Immunosuppressive Sesquiterpenoids from the Edible Mushroom *Craterellus odoratus*

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Abstract: The aim of this work was to comprehensively understand the chemical constituents of the edible mushroom *Craterellus odoratus* and their bioactivity. A chemical investigation on this mushroom led to the isolation of 23 sesquiterpenoids including eighteen previously undescribed bergamotane sesquiterpenes, craterodoratins A–R (1–18), and one new vioctoxinine derivative, craterodoratin S (19). The new structures were elucidated by detailed interpretation of spectrometric data, theoretical nuclear magnetic resonance (NMR) and electronic circular dichroism (ECD) calculations, and single-crystal X-ray crystallographic analysis. Compounds 1 and 2 possess a ring-rearranged carbon skeleton. Compounds 3, 10, 12–15, 19, 20 and 23 exhibit potent inhibitory activity against the lipopolysaccharide (LPS)-induced proliferation of B lymphocyte cells with the IC50 values ranging from 0.67 to 22.68 µM. Compounds 17 and 20 inhibit the concanavalin A (ConA)-induced proliferation of T lymphocyte cell with IC50 values of 31.50 and 0.98 µM, respectively. It is suggested that *C. odoratus* is a good source for bergamotane sesquiterpenoids, and their immunosuppressive activity was reported for the first time. This research is conducive to the further development and utilization of *C. odoratus*.

Keywords: *Craterellus odoratus*; sesquiterpenoids; isolation and structural elucidation; immunosuppresive activity

1. Introduction

Edible mushrooms are a large and fascinating group of fungi. Many species of wild edible mushrooms are valued ingredients due to their unique taste and short growth cycle. Yunnan Province is located in southwest China. Its unique climate and geological diversity make this area very favorable for the growth of wild mushrooms. It is estimated that more than 40% of the world’s and 90% of Chinese edible mushrooms (about 900 species) grow in Yunnan [1,2]. Many wild edible mushrooms are regarded as local delicacies such as *Tricholoma matsutake*, *Collybia albuminosa*, *Cantharellus cibarius*, and several species of the genus *Boletus*. Studying the chemical constituents of these edible mushrooms, therefore, has become our long-term research project [2–4]. The systematic mining of chemical components and evaluation of their biological activity will be beneficial to the scientific development and utilization of these edible fungi.

Species of the genus *Craterellus* (Cantharellaceae) include well-known edible mushrooms. At present, 142 records of *Craterellus* have been found and about 74 species are currently recognized as members of the genus. Ten species are originally described from Asia and four of these species have been reported in China [5]. Of them, *C. odoratus* is an edible mushroom in the family widespread in mainland China and characterized by possessing a bright orange or yellow cap [5–8]. In China, this wild edible mushroom is especially popular in Yunnan Province, where it is a delicacy on the dinner table from
June to August each year. In northern Thailand, *C. odoratus* is also a wild edible mushroom. Its nutritive value including the content of protein, fat, crude fiber, carbohydrate, and mineral contents was assessed. From the perspective of secondary metabolites, this mushroom has not been systematically studied, only a few polyketides and terpenoids have been reported [9–13]. Therefore, it is necessary to conduct systematic chemical component mining and biological activity evaluation on this mushroom. In this study, a total of 23 sesquiterpenoids (1–23, Figure 1) including eighteen new bergamotane-type ones, namely craterodoratins A–R (1–18), and one new victoxinine derivative, namely craterodoratin S (19), were isolated from *C. odoratus*. Their structures with absolute configurations were elucidated by extensive spectroscopic methods (including 1D and 2D NMR, MS, UV, and IR technologies), single-crystal X-ray diffraction analysis, as well as NMR and ECD calculations.

![Figure 1. Chemical structures of compounds 1–23.](image-url)
Previous pharmacological studies on bergamotane metabolites have demonstrated α-glucosidase inhibitory activity [14], antibacterial activity [9,15,16], inhibition of pancreatic lipase [17], and phytotoxic effects against Johnson grass and Sorghum [18–21]. In this study, all compounds were evaluated for their cytotoxic activities against five human cancer cell lines, and for their immunosuppressive activity on T-cell and B-cell proliferation. Herein the isolation, structural elucidation, and bioactivities of these isolates are reported.

2. Materials and Methods

2.1. General Experimental Procedures

IR spectra were obtained on a Shimadzu Fourier transform infrared spectrometer using KBr pellets. UV spectra were obtained by using a double beam spectrophotometer UH5300 (Hitachi High-Technologies, Tokyo, Japan). Optical rotations were measured on a Rudolph Autopol IV polarimeter (Hackettstown, NJ, USA). High resolution electrospray ionization mass spectra (HRESIMS) were recorded on an Agilent 6200 Q-TOF MS system or a Thermo Scientific Q Exactive Orbitrap MS system. Circular dichroism (CD) spectra were measured with an Applied Photochemistry spectrometer (Chirascan, New Haven, CT, USA). NMR spectra were recorded with a Bruker Avance III 600 MHz spectrometer (Bruker, Karlsruhe, Germany). Sephadex LH-20 (GE Healthcare, Pittsburgh, PA, USA), Silica gel (200–300 mesh), and RP-18 gel (20–45 µM, Fuji) were used for column chromatography (CC). HPLC was performed on an Agilent 1260 liquid chromatography system equipped with Zorbax SB-C18 columns (5 µM, 9.4 mm × 150 mm, or 21.2 mm × 150 mm).

2.2. Fungal Material

The fungus *Craterellus odoratus* was collected from the Southern part of the Gaoligong Mountains in Yunnan Province, China, in July 2007. The fungus was identified by Prof. Mu Zang at the Kunming Institute of Botany. A voucher specimen (HFC2007-20180714-DQ1) has been deposited in the School of Pharmaceutical Sciences, South-Central University for Nationalities.

2.3. Fermentation, Extraction and Isolation

The rice culture medium was composed of glucose 5%, yeast 5%, pork peptone 0.15%, KH$_2$PO$_4$ 0.05%, and MgSO$_4$ 0.05%. The initial pH was adjusted to 6.0. Cultures were grown in an Erlenmeyer flask (220 rpm, 24 °C) for 6 days until the mycelium biomass reached a maximum. This was then transferred to a rice medium and incubated at 24 °C in the dark for 40 days. The rice medium contained 50 g of rice and 50 mL of water, in a 250 mL Erlenmeyer flask, sterilized at 121 °C for 15 min. A total of 400 flasks were used in this work.

The solid rice culture broth of *C. odoratus* (20 kg) was extracted six time with MeOH to give a crude extract. The extract was partitioned between water and ethyl acetate (EtOAc). The EtOAc layer was concentrated under reduced pressure to give an organic extract (167 g). It was subjected to CC over silica gel (200–300 mesh) eluted with a solvent system of CHCl$_3$/MeOH (from 1:0 to 0:1, v/v) to obtain nine fractions A–I. Fraction D (20 g) was fractionated by MPLC over RP-18 silica gel eluted with MeOH/H$_2$O (from 5:95 to 100:0, v/v) to give 13 subfractions (D$_1$–D$_{13}$). Fraction D$_6$ (5 g) was repeatedly fractionated by CC over silica gel eluted with CHCl$_3$/MeOH (10:1) to give compounds 9 (7 mg), 10 (4 mg), and 11 (18 mg). Fraction D$_4$ (3 g) was fractionated by CC over Sephadex LH-20 (MeOH) and then purified by prep-HPLC (CH$_3$CN/H$_2$O 35:65 in 30 min) to give compounds 1 (3.0 mg, retention time (t$_R$) = 16.3 min), 8 (3.2 mg, t$_R$ = 20.1 min), and 4 (3.4 mg, t$_R$ = 24.7 min). Fraction D$_3$ (5 g) was fractionated by CC over Sephadex LH-20 (MeOH) and then purified by prep-HPLC (CH$_3$CN/H$_2$O 32.68 in 25 min) to give compounds 17 (2.3 mg, t$_R$ = 13.2 min), 20 (3.0 mg, t$_R$ = 15.4 min), and 18 (2.6 mg, t$_R$ = 22.0 min). Fraction E (9 g) was fractionated by MPLC over RP-18 eluted with MeOH/H$_2$O (from 5:95 to 100:0, v/v) to give seven subfractions (E$_1$–E$_7$). Fraction E$_3$ (800 mg) was subjected to CC over silica gel (80–100 mesh), Sephadex LH-20 (MeOH), and then purified by prep-HPLC.
(CH$_3$CN/H$_2$O from 25:75 to 61:39 in 25 min) to give compounds 3 (2.1 mg, $t_R = 11.2$ min), 6 (3 mg, $t_R = 15.3$ min), 7 (2.5 mg, $t_R = 17.9$ min), and 16 (3.8 mg, $t_R = 23.1$ min). Fraction E$_3$ (36 mg) was prepared by prep-HPLC (CH$_3$CN/H$_2$O 30:70 in 25 min) to give compounds 14 (2.1 mg, $t_R = 14.8$ min), 13 (2.4 mg, $t_R = 18.6$ min), and 15 (2.6 mg, $t_R = 23.0$ min). Fraction F (7 g) was separated by MPLC over RP-18 to give five subfractions F$_1$–F$_5$. Fraction F$_3$ (23 mg) was prepared by prep-HPLC (CH$_3$CN/H$_2$O 38:62 in 25 min) to give compounds 2 (2.3 mg, $t_R = 15.1$ min), 12 (2.0 mg, $t_R = 17.6$ min), and 5 (3.1 mg, $t_R = 20.3$ min). Fraction F$_4$ (30 mg) was prepared by prep-HPLC (CH$_3$CN/H$_2$O 40:60 in 25 min) to give compounds 21 (2.3 mg, $t_R = 13.0$ min), 22 (1.8 mg, $t_R = 17.0$ min), and 19 (3.1 mg, $t_R = 21.3$ min). Fraction G (1.2 g) was fractionated by CC over silica gel eluted with CHCl$_3$/CH$_3$OH (10:1) to give subfractions G$_1$–G$_6$. Compound 23 (3.2 mg) precipitated as acicular crystals from fraction G$_3$.

**Craterodoratin A (1).** Colorless oil; $[\alpha]_	ext{D}^{21} =$ −1.9 (c 0.11, MeOH); UV (MeOH) $\lambda_{\text{max}}$ (log $\epsilon$) 210 (1.04) nm; IR (KBr) $\nu_{\text{max}}$ 3365, 2945, 2833, 1660, 1454, 1114, 1031 cm$^{-1}$; $^1$H and $^{13}$C NMR spectroscopic data, see Table 1; HRESIMS $m/z$ 253.17986 [M + H]$^+$ (calcd for C$_{15}$H$_{25}$O$_5$, 253.17982).

**Table 1.** $^1$H (600 MHz) and $^{13}$C (150 MHz) NMR Spectroscopic Data for 1–4 in Methanol-$d_4$.

| Entry | $\delta_C$ (Type) | $\delta_H$ (in Hz) | $\delta_C$ (Type) | $\delta_H$ (in Hz) | $\delta_C$ (Type) | $\delta_H$ (in Hz) | $\delta_C$ (Type) | $\delta_H$ (in Hz) |
|-------|------------------|-------------------|------------------|-------------------|------------------|-------------------|------------------|-------------------|
| 1     | 49.9, C          |                   | 43.5, CH         |                   | 55.8, C          |                   | 41.5, C          |                   |
| 2     | 76.3, CH         | 4.02, d (9.1)     | 81.8, C          |                   | 79.7, CH         | 3.51, s           | 83.5, CH         | 3.44, s           |
| 3a    | 37.6, CH$_2$     | 2.16, m           | 48.2, CH$_2$     | 1.98, dd          | 43.2, C          |                   | 48.5, C          |                   |
| 3b    |                   | 1.00, dd (13.3, 3.3) |                   |                   |                   |                   |                   |                   |
| 4     | 41.9, CH         | 1.79, m           | 42.3, CH         | 1.86, t (4.3)     | 47.1, CH         | 1.83, m           | 46.5, CH         | 1.80, s           |
| 5a    | 27.5, CH$_2$     | 1.69, m           | 20.3, CH$_2$     | 1.73, m           | 26.5, CH$_2$     | 1.70, m           | 25.8, CH$_2$     | 1.68, m           |
| 5b    |                   | 1.27, m           |                   | 1.51, m           |                   | 1.39, m           |                   | 1.41, m           |
| 6a    | 25.8, CH$_2$     | 1.97, m           | 26.5, CH$_2$     | 1.72, m           | 21.9, CH$_2$     | 1.62, m           | 25.0, CH$_2$     | 1.69, m           |
| 6b    |                   | 1.23, m           |                   | 1.16, m           |                   | 1.10, m           |                   | 0.99, m           |
| 7a    | 50.9, C          |                   | 52.5, C          |                   | 37.2, CH$_2$     | 1.54, d (10.1)    | 40.4, CH$_2$     | 1.48, m           |
| 7b    |                   |                   |                   |                   |                   | 1.11, m           |                   | 1.11, d (10.3)    |
| 8a    | 30.9, CH$_2$     | 1.46, td (12.8, 12.3, 5.1) | 33.7, CH$_2$     | 1.98, dd (14.3, 4.3) | 42.3, CH$_2$     | 1.36, m           | 48.9, CH$_2$     | 1.71, m           |
| 8b    |                   | 1.17, td (12.8, 12.3, 5.1) |                   | 1.74, m           |                   |                   |                   | 1.45, m           |
| 9a    | 24.5, CH$_2$     | 2.25, m           | 66.4, CH         | 4.64, m           | 24.7, CH$_2$     | 2.15, m           | 65.3, CH         | 4.58, m           |
| 9b    |                   | 2.07, m           |                   |                   |                   |                   |                   |                   |
| 10    | 141.1, CH        | 6.69, t (7.4)     | 141.0, CH        | 6.48, d (7.8)     | 144.1, CH        | 6.72, t (7.4)     | 144.6, CH        | 6.57, d (9.28)    |
| 11    | 128.5, C         |                   | 129.4, C         |                   | 128.8, C         |                   | 126.6, C         |                   |
| 12    | 171.3, C         |                   | 171.2, C         |                   | 172.0, C         |                   | 170.4, C         |                   |
| 13    | 11.2, CH$_3$     | 1.80, s           | 11.8, CH$_3$     | 1.84, s           | 12.3, CH$_3$     | 1.78, s           | 11.4, CH$_3$     | 1.84, d (1.5)     |
| 14    | 12.3, CH$_3$     | 0.85, s           | 22.4, CH$_3$     | 1.25, s           | 17.0, CH$_3$     | 0.86, s           | 18.5, CH$_3$     | 1.07, s           |
| 15a   | 15.5, CH$_3$     | 0.93, s           | 63.4, CH$_2$     | 3.64, d (11.0)    | 65.1, CH$_2$     | 3.39, d (11.0)    | 16.1, CH$_3$     | 0.91, s           |
| 15b   |                   |                   |                   | 3.47, d (11.0)    |                   | 3.51, d (11.0)    |                   |                   |

**Craterodoratin B (2).** Colorless crystals (MeOH), mp 138.2–140.3 °C; $[\alpha]_	ext{D}^{21} =$ −11.4 (c 0.09, MeOH); UV (MeOH) $\lambda_{\text{max}}$ (log $\epsilon$) 215 (1.88) nm; IR (KBr) $\nu_{\text{max}}$ 3442, 2951, 2841, 1647, 1018 cm$^{-1}$; $^1$H and $^{13}$C NMR spectroscopic data, see Table 1; HRESIMS $m/z$ 267.15903 [M + H]$^+$ (calcd for C$_{15}$H$_{23}$O$_4$, 267.15909).
Craterodoratin C (3). Colorless crystals (MeOH), mp 180.7–182.4 °C; \([\alpha]^{21}_D - 14.5\) (c 0.11, MeOH); UV (MeOH) \(\lambda_{\text{max}}\) (log \(e\)) 230 (3.12) nm; IR (KBr) \(v_{\text{max}}\) 3464, 2924, 1647, 1280, 1265 cm\(^{-1}\); \(^1\)H and \(^{13}\)C NMR spectroscopic data, see Table 1; HRESIMS \(m/z\) 291.15650 [M + Na]\(^+\) (calcd for C\(_{15}\)H\(_{24}\)O\(_4\)Na\(^+\), 291.15668).

Craterodoratin D (4). Colorless crystals (MeOH), mp 159.1–162.5 °C; \([\alpha]^{21}_D + 32\) (c 0.10, MeOH); UV (MeOH) \(\lambda_{\text{max}}\) (log \(e\)) 225 (3.02) nm; IR (KBr) \(v_{\text{max}}\) 3468, 2967, 2541, 1647, 1016 cm\(^{-1}\); \(^1\)H and \(^{13}\)C NMR spectroscopic data, see Table 1; HRESIMS \(m/z\) 267.14712 [M – H]\(^-\) (calcd for C\(_{15}\)H\(_{22}\)O\(_3\)Na\(^-\), 267.16018).

Craterodoratin E (5). Colorless crystals (MeOH), mp 140.9–142.4 °C; \([\alpha]^{21}_D + 6.9\) (c 0.10, MeOH); UV (MeOH) \(\lambda_{\text{max}}\) (log \(e\)) 210 (1.27) nm; IR (KBr) \(v_{\text{max}}\) 3408, 2951, 2841, 1651, 1018 cm\(^{-1}\); \(^1\)H and \(^{13}\)C NMR spectroscopic data, see Table 2; HRESIMS \(m/z\) 307.15146 [M + Na]\(^+\) (calcd for C\(_{15}\)H\(_{22}\)O\(_3\)Na\(^+\), 307.15159).

| Table 2. \(^1\)H (600 MHz) and \(^{13}\)C (150 MHz) NMR Spectroscopic Data for 5–8 in Methanol-d\(_4\). |
|---|---|---|---|---|---|---|
| Entry | \(\delta_C\), Type | \(\delta_H\) (J in Hz) | \(\delta_C\), Type | \(\delta_H\) (J in Hz) | \(\delta_C\), Type | \(\delta_H\) (J in Hz) |
| 1 | 49.9, C | – | 49.8, C | – | 52.0, CH | 2.64, t, (5.3, 10.8) |
| 2 | 86.0, CH | 3.34, d, (1.3) | 82.2, CH | 3.47, d, (1.3) | 150.0, C | – |
| 3a | 47.3, C | – | 47.8, C | – | 23.1, CH\(_2\) | 2.61, m |
| 3b | 2.33, m | 24.3, CH\(_2\) | 2.65, m |
| 4a | 44.0, CH | 2.06, d, (3.8) | 44.7, CH | 2.23, d, (3.5) | 23.5, CH\(_2\) | 2.11, m |
| 4b | 1.82, m | 24.7, CH\(_2\) | 1.96, m |
| 5a | 27.0, CH\(_2\) | 1.71, m | 27.6, CH\(_2\) | 1.65, m | 39.4, CH | 2.32, m |
| 5b | 1.39, m | 40.6, CH | 2.27, m |
| 6a | 26.7, CH\(_2\) | 1.72, m | 26.7, CH\(_2\) | 1.66, m | 26.5, CH\(_2\) | 2.20, m |
| 6b | 0.99, m | 29.1, CH\(_2\) | 2.28, m |
| 7a | 41.9, CH\(_2\) | 1.38, d, (10.6) | 41.5, CH\(_2\) | 1.47, d, (9.7) | 54.7, C | 56.5, C |
| 7b | 1.13, d, (10.6) | – | 1.07, d, (9.7) | – |
| 8a | 47.0, CH\(_2\) | 1.70, m | 80.5, CH | 3.39, d, (6.0) | 40.4, CH\(_2\) | 2.50, dd, (12.4, 9.7) |
| 8b | 1.53, dd, (2.6, 14.8) | 2.02, dd, (12.4, 4.2) | 39.4, CH\(_2\) |
| 9 | 66.6, CH | 4.60, m | 70.6, CH | 4.38, dd, (9.1, 6.0) | 73.7, CH | 4.91, m |
| 10 | 6.49, d (8.2) | 138.4, CH | 6.53, d (8.6) | 143.0, CH | 6.74, dd, (1.5, 8.0) | 144.2, CH |
| 11 | 138.1, C | – | 128.1, C | – | 130.2, C | – |
| 12 | 174.9, C | – | 176.1, C | – | 169.8, C | – |
| 13 | 143.1, CH\(_3\) | 1.80, s | 14.3, CH\(_3\) | 1.86, s | 11.4, CH\(_3\) | 1.85, d, (1.5) |
| 14a | 12.8, CH\(_3\) | 1.85, s |
| 14b | 64.0, CH\(_2\) | 3.64, d, (11.7) | 19.9, CH\(_3\) | 1.04, s | 106.4, CH | 4.59, s |
| 15a | 106.8, CH | 4.57, s |
| 15b | 19.4, CH\(_3\) | 1.03, s | 12.2, CH\(_3\) | 0.81, s | 107.0, CH\(_2\) | 4.74, q, (1.8) |
| OCH\(_3\) | – | 53.3, CH\(_3\) | 3.29, s |

Craterodoratin F (6). Colorless oil; \([\alpha]^{21}_D + 18\) (c 0.10, MeOH); UV (MeOH) \(\lambda_{\text{max}}\) (log \(e\)) 210 (0.84) nm; IR (KBr) \(v_{\text{max}}\) 3400, 2949, 2837, 1653, 1456, 1411, 1112, 1024 cm\(^{-1}\); \(^1\)H and \(^{13}\)C NMR spectroscopic data, see Table 2; HRESIMS \(m/z\) 307.15161 [M + Na]\(^+\) (calcd for C\(_{15}\)H\(_{24}\)O\(_5\)Na\(^+\), 307.15159).
Craterodoratin G (7). Colorless oil; [α]_D^{21} + 1.10 (c 0.10, MeOH); UV (MeOH) λ_max (log ε) 210 (1.74) nm; IR (KBr) ν_max, 3444, 2933, 1647, 1091, 1016 cm⁻¹; ¹H and ¹³C NMR spectroscopic data, see Table 2; HRESIMS m/z 279.15903 [M + H]^+ (calcd for C_{15}H_{23}O_{4}^+, 279.15909).

Craterodoratin H (8). Colorless oil; [α]_D^{21} − 30.6 (c 0.16, MeOH); UV (MeOH) λ_max (log ε) 210 (0.68) nm; IR (KBr) ν_max, 3398, 2949, 2835, 1653, 1452, 1112, 1031 cm⁻¹; ¹H and ¹³C NMR spectroscopic data, see Table 2; HRESIMS m/z 279.15920 [M + H]^+ (calcd for C_{15}H_{23}O_{4}^+, 279.15909).

Craterodoratin I (9). Colorless oil; [α]_D^{21} + 31.6 (c 0.10, MeOH); UV (MeOH) λ_max (log ε) 230 (3.01) nm; IR (KBr) ν_max, 3379, 2947, 2835, 1653, 1456, 1114, 1031 cm⁻¹; ¹H and ¹³C NMR spectroscopic data, see Table 3; HRESIMS m/z 251.16409 [M + H]^+ (calcd for C_{15}H_{23}O_{5}^+, 251.16417).

### Table 3. ¹H (600 MHz) and ¹³C (150 MHz) NMR Spectroscopic Data for 9–12 in Methanol-d₄.

| Entry | 9   | 10  | 11  | 12  |
|-------|-----|-----|-----|-----|
|       | δ_C, Type | δ_H (J in Hz) | δ_C, Type | δ_H (J in Hz) | δ_C, Type | δ_H (J in Hz) | δ_C, Type | δ_H (J in Hz) |
| 1     | 51.0, CH | 2.10, t, (5.4) | 48.0, CH | 2.29, t, (5.6) | 51.3, CH | 2.09, t, (5.7) | 47.4, CH | 2.70, t, (5.3) |
| 2     | 87.4, C   | –            | 88.2, C   | –            | 87.3, C   | –            | 89.2, C   | –            |
| 3a    | 32.0, CH₂ | 1.88, m      | 161, m    | 27.4, CH₂   | 1.92, m   | 156 td, (10,2, 4,2) | 722, CH | 3.63, d, (6.8) | 29.5, CH₂ | 2.06, m      | 1.83, m    |
| 3b    | 22.4, CH₂ | 1.88, m      | 176, m    | 22.0, CH₂   | 1.91, m   | 1.82, m    | 32.8, CH₂ | 2.25, m      | 1.65, m    | 22.4, CH₂   | 1.95, m    |
| 4a    | 39.2, CH   | 2.24, q, (5.4) | 39.2, CH   | 2.32, m    | 37.8, CH   | 2.27, m    | 40.2, CH   | 2.43, q, (5.3) |
| 4b    | 22.2, CH₂ | 2.13, m      | 150, d (10.1) | 22.3, CH₂ | 2.14, m | 1.51, d (10.2) | 21.7, CH₂ | 2.11, m      | 2.05, m    | 22.1, CH₂   | 2.28, m    |
| 5     | 55.3, C   | –            | 53.7, C   | –            | 54.7, C   | –            | 53.6, C   | –            |
| 6a    | 32.4, CH₂ | 1.91, m      | 172, m    | 40.2, CH₂   | 2.01, dd, (14,2, 4,2) | 1.84, m   | 40.1, CH₂ | 2.00, dd, (14,2, 4,0) | 1.81, dd, (14,2, 4,0) | 43.4, CH₂ | 3.15, q, (3.2) |
| 6b    | 24.5, CH₂ | 2.19, m      | 210, m    | 65.7, CH   | 4.45, td, (8.7, 3.8) | 65.8, CH | 4.42, td, (9.0, 4,0) | 199.4, C | –              |
| 7     | 141.7, CH | 6.77, t, (7.5) | 143.6, CH | 6.67, d (7.7) | 141.7, CH | 6.57, d (9.0) | 130.6, CH | 7.11, s    |
| 10    | 127.9, C  | –            | 127.3, C  | –            | 129.3, C  | –            | 142.4, C  | –            |
| 11    | 170.4, C  | –            | 170.5, C  | –            | 172.2, C  | –            | 169.9, C  | –            |
| 12    | 11.0, CH₃ | 1.80, s      | 11.4, CH₃ | 1.83, s    | 11.8, CH₃ | 1.83, s    | 13.4, CH₃ | 2.15, s    |
| 13    | 70.2, CH₂ | 3.82, d (8.8) | 347, d (8.8) | 71.7, CH₂ | 3.94, d (9.4) | 3.63, d (9.4) | 71.5, CH₂ | 3.85, d (9.4) | 3.61, d (9.4) | 179.3, C | –            |
| 14a   | 24.0, CH₃ | 1.24, s      | 65.9, CH₂ | 3.49, d (11.4) | 3.45, d (11.4) | 21.0, CH₃ | 1.31, s   | 23.6, CH₃ | 1.51, s    |
| 15a   | 24.0, CH₃ | 1.24, s      | 65.9, CH₂ | 3.49, d (11.4) | 3.45, d (11.4) | 21.0, CH₃ | 1.31, s   | 23.6, CH₃ | 1.51, s    |

Craterodoratin J (10). Colorless oil; [α]_D^{21} + 52 (c 0.10, MeOH); UV (MeOH) λ_max (log ε) 210 (1.48) nm; IR (KBr) ν_max, 3465, 2947, 2835, 1653, 1456, 1114, 1031 cm⁻¹; ¹H and ¹³C NMR spectroscopic data, see Table 3; HRESIMS m/z 305.13602 [M + Na]^+ (calcd for C_{15}H_{23}O_{5}Na^+, 305.13594).

Craterodoratin K (11). Colorless oil; [α]_D^{21} + 37 (c 0.10, MeOH); UV (MeOH) λ_max (log ε) 210 (1.34) nm; IR (KBr) ν_max, 3456, 2924, 2815, 1647, 1396, 1018 cm⁻¹; ¹H and ¹³C NMR spectroscopic data, see Table 3; HRESIMS m/z 283.15136 [M + H]^+ (calcd for C_{15}H_{23}O_{5}^+, 283.15400).

Craterodoratin L (12). Colorless oil; [α]_D^{21} + 53 (c 0.11, MeOH); UV (MeOH) λ_max (log ε) 235 (1.12) nm; IR (KBr) ν_max, 3390, 2947, 2833, 1653, 1456, 1112, 1031 cm⁻¹; ¹H and
13C NMR spectroscopic data, see Table 3; HR-ESIMS m/z 279.12225 [M + H]+ (calcd for \( \text{C}_{19}\text{H}_{19}\text{O}_{4}\text{Na}^+; 279.12270\)).

**Craterodoratin M (13).** Colorless oil; \([\alpha]_D^{21} = -23\) (c 0.10, MeOH); UV (MeOH) \(\lambda_{\text{max}}\) (log \(\epsilon\)) 215 (1.90) nm; IR (KBr) \(v_{\text{max}}\) 3487, 1645 cm\(^{-1}\); \(^{1}\)H and 13C NMR spectroscopic data, see Table 4; HRESIMS m/z 253.17992 [M + H]+ (calcd for \(\text{C}_{13}\text{H}_{25}\text{O}_{3}^+; 253.17982\)).

### Table 4. 1H (600 MHz) and 13C (150 MHz) NMR Spectroscopic Data for 13–16 in Methanol-\(d_4\).

| Entry | \(\delta_{^13}\) Type | \(\delta_{^13} \text{ (J in Hz)}\) | \(\delta_{^12}\) Type | \(\delta_{^12} \text{ (J in Hz)}\) | \(\delta_{^11}\) Type | \(\delta_{^11} \text{ (J in Hz)}\) |
|-------|-----------------|-------------------|-----------------|-------------------|-----------------|-------------------|
| 1     | 40.3, CH        | 2.04, m           | 73.5, C         | –                 | 43.2, CH        | 2.48, d, (6.7)    |
|       | 2               |                   |                 |                   | 47.6, CH        | 1.87, m          |
| 2     | 39.2, CH        | 1.96, q, (5.1)    | 40.3, CH        | 1.38, m           | 149.4, C        | –                 |
|       | 3                 |                   |                 |                   | 150.2, C        | –                 |
| 3a    | 37.3, CH\(_2\)  | 1.84, m           | 29.6, CH\(_2\)  | 1.86, m           | 24.7, CH\(_2\)  | 2.64, m           |
| 3b    | 37.1, CH\(_2\)  | 1.76, m           | 26.7, CH\(_2\)  | 1.79, m           | 30.2, CH\(_2\)  | 1.95, m           |
| 4a    | 23.9, CH\(_2\)  | 3.16, m           | 74.9, C         | –                 | 37.6, CH        | 2.18, q, (5.4)    |
| 4b    | 23.8, CH\(_2\)  | 1.09, s           | 25.9, CH\(_2\)  | 1.92, m           | 34.6, CH\(_2\)  | 2.33, m           |
| 5     | 37.3, CH        | 2.13, m           | 74.9, C         | –                 | 37.6, CH        | 2.18, q, (5.4)    |
| 6a    | 18.0, CH\(_2\)  | 1.63, m           | 25.9, CH\(_2\)  | 1.92, m           | 34.6, CH\(_2\)  | 2.33, m           |
| 6b    | 17.2, CH\(_2\)  | 1.27, m           | 25.9, CH\(_2\)  | 1.92, m           | 34.6, CH\(_2\)  | 2.33, m           |
| 7     | 42.1, C         | –                 | 48.4, C         | –                 | 46.7, C         | –                 |
| 8a    | 22.9, CH\(_2\)  | 2.01, d, (5.7)    | 38.1, CH\(_2\)  | 1.53, t, (1.5)    | 32.3, CH\(_2\)  | 1.82, m           |
| 8b    | 22.9, CH\(_2\)  | 1.37, m           | 22.3, CH\(_2\)  | 2.21, m           | 23.8, CH\(_2\)  | 2.22, m           |
| 9a    | 23.7, CH        | 1.84, m           | 138.9, CH       | 6.60, t, (6.6)    | 142.5, CH       | 6.81, t, (7.0)    |
| 9b    | 23.7, CH        | 1.84, m           | 138.9, CH       | 6.60, t, (6.6)    | 142.5, CH       | 6.81, t, (7.0)    |
| 10    | 140.7, CH       | 6.71, dd, (7.4, 14.5) | 127.8, C       | –                 | 127.5, C       | –                 |
| 11    | 129.3, C        | –                 | 130.8, C        | –                 | 127.8, C       | –                 |
| 12    | 171.3, C        | –                 | 174.5, C        | –                 | 171.3, C       | –                 |
| 13    | 11.4, CH\(_3\) | 1.81, s           | 11.8, CH\(_3\)  | 1.81, s           | 11.1, CH\(_3\)  | 1.82, s           |
| 14a   | 15.8, CH\(_3\)  | 0.89, s           | 22.0, CH\(_3\)  | 1.09, s           | 15.6, CH\(_3\)  | 0.81, s           |
| 14b   | 15.8, CH\(_3\)  | 0.89, s           | 22.0, CH\(_3\)  | 1.09, s           | 15.6, CH\(_3\)  | 0.81, s           |
| 15a   | 65.3, CH\(_2\)  | 3.34, d, (2.6, 6.0) | 67.3, CH\(_2\)  | 3.34, d, (3.3)    | 106.1, CH\(_2\)  | 4.63, d, (2.0)    |
| 15b   | 65.3, CH\(_2\)  | 3.34, d, (2.6, 6.0) | 67.3, CH\(_2\)  | 3.34, d, (3.3)    | 106.1, CH\(_2\)  | 4.63, d, (2.0)    |

**Craterodoratin N (14).** Colorless oil; \([\alpha]_D^{21} = -11\) (c 0.10, MeOH); UV (MeOH) \(\lambda_{\text{max}}\) (log \(\epsilon\)) 210 (1.04) nm; IR (KBr) \(v_{\text{max}}\) 3487, 1645 cm\(^{-1}\); \(^{1}\)H and 13C NMR spectroscopic data, see Table 4; HRESIMS m/z 291.15658 [M + Na]+ (calcd for \(\text{C}_{15}\text{H}_{25}\text{O}_{4}\text{Na}^+; 291.15668\)).

**Craterodoratin O (15).** Colorless oil; \([\alpha]_D^{21} = -28.6\) (c 0.10, MeOH); UV (MeOH) \(\lambda_{\text{max}}\) (log \(\epsilon\)) 210 (1.48) nm; IR (KBr) \(v_{\text{max}}\) 3460, 2951, 2843, 1645, 1016 cm\(^{-1}\); \(^{1}\)H and 13C NMR spectroscopic data, see Table 4; HRESIMS m/z 251.16431 [M + H]+ (calcd for \(\text{C}_{15}\text{H}_{25}\text{O}_{3}^+; 251.16417\)).

**Craterodoratin P (16).** Colorless oil; \([\alpha]_D^{21} = -27.9\) (c 0.10, MeOH); UV (MeOH) \(\lambda_{\text{max}}\) (log \(\epsilon\)) 210 (1.77) nm; IR (KBr) \(v_{\text{max}}\) 3367, 2943, 2833, 1654, 1456, 1112, 1031 cm\(^{-1}\); \(^{1}\)H and 13C NMR spectroscopic data, see Table 4; HRESIMS m/z 251.16417 [M + H]+ (calcd for \(\text{C}_{15}\text{H}_{25}\text{O}_{3}^+; 251.16417\)).

**Craterodoratin Q (17).** Colorless oil; \([\alpha]_D^{21} = +22\) (c 0.07, MeOH); UV (MeOH) \(\lambda_{\text{max}}\) (log \(\epsilon\)) 210 (1.37) nm; IR (KBr) \(v_{\text{max}}\) 3468, 1645, 1016 cm\(^{-1}\); \(^{1}\)H and 13C NMR spectroscopic data, see Table 5; HRESIMS m/z 331.15140 [M + Na]+ (calcd for \(\text{C}_{17}\text{H}_{24}\text{O}_{5}\text{Na}^+; 331.15159\)).
Table 5. \(^1\)H (600 MHz) and \(^{13}\)C (150 MHz) NMR Spectroscopic Data for 17–19 in Methanol-d$_4$.

| Entry | \(\delta_\text{C}, \text{Type} \) | \(\delta_\text{H} \) (J in Hz) | \(\delta_\text{C}, \text{Type} \) | \(\delta_\text{H} \) (J in Hz) | \(\delta_\text{C}, \text{Type} \) | \(\delta_\text{H} \) (J in Hz) |
|-------|-------------------------------|-------------------|-------------------------------|-------------------|-------------------------------|-------------------|
| 1     | 48.2, CH                       | 3.00, t, (5.3, 10.6) | 45.0, CH                       | 2.03, t, (6.2)    | 40.8, CH                       | 2.31, br s        |
| 2     | 149.7, C                       | –                 | 44.2, CH                       | 1.94, q, (6.9)    | 42.2, CH                       | 2.82, s           |
| 3a    | 23.2, CH$_2$                   | 2.64, m           | 2.34, m                       | 96.5, C           | –                             | 159.1, C          |
| 3b    |                                |                   |                               |                   |                               |                   |
| 4a    | 22.6, CH$_2$                   | 1.90, m           | 41.0, CH$_2$                   | 2.24, m           | 58.7, CH$_2$                   | 3.51, m           |
| 4b    |                                |                   |                               | 1.87, d, (12.4)   |                               |                   |
| 5     | 38.5, CH                       | 2.21, m           | 37.7, CH$_3$                   | 2.33, q, (6.2)    | 58.8, CH$_2$                   | 3.51, m           |
| 6a    | 44.1, C                        | –                 | 35.6, CH$_2$                   | 2.49, m           | 58.7, CH                       | 1.99, br s        |
| 6b    |                                |                   |                               | 1.16, d, (9.7)    |                               |                   |
| 7a    | 25.5, CH$_2$                   | 2.43, m           | 1.51, d, (10.0)                | 39.2, C           | –                             | 48.4, C           |
| 7b    |                                |                   |                               |                   |                               |                   |
| 8a    | 37.9, CH$_2$                   | 2.17, dd, (8.7, 15.0) | 1.81, m | 39.5, CH$_2$                   | 1.85, m           | 40.8, CH$_2$                   | 1.41, m           |
| 8b    |                                |                   |                               | 1.71, dd, (14.8, 4.4) |                               |                   |
| 9a    | 65.7, CH                       | 4.60, m           | 65.7, CH                       | 4.45, m           | 24.8, CH$_2$                   | 1.63, m           |
| 9b    |                                |                   |                               |                   | 1.08, m                       |                   |
| 10    | 143.1, CH                      | 6.65, d, (8.4)    | 141.4, CH                      | 6.52, d, (8.2)    | 44.7, CH                       | 1.08, m           |
| 11    | 127.8, C                       | –                 | 129.7, C                       | –                 | 30.9, CH                       | 1.35, m           |
| 12    | 171.6, C                       | –                 | 172.6, C                       | –                 | 20.2, CH$_3$                   | 0.87, d, (6.5)    |
| 13    | 11.6, CH$_3$                   | 1.83, s           | 12.0, CH$_3$                   | 1.85, s           | 20.0, CH$_3$                   | 0.81, d, (6.5)    |
| 14a   | 64.8, CH$_2$                   | 4.00, d, (11.9)   | 3.93, d, (11.9)                | 69.3, CH$_2$      | 4.01, d, (10.2)                | 103.4, CH$_2$     |
| 14b   |                                |                   |                               | 3.94, d, (10.2)   |                               | 5.02, s           |
| 15a   | 106.7, CH$_2$                  | 4.67, br s        | 4.64, br s                     | 13.8, CH$_3$      | 1.06, d, (6.9)                 | 20.1, CH$_3$      |
| 15b   |                                |                   |                               |                   | 0.98, s                       |                   |
| -OOCCH$_3$ |                   | 2.00, s | 45.0, CH$_2$                   | 2.03, t, (6.2)    | 48.2, CH$_2$                   | 3.26, t, (6.0)    |
| -OOCCH$_3$ |                   | – | 44.2, CH                       | 1.94, q, (6.9)    | 174.0, C                       |                   |

Craterodoratin R (18). Colorless oil; \([\alpha]_{D}^{21} = 42 \) (c 0.10, MeOH); UV (MeOH) \(\lambda_{\text{max}}\) \(\text{nm}\): \(3412, 2924, 1637, 1574, 1435, 1065 \text{ cm}^{-1}\); \(^1\)H and \(^{13}\)C NMR spectroscopic data, see Table 5; HRESIMS \(m/z\) 305.13596 [M + Na]$^+$ (calcd for C$_{15}$H$_{22}$O$_5$Na$^+$, 305.13594).

Craterodoratin S (19). Colorless oil; \([\alpha]_{D}^{21} = 125 \) (c 0.10, MeOH); UV (MeOH) \(\lambda_{\text{max}}\) \(\text{nm}\): \(3412, 2924, 1637, 1574, 1435, 1065 \text{ cm}^{-1}\); \(^1\)H and \(^{13}\)C NMR spectroscopic data, see Table 5; HRESIMS \(m/z\) 278.21140 [M + H]$^+$ (calcd for C$_{17}$H$_{26}$NO$_2$$^+$, 278.21146).

X-ray Crystallographic Data for Craterodoratin B (2). C$_{15}$H$_{22}$O$_4$: \(m = 284.34\), \(a = 8.6658(3)\) \(\text{Å}\), \(b = 10.0982(4)\) \(\text{Å}\), \(c = 17.1595(6)\) \(\text{Å}\), \(a = 90^\circ\), \(\beta = 90^\circ\), \(\gamma = 90^\circ\), \(V = 1501.61(9)\) \(\text{Å}^3\), \(T = 100(2)\) \(\text{K}\), space group \(P2_12121\), \(Z = 4\), \(\mu(\text{Cu K}) = 0.768 \text{ mm}^{-1}\), 10292 reflections measured, 2967 independent reflections (R$_{\text{int}} = 0.0391$). The final R$_1$ values were 0.0314 (\(I > 2\sigma(I)\)). The final wR($F^2$) values were 0.0802 (\(I > 2\sigma(I)\)). The final R$_1$ values were 0.0325 (all data). The final wR($F^2$) values were 0.0813 (all data). The goodness of fit on \(F^2\) was 1.049. Flack parameter = 0.06(7). CCDC: 2059695 (https://www.ccdc.cam.ac.uk (accessed on 13 November 2021)).

X-ray Crystallographic Data for Craterodoratin C (3). C$_{15}$H$_{24}$O$_4$: \(m = 268.34\), \(a = 9.9718(3)\) \(\text{Å}\), \(b = 7.2863(2)\) \(\text{Å}\), \(c = 10.4844(3)\) \(\text{Å}\), \(a = 90^\circ\), \(\beta = 111.5850(10)^\circ\), \(\gamma = 90^\circ\), \(V = 708.35(4)\) \(\text{Å}^3\), \(T = 100(2)\) \(\text{K}\), space group \(P2_1211\), \(Z = 2\), \(\mu(\text{Cu K}) = 0.729 \text{ mm}^{-1}\), 13370 reflections measured, 2751 independent reflections (R$_{\text{int}} = 0.0334$). The final R$_1$ values were 0.0290 (\(I > 2\sigma(I)\)). The final wR($F^2$) values were 0.0749 (\(I > 2\sigma(I)\)). The final R$_1$ values were 0.0291 (all data).
The final \( wR(F^2) \) values were 0.0750 (all data). The goodness of fit on \( F^2 \) was 1.039. Flack parameter = 0.06(6). CCDC: 2059696 (https://www.ccdc.cam.ac.uk (accessed on 13 November 2021)).

**X-ray Crystallographic Data for Craterodoratin D** (4). \( \text{C}_{15}\text{H}_{24}\text{O}_4, M = 268.34, a = 6.4802(4) \text{ Å}, b = 10.8539(7) \text{ Å}, c = 10.8186(7) \text{ Å}, \alpha = 90.00^\circ, \beta = 101.555(2)^\circ, \gamma = 90.00^\circ, V = 745.51(8) \text{ Å}^3, T = 297(2) \text{ K}, \) space group \( \text{P}1211, Z = 2, \mu(\text{Cu K}) = 1.54178, 15119 \) reflections measured, 3109 independent reflections (\( R_{int} = 0.0263 \)). The final \( R_1 \) values were 0.0293 (all data). The final \( wR(F^2) \) values were 0.0798 (all data). The goodness of fit on \( F^2 \) was 1.051. Flack parameter = 0.09(4). CCDC: 2059697 (https://www.ccdc.cam.ac.uk (accessed on 13 November 2021)).

**X-ray Crystallographic Data for Craterodoratin E** (5). \( \text{C}_{15}\text{H}_{24}\text{O}_5 \cdot \text{H}_2\text{O}, M = 302.36, a = 25.5045(11) \text{ Å}, b = 6.4589(3) \text{ Å}, c = 19.4274(8) \text{ Å}, \alpha = 90^\circ, \beta = 97.923(2)^\circ, \gamma = 90^\circ, V = 3169.7(2) \text{ Å}^3, T = 100(2) \text{ K}, \) space group \( \text{C}121, Z = 8, \mu(\text{Cu K}) = 0.805 \text{ mm}^{-1}, 50,328 \) reflections measured, 6168 independent reflections (\( R_{int} = 0.0956 \)). The final \( R_1 \) values were 0.0680 (\( I > 2\sigma(I) \)). The final \( wR(F^2) \) values were 0.1739 (\( I > 2\sigma(I) \)). The final \( R_1 \) values were 0.0741 (all data). The final \( wR(F^2) \) values were 0.1821 (all data). The goodness of fit on \( F^2 \) was 1.085. Flack parameter = 0.26(11). CCDC: 2059698 (https://www.ccdc.cam.ac.uk (accessed on 13 November 2021)).

2.4. NMR and ECD Calculations

Details of NMR and ECD calculations for compounds 1, 6–8, 10, 11 and 18 were given in the Supplementary Materials.

2.5. Cytotoxicity Assay

There are five human cancer cell lines using in this assay including human myeloid leukemia HL-60, human breast cancer MCF-7, human colon cancer SW480, human hepatocellular carcinoma SMMC-7721, and human lung cancer A-549 cells. All selected cells were stored in DMEM medium or RPMI-1640, supplemented with 10% fetal bovine serum (Hyclone, Logan, UT, USA) at 37\(^\circ\)C. The MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide) method in 96-well microplates was used for cytotoxicity assay [22]. In brief, 100 \( \mu \)L adherent cells were seeded into each well for 12 h before drug addition, while suspended cells were seeded just before adding the test compound with initial density of \( 1 \times 10^5 \) cells/mL. The tumor cell line was exposed to the test compound at concentrations of 0.0625, 0.32, 1.6, 8 and 40 \( \mu \)M in triplicates for 48 h. Taxol (Sigma, St. Louis, MO, USA) was used as a positive control. The cell viability was detected, and the cell growth curve was graphed after compound treatment. The IC\(_{50}\) values were calculated by the Reed and Muench’s method [23].

2.6. Immunosuppressive Activities Assay

2.6.1. Preparation of Spleen Cells from Mice

Female BALB/c mice were sacrificed by cervical dislocation, and their spleens were aseptically removed. After cell debris, mononuclear cell suspensions were prepared, and clumps were removed. Erythrocytes were depleted with ammonium chloride buffer solution. Lymphocytes were washed and resuspended in RPMI 1640 medium supplemented with 10% FBS, penicillin (100 U/mL), and streptomycin (100 mg/mL).

2.6.2. Cytotoxicity Assay

We used the Cell Counting Kit-8 (CCK-8) assay to test cytotoxicity. In brief, fresh spleen cells were obtained from female BALB/c mice (18–20 g). Spleen cells (\( 1 \times 10^6 \) cells) were seeded in triplicate in 96-well flat plates and cultured at 37\(^\circ\)C for 48 h, with or without compounds of various concentrations, in a humidified and 5% CO\(_2\)-containing incubator. A certain amount of CCK-8 was added to each well during the last 8–10 h of culture. At the end of the culture, we used a microplate reader (Bio-Rad 650) to measure the OD value at 450 nm. Cyclosporin A (CsA) is an immunosuppressant agent which is used as a positive
control with definite activity. Only the OD value of culture medium is used as background. The cytotoxicity of compounds was expressed as the concentration of the compounds that reduces cell viability to 50% (CC\textsubscript{50}).

2.6.3. T and B Cell Function Assay

As mentioned above, fresh spleen cells were obtained from female BALB/c mice (18–20 g). Similarly, the 5 × 10\textsuperscript{5} spleen cells were cultured at the same conditions. The cultures, with or without various concentrations of compounds, were stimulated with 5 µg/mL of concanavalin A (ConA) to induce the T cells’ proliferative response or 10 µg/mL of lipopolysaccharide (LPS) to induce B cells’ proliferative response. Proliferation was assessed in terms of uptake of [\textsuperscript{3}H]-thymidine during 8 h of pulsing with 25 µL/well of [\textsuperscript{3}H]-thymidine, then cells will be harvested onto glass fiber filters. A Beta scintillation counter was used to count the incorporated radioactivity. Cells treated without any stimuli were used as a negative control. The immunosuppressive activity was expressed as the concentration of the compound that inhibited T or B cell proliferation to 50% (IC\textsubscript{50}) of the control value. Both the cytotoxicity and proliferation assessment were repeated twice.

3. Results and Discussion

Compound 1 was isolated as a colorless oil. Its molecular formula of C\textsubscript{15}H\textsubscript{24}O\textsubscript{3} was determined by positive high-resolution electrospray ionization mass spectrometry (HRESIMS) analysis, corresponding to four degrees of unsaturation. In the \textsuperscript{1}H NMR data, three singlets for methyl groups were readily observed at δ\textsubscript{H} 1.80 (3H, s, Me-13), δ\textsubscript{H} 0.93 (3H, s, Me-15), δ\textsubscript{H} 0.85 (3H, s, Me-14) (Table 1). The \textsuperscript{13}C NMR and DEPT data revealed 15 carbon resonances including three CH\textsubscript{3}, five CH\textsubscript{2}, three CH, and four non-protonated carbons (Table 1). Of them, two olefinic carbons at δ\textsubscript{C} 141.1 (C-10) and 128.5 (C-11), and one carboxy carbon at δ\textsubscript{C} 171.3 (C-12) occupied two degrees of unsaturation, which suggested that 1 should be a bicycle sesquiterpenoid. Preliminary analysis of 1D and 2D NMR data, with respect to those in previous isolated from the same source, suggested that 1 might be a bergamotane-type sesquiterpenoid. The theoretical NMR calculations and DP4+ probability analyses were employed on two possible structures of (1\textsuperscript{S}*,2\textsuperscript{R}*,4\textsuperscript{S}*,7\textsuperscript{R}*)-\textsuperscript{1}a and (1\textsuperscript{S}*,2\textsuperscript{S}*,4\textsuperscript{S}*,7\textsuperscript{R}*)-\textsuperscript{1}b, and the calculations messages suggested that (1\textsuperscript{S}*,2\textsuperscript{R}*,4\textsuperscript{S}*,7\textsuperscript{R}*)-\textsuperscript{1}a was the correct relative configuration for 1 (see Table S3 in Section S1). Finally, the absolute configuration of 1 was established to be 1\textsuperscript{S},2\textsuperscript{R},4\textsuperscript{S},7\textsuperscript{R} by ECD calculations (Figure 5). Therefore, compound 1 was identified and named as craterodoratin A.
Compound 2 was isolated as colorless crystals. Its molecular formula of C_{15}H_{22}O_{4} was determined by HRESIMS analysis, corresponding to five degrees of unsaturation. All the spectroscopic data indicated similar patterns to those of 1, suggesting that 2 has a similar structure to 1. Detailed analysis of 1D and 2D NMR data revealed the differences. Firstly, Me-14 shifted to δC 79.7, suggesting that (1S,2S,7R,9S,13R)-hydroxyalbumol [24]. The double bond between C-7 and C-8 was supported by the double bond in (1S,2S,7R,9S,13R)-hydroxyalbumol [24]. The double bond between C-7 and C-8 was suggested by the HMBC correlation from H-7a and H-8 in 2.

Figure 2. ^1^H-^1^H COSY and key HMBC correlations of 1–3, 7, 9, 13, and 17–19.

Figure 3. ROESY correlations of 1, 2, 7, 8, and 13.
similar structure to 1. Detailed analysis of 1D and 2D NMR data revealed the differences. Firstly, Me-15 was oxygenated into a hydroxymethylene in 2 as suggested by the HMBC correlations from δ\textsubscript{H} 3.64 (1H, J = 11.0 Hz, H-15a) and δ\textsubscript{H} 3.47 (1H, d, J = 11.0 Hz, H-15b) to δ\textsubscript{C} 43.5 (C-1), 42.3 (C-4), 52.5 (C-7) and 33.7 (C-8) (Figure 2). Secondly, Me-14 shifted from C-1 to C-2 in 2 which supported by HMBC correlations from δ\textsubscript{H} 1.25 (3H, s, Me-14) to δ\textsubscript{C} 43.5 (C-1), 81.8 (C-2), and 48.2 (C-3). Thirdly, analysis of the MS data and carbon shifts at δ\textsubscript{C} 81.8 (C-2) and δ\textsubscript{C} 66.4 (C-9), as well as the HMBC from δ\textsubscript{H} 4.64 (1H, m, H-9) to δ\textsubscript{C} 81.8 (C-2) indicated an ether bond between C-2 and C-9. The ROESY (Figure 3) cross peaks of H\textsubscript{3}-14/H-5b, and H\textsubscript{3}-14/H-6b indicated Me-14, H-5b, and H-6b were on the same side, cross peaks of H\textsubscript{2}-15/H-6a, and H\textsubscript{2}-15/H-5a indicated CH\textsubscript{2}-15, H-5a, and H-6a were on the same side, while correlations between H-9/H\textsubscript{3}-13 and the absence of the ROESY correction of between H\textsubscript{3}-13/H-10 confirmed the E-configured double bond. Finally, the single-crystal X-ray diffraction established the structure of 2 with the absolute configuration (Flack parameter = 0.06 (7), CCDC: 2059695. Figure 4). Therefore, compound 2 was identified and named as craterodoratin B.

Compound 3 was isolated as colorless crystals. Its molecular formula of C\textsubscript{15}H\textsubscript{24}O\textsubscript{5} was determined by HRESIMS data, corresponding to four degrees of unsaturation. The \textsuperscript{13}C NMR and DEPT data (Table 1) displayed 15 carbon resonances including two methyl carbons (δ\textsubscript{C} 12.3 and 17.0), one olefinic methine carbons (δ\textsubscript{C} 144.1), one oxygenated methine carbon (δ\textsubscript{C} 79.7), six methylenes, one methine, two sp\textsuperscript{3} quaternary carbons (δ\textsubscript{C} 55.8 and 43.2), and one carboxyl carbon (δ\textsubscript{C} 172.0). Analysis of 2D NMR data including \textsuperscript{1}H-\textsuperscript{1}H COSY and HMBC correlations as shown in Figure 2 suggested that 3 should be a bergamotane-type sesquiterpenoid related to (Z)-2\textalpha-Hydroxyalbumol [24]. The differences were that C-12 and C-15 in 3 were oxidized into a carboxy group and a hydroxymethylene group, respectively. In the ROESY spectrum, cross peaks of H-7a and H-8 supported that C-7 and C-8 were on the same side. Besides, the double bond between C-10 and C-11 in 3 was
assigned as E geometry by the ROESY correlation of H-9/H-13. The single-crystal X-ray diffraction established the absolute configuration of 3 (Flack parameter = 0.06(6), CCDC: 2059696, Figure 4). Therefore, compound 3 was identified and named as craterodoratin C.

Compound 4 was isolated as colorless crystals. Its molecular formula of C_{13}H_{24}O_{4} was determined by HRESIMS data, the same as that of 3. All the spectroscopic data showed similar patterns to those of 3, except one oxygenated methylene group of C-15 was reduced to a methyl group in 4. This was supported by the key HMBC correlations from δH 0.91 (3H, s, Me-15) to δC 41.5 (C-1), 83.5 (C-2), and 25.0 (C-6). In addition, C-9 was oxidized into a hydroxymethine group, as demonstrated by the HMBC correlations from δH 4.58 (1H, m, H-9) to δC 48.9 (C-8), 144.6 (C-10), and 126.6 (C-11). The single-crystal X-ray diffraction not only confirmed the planar structure as elucidated above but also established the absolute configuration (Flack parameter = 0.09(4), CCDC: 2059697, Figure 4). Therefore, compound 4 was identified and named as craterodoratin D.

Compound 5 was isolated as colorless crystals. Its molecular formula of C_{13}H_{24}O_{5} was determined by HRESIMS data, corresponding to four degrees of unsaturation. The 1D NMR data (Table 2) indicated that 5 has a closely related structure to that of 4, except that one methyl group of C-14 was oxygenated into a hydroxymethylene group in 5. It was supported by the loss of one methyl signal in the 1H NMR spectrum and the HMBC correlations from δH 3.64 (1H, d, J = 11.7 Hz, H-14a) and δH 3.53 (1H, d, J = 11.7 Hz, H-14b) to δC 86.0 (C-2), 47.3 (C-3), 44.0 (C-4), and 47.0 (C-8). The single-crystal X-ray diffraction confirmed the planar structure and established the absolute configuration (Flack parameter = 0.26(11), CCDC: 2059698. Figure 4). Thus, compound 5 was identified and named as craterodoratin E.

Compound 6 was isolated as a colorless oil. Its molecular formula of C_{15}H_{26}O_{5} was determined by HRESIMS data, corresponding to four degrees of unsaturation. All the spectroscopic data indicated that 6 had a similar structure to that of 4. Detailed analysis of 1D and 2D NMR data revealed that C-8 was oxygenated into a hydroxyethene group in 6 as established by the shift at δC 80.5 (C-8) and MS data. The coupling constant (ν_{H-H} = 6.0 Hz) of H-8/H-9 of 6 observed in 1H NMR spectrum and a strong ROESY correlation between H-9 and H-2 suggested anti configuration of H-8 and H-9 [25]. To determine the stereochemistry of C-8, the theoretical NMR calculations and DP4 + probability analyses were employed on two possible relative structures (1R*,2R*,3R*,4S*,8S*,9S*)-6a and (1R*,2R*,3R*,4S*,8R*,9S*)-6b. The results suggested that (1R*,2R*,3R*,4S*,8R*,9S*)-6b was the correct relative configuration for 6 (see Table S6 in Section S2). Based on this, the absolute configuration of 6 was suggested to be 1R,2R,3R,4S,8R,9S by the ECD calculations (Figure 5). Therefore, compound 6 was identified and named as craterodoratin F.

Compounds 7 and 8 were isolated as a pair of epimers. They possessed the same molecular formula of C_{18}H_{22}O_{4}, on the basis of HRESIMS data. Analysis of 1D (Table 1) and 2D NMR data suggested that the planar structures of 7 and 8 were similar to that of donacinoic acid A (23) [9], except the ether bond between C-2 and C-14 was cut off to give a methoxy group at C-14. In the ROESY spectra, the observed correlations of H-14/H-15a in 7 and H-5/H-14 in 8 suggested that the stereo-configurations of C-14 in 7 and 8 were different. The theoretical NMR calculations and DP4 + probability analyses were employed to elucidate the relative configurations of 7 and 8 (see Tables S9 and S10). Then, the ECD calculations established the absolute configurations to be 7S,9S,14S for 7 and 7S,9S,14R for 8 (Figure S9 in Section S3). Finally, compounds 7 and 8 were identified and named as craterodoratins G and H, respectively.
the correct relative configuration for \( \text{6} \) (see Table S6 in Section S2). Based on this, the absolute configuration of \( \text{6} \) was suggested to be \( 1^R, 2^R, 3^R, 4^S, 8^R, 9^S \) by the ECD calculations (Figure 5). Therefore, compound \( \text{6} \) was identified and named as craterodoratin F.

Figure 5. ECD calculations for compounds 1, 6, 7, 8, 10, 11, and 18.

Compound 9 was isolated as a colorless oil. Its molecular formula of \( \text{C}_{15}\text{H}_{22}\text{O}_3 \) was determined on the basis of the HRESIMS data, corresponding to five degrees of unsaturation. Analysis of its NMR data (Table 3) indicated similar patterns to those of massarinolin B [15], except that C-9 in massarinolin B was reduced to a methylene in 9 as determined by the MS data and \(^1\text{H}--^1\text{H} \) COSY correlations (Figure 2). Therefore, compound 9 was identified and named as craterodoratin I.
Compound 10 was isolated as a colorless oil. Its molecular formula of C_{15}H_{22}O_{5} was determined by HRESIMS analysis, corresponding to five degrees of unsaturation. The \(^1\)H and \(^{13}\)C NMR (Table 3) spectroscopic characteristics were similar to those of 9, except for two hydroxy groups placed at C-15 and C-9 in 10. These were determined by the HMBC correlations from \(\delta_1\) 4.45 (1H, td, \(J = 8.7, 3.8\) Hz, H-9) to \(\delta_C\) 40.2 (C-8), 143.6 (C-10), 127.3 (C-11), and from \(\delta_1\)H 3.49 (1H, d, \(J = 11.4\) Hz, H-15a), 3.45 (1H, d, \(J = 11.4\) Hz, H-15b) to \(\delta_C\) 88.2 (C-2), 27.4 (C-3), 48.0 (C-1). According to the ROESY correlation between H-9 and H-13, the double bond was established as E form. The absolute configuration was established by ECD calculations as shown in Figure 5. Therefore, compound 10 was identified and named as craterodoratin J.

Compound 11 was isolated as a colorless oil. Its molecular formula of C_{15}H_{22}O_{5} was determined by HRESIMS analysis, corresponding to five degrees of unsaturation. The \(^1\)H and \(^{13}\)C NMR (Table 3) and DEPT (Table 4) data of 11 displayed signals for structural features similar to 10, except that one hydroxy was transferred from C-15 to C-3. The location was determined by the HMBC correlations from \(\delta_1\)H 1.31 (3H, s, Me-15) to \(\delta_C\) 87.3 (C-2), 72.2 (C-3), 51.3 (C-1), and from \(\delta_1\)H 3.63 (1H, d, \(J = 6.8\) Hz, H-3) to \(\delta_C\) 87.3 (C-2), 32.8 (C-4). The stereo-configurations for C-3 and C-9 could not be established according to the ROESY data. Thus, the theoretical NMR calculations and DP4 + probability analyses were employed on four possible structures (see Table S17 in Section S5). Based on these data, the absolute configuration of 11 was suggested to be 1\(R\),2\(S\),3\(R\),5\(R\),7\(S\),9\(S\) by the ECD calculations (Figure 5). Therefore, compound 11 was identified and named as craterodoratin K.

Compound 12 was isolated as a colorless oil. Its molecular formula of C_{15}H_{18}O_{5} was determined by HRESIMS analysis, corresponding to seven degrees of unsaturation. The \(^1\)H and \(^{13}\)C NMR and DEPT (Table 3) data of 12 displayed signals for structural features similar to 9, except that C-14 and C-9 were oxidized into two carbonyl carbons in 12. The locations were determined by the HMBC correlations from \(\delta_1\)H 1.32 (2H, q, \(J = 3.2\) Hz, H-8) to \(\delta_C\) 40.2 (C-5), 53.6 (C-7), 179.3 (C-14), and 199.4 (C-9). Therefore, compound 12 was identified and named as craterodoratin L.

Compound 13 was isolated as a colorless oil. Its molecular formula of C_{15}H_{24}O_{3} was determined by HRESIMS analysis, corresponding to four degrees of unsaturation. The \(^{13}\)C NMR and DEPT spectrum (Table 4) displayed 15 carbon resonances including two methyl carbons, one olefinic methine carbon, one quaternary olefinic carbon, five methylenes, three methines, and one quaternary carbon. Analysis of 1D and 2D NMR data suggested that 13 had a similar structure to that of massarinolin C (21) [15]. The locations of 7-Me and 2-CH_{2}OH were determined by the HMBC correlations from \(\delta_1\)H 0.89 (3H, s, Me-14) to \(\delta_C\) 40.3 (C-1), 39.2 (C-5), 42.1 (C-7), 37.3 (C-8), and from \(\delta_1\)H 3.34 (2H, dd, \(J = 6.0, 2.6\) Hz, H-15) to \(\delta_C\) 40.3 (C-1), 37.2 (C-2), 18.0 (C-3). In the ROESY spectrum (Figure 3), the cross peak of H-13/H-2 indicated that Me-14 and H-2 were on the same side, while the cross peak of H-9/H-13 indicated the E form of the double bond. Therefore, compound 13 was identified as craterodoratin M.

Compound 14 was isolated as a colorless oil. Its molecular formula of C_{15}H_{24}O_{4} was determined by HRESIMS analysis, corresponding to four degrees of unsaturation. All 1D and 2D NMR data suggested that 14 had a structure closely related to that of 13 except that one more hydroxy group at C-1 in 14, which was supported by the HMBC correlations from \(\delta_1\)H 1.09 (3H, s, Me-14) to \(\delta_C\) 73.5 (C-1), 47.3 (C-5), and 48.4 (C-7). Detailed analysis of 2D NMR data suggested that the other parts of 14 were the same as those of 13. Therefore, compound 14 was identified and named as craterodoratin N.

Compound 15 was isolated as a colorless oil. Its molecular formula of C_{15}H_{22}O_{3} was determined by HRESIMS analysis, corresponding to five degrees of unsaturation. The \(^1\)H and \(^{13}\)C NMR and DEPT (Table 4) data of 15 displayed a close resemblance to those of 13. One significant difference was that the hydroxy group was substituted at C-5, as evidenced by HMBCs from \(\delta_1\)H 2.33 (1H, m, H-6a) and 1.79 (1H, d, \(J = 9.5\) Hz, H-6b) to \(\delta_C\) 43.2 (C-1), 74.9 (C-5), and 48.6 (C-7). In addition, one terminal double bond was established between C-2 and C-15, as proved by HMBC correlations from \(\delta_1\)H 4.63 (2H, d, \(J = 2.0\) Hz, H-15) to \(\delta_C\)
Compound 16 was isolated as a colorless oil. Its molecular formula of $C_{15}H_{22}O_3$ was determined to be the same to that of 15 by HRESIMS data. Detailed analysis of 1D and 2D NMR data suggested that 16 had a very similar structure to that of 15 except for the hydroxy group at C-14 in 16 replaced at C-5 in 15. It was supported by the HMBC correlations from $\delta_H 3.43$ (1H, d, $J = 11.7$ Hz, H-14a) and $\delta_H 3.33$ (1H, d, $J = 11.7$ Hz, H-14b) to $\delta_C 47.6$ (C-1), 37.6 (C-5), 29.9 (C-8). Therefore, compound 16 was identified and named as craterodoratin P.

Compound 17 was isolated as a colorless oil. Its molecular formula of $C_{17}H_{24}O_5$ was determined by HRESIMS analysis, corresponding to six degrees of unsaturation. The $^1H$ and $^{13}C$ NMR and DEPT (Table 5) data of 17 displayed a close resemblance to those of massarinolin C (21) [15]. Analysis of 2D NMR data suggested that one more O-acetyl group was substituted at C-14, as evidenced by HMBC correlations from $\delta_H 4.00$ (1H, d, $J = 11.9$ Hz, H-14a) and 3.93 (1H, d, $J = 11.9$ Hz, H-14b) to $\delta_C 48.2$ (C-1), 38.5 (C-5), 37.9 (C-8), 171.6 (OOCCH$_3$). The absolute configuration of 17 was established by ECD calculations as shown in Figure S18 in Section S6. Therefore, compound 17 was identified and named craterodoratin Q.

Compound 18 was isolated as a colorless oil. Its molecular formula of $C_{17}H_{22}O_5$ was determined by HRESIMS data, corresponding to five degrees of unsaturation. The 1D NMR data (Table 5) indicated that 18 should have a closely related structure to that of brasiliamide A [26]. One significant difference was that the amide group was replaced by a carboxy group at $\delta_C 172.6$ (C-12), as evidenced by the MS data. In addition, C-9 and C-14 in 18 was reduced into a hydroxymethine group ($\delta_C 65.7$) and a methylene ($\delta_C 69.3$), respectively, as supported by the HMBC correlations from $\delta_H 4.41$ (1H, m, H-9) to $\delta_C 39.5$ (C-8) and 141.4 (C-10), and from $\delta_H 4.01$ (1H, d, $J = 10.2$ Hz, H-14a) and 3.94 (1H, d, $J = 10.2$ Hz, H-14b) to $\delta_C 45.0$ (C-1), 39.2 (C-7), 96.5 (C-3), and 37.7 (C-5). Based on the ROESY data, cross peaks of H-9/H-14 supported that H-9 and C-14 were on the same side; cross peaks of H-2/H-6b supported that H-2 and C-14 were on the same side. Finally, the absolute configuration of 18 was suggested to be 1S, 2S, 3R, 5R, 7S, 9S by the ECD calculations (Figure S5). Therefore, compound 18 was identified and named craterodoratin R.

Compound 19 was isolated as a colorless oil. Its molecular formula of $C_{17}H_{27}NO_2$ was determined by HRESIMS data, which suggested an N-containing structure. The 1D and 2D NMR data of 19 were similar to those of vitoroxine [19,27], except that one oxygenated methylene carbon at C-17 in vitoroxine was replaced by a carboxyl group in 19 as proved by HMBC correlation from $\delta_H 3.26$ (2H, t, $J = 6.0$ Hz, H-16) to $\delta_C 174.0$ (C-17). Detailed analysis of 2D NMR data suggested that the other parts of 19 were the same as that of vitoroxine. Therefore, compound 19 was identified and named craterodoratin S.

In addition to the new compounds as described above, four known sesquiterpenoids obtained in this study were identified as massarinolin B (20) [15,28], massarinolin C (21) [15], massarinolin A (22) [15], and donacinoic acid A (23) [9] by comparison of their spectroscopic data with those reported in the literature. The biosynthesis of the isolated compounds 1–18 and 20–23 was proposed as shown in Scheme 1. Bergamotane sesquiterpenoids, bearing a borneol ring system or a $\beta$-pinene ring system, are naturally occurring in plants and fungi (Scheme 1) [9,14–17,29–34]. In this study, compounds 1 and 2 possess a rare carbon skeleton while the methyl group (C-14) in 2 had a further 1,2-migration. The sesquiterpenes 7–18 belong to $\beta$-pinene derivatives (Scheme 1), which produced compounds 3–6 by an alkyl migration.
In addition to the new compounds as described above, four known compounds were evaluated for their cytotoxicity to five human cancer cell lines (HL-60, A-549, SMMC-7721, SW480, MCF-7). However, no compounds are active at the concentration of 40 µM. In addition, all the compounds were investigated for their in vitro immunomodulatory effect on BALB/c mice T and B lymphocyte proliferation. Compounds 3, 10, 12–15, 19, 20, and 23 exhibited potent inhibitory activity against LPS-induced proliferation of B lymphocyte cell with IC50 values ranging from 0.67 to 22.68 µM. Compounds 17 and 20 exhibited inhibitions on ConA-induced proliferation of T lymphocyte cells with IC50 values of 31.50 and 0.98 µM, respectively (Table 6).

Table 6. Immunosuppressive Tests of the Isolates.

| Entry | CC50 (µM) | Con A-Induced T-Cell Proliferation | LPS-Induced B-Cell Proliferation |
|-------|-----------|----------------------------------|---------------------------------|
|       | IC50 (µM) | SI a                             | IC50 (µM) | SI a |
| 3     | >40       | –                                 | 12.62 ± 1.14 | >3.17 |
| 10    | >40       | –                                 | 19.40 ± 0.48 | >2.06 |
| 12    | >40       | –                                 | 13.71 ± 0.65 | >2.92 |
| 13    | >40       | –                                 | 15.43 ± 1.03 | >2.59 |
| 14    | >40       | –                                 | 13.26 ± 1.29 | >3.02 |
| 15    | >40       | –                                 | 17.12 ± 1.14 | >2.34 |
| 17    | 31.50 ± 1.79 | >1.27                             | – | – |
| 19    | >40       | –                                 | 22.68 ± 1.67 | >1.76 |
| 20    | 0.98 ± 0.01 | >40.82                           | 0.67 ± 0.004 | >59.26 |
| 23    | >40       | –                                 | 13.23 ± 0.97 | >3.02 |
| CsA   | >2.80     | 0.04                             | >70.00 | 0.47 | >5.95 |

SI (selectivity index) is determined as the ratio of the concentration of the compounds that reduced cell viability to 50% (CC50) to the concentration of the compounds needed to inhibit the proliferation by 50% relative to the control value (IC50).
Structurally, almost all bergamotane sesquiterpenoids in this study contain an \( \alpha,\beta \)-unsaturated carboxylic acid moiety, which might be the key functional group for their immunosuppressive activity. However, it seems that the compounds (10 and 12–15) with a basic core of a \( \beta \)-pinene showed a wider range of biological activities. Immunosuppressants are a kind of drug that can inhibit human immunity. They are mainly used in organ transplantation to combat rejection and autoimmune diseases. At present, there are several immunosuppressive drugs that work by inhibiting T cell proliferation, but new, efficient, and safe immunosuppressive drugs inhibiting B cell proliferation are still unavailable [35,36]. In this study, many bergamotane sesquiterpenoids were found to have potential inhibition of B cell proliferation. To the best of our knowledge, bergamotane sesquiterpenoids were reported for their immunosuppressive activity for the first time.

4. Conclusions

In summary, a total of 23 sesquiterpenoids including 19 new ones were isolated from the edible fungus \( C. \) ordoratus. Of them, 22 compounds belong to bergamotane sesquiterpenoids in three carbon skeletons, while compounds 1 and 2 possess a rare ring-rearranged backbone. In addition, many bergamotane sesquiterpenoids exhibited selective inhibitions on LPS-induced B cell proliferation. This study suggests that \( C. \) odoratus is rich in bergamotane sesquiterpenoids with promising immunosuppressive activity and provides strong support for the further development and utilization of the edible mushroom \( C. \) odoratus.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/jof7121052/s1, Section S1: Calculational details for 1, Section S2: Calculational details for 6, Section S3: Calculational details for 6S,9S,14S-7 and 6S,9S,14R-8, Section S4: Calculational details for 10, Section S5: Calculational details for 11, Section S6: Calculational details for 17, Section S7: Calculational details for 18, Section S8: NMR and MS spectra for 1, Section S9: NMR and MS spectra for 2, Section S10: NMR and MS spectra for 3, Section S11: NMR and MS spectra for 4, Section S12: NMR and MS spectra for 5, Section S13: NMR and MS spectra for 6, Section S14: NMR and MS spectra for 6S,9S,14S-7, Section S15: NMR and MS spectra for 6S,9S,14R-8, Section S16: NMR and MS spectra for 9, Section S17: NMR and MS spectra for 10, Section S18: NMR and MS spectra for 11, Section S19: NMR and MS spectra for 12, Section S20: NMR and MS spectra for 13, Section S21: NMR and MS spectra for 14, Section S22: NMR and MS spectra for 15, Section S23: NMR and MS spectra for 16, Section S24: NMR and MS spectra for 17, Section S25: NMR and MS spectra for 18, and Section S26: NMR and MS spectra for 19.

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