen H. H., Do T. T., Duong T. D., Nguyen T. C., Nguyen T. C., Nguyen X. N., Bui H. T., Phan V. K. (2024), New diterpene lactone derivatives from *Aphanamixis polystachya* leaves inhibit nitric oxide production in RAW264.7 cells. *RSC Advances*, 14(29), 20536–20542.
17. Nguyen V. Q., Bui H. T., Pham H. Y., Nguyen H. H., Dan T. T. H., Phan T. T. Huong, Nguyen A. B., Duong T. D., Do T. T., Le D. G., Phan V. K. (2024), Three undescribed furanoditerpenoids from the *Tinospora crispa* that inhibit NO production. *Chemistry & Biodiversity*, 21(12), e202401679.
18. Odonbayar B., Murata T., Batkhuu J., Yasunaga K., Goto R., Sasaki K. (2016), Antioxidant flavonols and phenolic compounds from *Atraphaxis frutescens* and their inhibitory activities against insect phenoloxidase and mushroom tyrosinase. *Journal of Natural Products*, 79(12), 3065–3071.
19. Li X. C., ElSohly H. N., Walker L. A., Clark A. M. (2005), Phenolic glycosides from *Potalia amara. Planta Medica*, 71(10), 977–979.
20. Imai T., Inoue S., Ohdaira N., Matsushita Y., Suzuki R., Sakurai M., Jesus J. M. H., Ozaki S. K., Finger Z., Fukushima K. (2008), Heartwood extractives from the Amazonian trees *Dipteryx odorata*, *Hymenaea courbaril*, and *Astronium lecointei* and their antioxidant activities. *Journal of Wood Science*, 54, 470–475.
21. Hu Y. J., Diao N., Liang D. (2026), Flavonoid derivatives and lignan enantiomers from *Phanera championii* Benth. and their anti-neuroinflammatory activity. *Phytochemistry*, 247, e114836.
22. Slade D., Ferreira D., Marais J. P. J. (2005), Circular dichroism, a powerful tool for the assessment of absolute configuration of flavonoids. *Phytochemistry*, 66(18), 2177–2215.
23. Porta A., Gemma G., Vittoria C. P. (International publication date 17 April 2003), *International application published under the Patent Cooperation Treaty (PCT/EP02/11181).* World Intellectual Property Organization, WO 03/031430 A2, 29.
24. Rasoarivelo T. S. R., Grougnet R., Michel S., Guillou C. R., Deguin B. (2017), Chemical study of *Anthospermum emirnense* (Rubiaceae). *Biochemical Systematics and Ecology*, 70, 186–191.
25. Samoylenko V., Zhao J., Dunbar D. C., Khan I. A., Rushing J. W., Muhammad I. (2006), New constituents from noni (*Morinda citrifolia*) fruit juice. *Journal of Agricultural and Food Chemistry*, 54(17), 6398–6402.
26. Vieira I. J. C., Mathias L., Braz-Filho R., Schripsema J. (1999), Iridoids from *Borreria verticillata. Organic Letters*, 1(8), 1169–1171.
27. Sekine T., Arita J., Yamaguchi A., Saito K., Okonogi S., Morisaki N., Iwasaki S., Murakoshi I. (1991), Two flavonol glycosides from seeds of *Camellia sinensis*. *Phytochemistry*, 30(3), 991–995.
28. Rosa S. D., Giulio A. D., Tommonaro G. (1996), Aliphatic and aromatic glycosides from the cell cultures of *Lycopersicon esculentum*. *Phytochemistry*, 42(4), 1031–1034.
29. Disadee W., Mahidol C., Sahakitpichan P., Sitthimonchai S., Ruchirawat S., Kanchanapoom T. (2012), Unprecedented furan-2-carbonyl *C*-glycosides and phenolic diglycosides from *Scleropyrum pentandrum. Phytochemistry*, 74, 115–122.
30. Luo G., Lin J., Cheng W., Liu Z., Yu T., Yang B. (2022), UHPLC-Q-Orbitrap-MS-based metabolomics reveals chemical variations of two types of rhizomes of *Polygonatum sibiricum. Molecules*, 27, e4685.
31. Jouogo D. C. N., Tamokou J. D. D., Teponno R. B., Matsuete T. G., Voutquenne N. L., Tapondjou L. A., Ngnokam D. (2022), Chemotaxonomy and antibacterial activity of the extracts and chemical constituents of *Psychotria succulenta* Hiern. (Rubiaceae). *BioMed Research International*, Article ID 7856305, 10 pages.