Research Article

Anti-Inflammatory and α-Glucosidase Inhibitory Activities of Chemical Constituents from Bruguiera parviflora Leaves

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Bruguiera parviflora (Rhizophoraceae) is one of the Bruguiera genus-based mangrove plants which has not been investigated for the chemical compositions as well as biological activities so far. The present study was aimed at investigating the phytochemicals as well as anti-inflammatory and α-glucosidase inhibitory activities of B. parviflora leaves. The results showed that the crude extract and its fractions significantly increased the percentage inhibitory activity against α-glucosidase and decreased NO production in LPS-stimulated RAW 264.7 cells in a dose-dependent manner. The most effective fraction BP5 was further chromatographed and purified. As a result, eight compounds were isolated and elucidated, including five flavonoids (1–5) and three triterpenoids (6–8). All isolated compounds were evaluated for the anti-inflammatory and α-glucosidase inhibitory effects. The results indicated that flavonoids namely taxifolin (1), quercetin (2), myricetin (3), rutin (4), and kaempferol (5) exhibited potent anti-inflammatory as well as α-glucosidase inhibitory activities. Among them, compound 2 showed the most potent inhibitory effect against an α-glucosidase activity with an IC50 value of 3.4 ± 0.5 μg/mL and the LPS-induced NO production of 11.8 μM at the concentration of 100 μg/mL. These findings suggest that flavonoids (1–5) from B. parviflora leaves may be useful as the potential α-glucosidase inhibitor as well as anti-inflammatory agent.

1. Introduction

Medicinal plants have long been recognized as important sources containing bioactive compounds such as phenolics, flavonoids, alkaloids, and triterpenoids. The recent research keeps on contributing important achievements in finding natural compounds that could be of potential medical and pharmacological effects [1]. Bruguiera, the largest genus in the family Rhizophoraceae, includes approximately 120 species distributed in mangrove forests from Africa to Asia. Numerous studies reported that Bruguiera possesses several biological activities such as antioxidant [2], antifungal, cytotoxic [3], antimalarial [4], antidiabetic [5], and antibacterial activities [6, 7]. Traditionally, fruits of B. gymnorrhiza were widely used as drugs to treat eye diseases and herpes [7], and its bark was used as an astrin-
mangrove plants [13, 14], the objective of this work was to determine the anti-inflammatory and antidiabetic activities of extracts and isolated compounds from B. parviflora leaves collected in the Can Gio mangrove forest, Vietnam, in order to confirm their pharmaceutical support.

2. Materials and Methods

2.1. General Experimental Procedure. Column chromatography was performed on silica gel 60 (70–230 mesh, Merck, Darmstadt, Germany) or Sephadex LH-20 (GE Healthcare Life Sciences AB, Uppsala, Sweden), monitored by analytical thin-layer chromatography (TLC) on a precoated silica gel 60 F-254 (Merck, Darmstadt, Germany). Spots were visualized under UV light (254 and 365 nm) or sprayed with 10% H2SO4 solution and then heated at 105°C for 5 min. Melting points were determined on an IA9100 Digital Melting Point Apparatus (Cole-Parmer, United States). A spectrometer Bruker Avance III (125 and 500 MHz) was used for NMR spectra. CDCl3 or DMSO-d6 was used as solvents and TMS as the internal standard. APCI-MS were recorded on an X500 Q QTOF-Q mass spectrometer. ESI-MS was recorded by MSQ-Plus-DAD. A mouse macrophage cell line (RAW 264.7) was obtained from the American Type Culture Collection (Manassas, Virginia, USA). Lipopolysaccharide (LPS), 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT), N-(1-naphthyl) ethylenediamine dihydrochloride (NED), Griess Reagent, Dulbecco’s modified Eagle’s medium (DMEM) supplemented with 10% fetal bovine serum (FBS) and 1% L-glutamine. The cells were incubated at 37°C in humidified atmosphere containing 5% CO2.

2.2. Extraction, Isolation, and Purification. Leaves of B. parviflora were collected at the Can Gio mangrove forest, Ho Chi Minh City, Vietnam, in August 2019. A voucher specimen (No. US-B014) was deposited in the laboratory of the Faculty of Biotechnology, Ho Chi Minh City Open University, Vietnam.

The crude ethanol residue (300 g) of dried leave powder of B. parviflora (3 kg) was obtained by the maceration method with ethanol (5 × 40 L) at room temperature. This crude was fractionated by flash column chromatography with solvent systems of n-hexane and ethyl acetate (step-wise, 10:0, 9:1, 8:2, 5:5, and 0:10, v/v) then ethyl acetate and methanol (step-wise, 9:1, 8:2, 5:5, and 0:10, v/v) to afford nine fractions (BP1–9). A sample was taken from each fraction for preliminary screening of anti-inflammatory and α-glucosidase inhibitory activities. The bioassay result showed that the fraction BP5 was potent; therefore, it was chosen to be chemically studied.

The fraction BP5 (200 mg) was fractionated by a silica gel column chromatography using a mixture of n-hexane and ethyl acetate (95:5 to 0:100, v/v) then ethyl acetate and methanol (0:100 to 100:0, v/v) to yield ten subfractions (BP5.1–10). The subfraction BP5.1 (37.8 g) was chromatographed on a silica gel column with n-hexane-ethyl acetate (0:100 to 100:0, v/v) as eluent to obtain four subfractions (BP5.1.1–4). The subfraction BP5.1.2 (80 mg) was rechromatographed on a Sephadex LH–20 eluting with chloroform-methanol (1:1, v/v) to obtain compounds 1 (10.2 mg) and 4 (7.2 mg). The subfraction BP5.1.3 (128 mg) was further subjected to a silica gel column and eluted with n-hexane-chloroform (95:5 to 0:100, v/v) to get compounds 3 (5.1 mg) and 6 (14.2 mg). The fraction BP5.3 (33.3 g) was chromatographed on Sephadex LH–20 using chloroform-methanol (1:1, v/v) as eluent to obtain four compounds, 5 (6.7 mg), 2 (9.8 mg), 7 (8.8 mg), and 8 (9.5 mg).

2.3. Anti-Inflammatory Assay

2.3.1. Cell Culture. The RAW 264.7 cells were cultured in Dulbecco’s modified Eagle’s medium (DMEM) supplemented with 10% fetal bovine serum (FBS) and 1% L-glutamine. The cells were incubated at 37°C in humidified atmosphere containing 5% CO2.

2.3.2. Cell Viability. Cells (3 × 105) were cultured in 96 well plates containing DMEM supplemented with 10% FBS and incubated at 37°C, 5% carbon dioxide for 24 hours. After, the cells were treated with 100 μL of samples (25, 50, 75, and 100 μg/mL) in the presence of 100 μg/mL LPS and incubated for 24 hours with 5% CO2 at 37°C. Then, 20 μL of MTT solution (5 mg/mL) was added to each well and further incubated for 2 hours. MTT is reduced by mitochondrial dehydrogenases to the water-insoluble pink compound formazan, depending on the viability of cells. After incubation, the medium was removed, and the remaining formazan crystals were dissolved with 100 μL of dimethyl sulfoxide (DMSO). After 30 minutes, the absorbance was measured at 570 nm by using a microplate reader. The percentages of cell viability were calculated using the following equation:

\[
\text{Cell viability (\%)} = \left( \frac{A_{\text{sample}}}{A_{\text{control}}} \right) \times 100. \tag{1}
\]

Dexamethasone (Dexan), commonly used to treat inflammation, is a positive control at a concentration of 15 μM [15].

2.3.3. Determination of NO Production. The NO level was determined by the Griess reaction. RAW 264.7 cells (3 × 105 cells/well) were pretreated with the samples at the various concentrations of 25, 50, 75, and 100 μg/mL for 30 minutes and then stimulated with 2 μL LPS (100 μg/mL) for 24 hours at 37°C in an incubator with 5% CO2. A reaction mixture containing 20 μL of the Griess reagent, 150 μL of each supernatant, and 130 μL of distilled water was incubated at room temperature for 30 minutes. The absorbance of the mixture was recorded at 540 nm by a microplate reader. A standard curve was prepared using NaNO2 as a standard solution in the same manner and was used to calculate the concentration of NO [16].

2.4. α-Glucosidase Inhibitory Assay. The α-glucosidase inhibitory assay was based on the hydrolysis of the substrate 1-nitro-4-hydroxybenzene α-D-glucopyranoside (pNPG) of α-glucosidase. The reaction mixture containing 60 μL of sodium
phosphate buffer (100 mM, pH 6.8), 20 μL of the sample at different concentrations, and 20 μL of α-glucosidase (0.3 IU/mL) in the phosphate buffer was incubated in 96-well plates at 37°C for 10 minutes. After 10 minutes, the reaction was started with the addition of 100 μL of p-nitrophenyl-α-D-glucopyranoside solution (200 μM) in phosphate buffer (substrate), and the mixture was incubated at 37°C for 10 minutes. Then, the reaction was stopped by adding 100 μL of a NaOH solution (50 mM). The α-glucosidase inhibitory activity was measured by determining the color of the released p-nitrophenol (pNPG) from pNPG and expressed as inhibition percentage by the following equation:

\[
\text{Inhibition (\%) = \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100.}
\]

The inhibitory concentration (IC_{50}) for each sample was calculated using a regression analysis from the graph plotting the percentage of inhibition and the different sample concentrations [13].

2.5. Statistical Analysis. All results were expressed in the mean values ± standard deviation (SD) of triplicate determinations. Differences between test samples were assessed for significance using one-way analysis of variance (ANOVA) and Duncan’s test, where the probability (p < 0.05) was considered significant.

3. Results and Discussion

3.1. Effect of BPFs on Cell Viability. To determine the cytotoxic effect of B. parviflora fractions (BPFs), the viability of RAW 264.7 cells was measured using the MTT assay. Cells were treated with various BPFs at different concentrations from 25 to 100 μg/mL and incubated for 24 hours. The cell viability was greater than 90% for the BPFs. These results indicated that BPFs at the tested concentrations were not cytotoxic to RAW 264.7 cells, compared to that of nontreated control (Figure 1). Based on this, concentrations ranging from 25 to 100 μg/mL were used for determining the anti-inflammatory effect in LPS-stimulated RAW 264.7 cells of BPFs.

3.2. Effect of BPFs on NO Production in LPS-Induced RAW 264.7 Cells. NO plays as a proinflammatory mediator and is synthesized by inducible nitric oxide synthase (iNOS). Finding medicinal resources that can reduce NO production has been characterized as a new pharmacological strategy for the treatment of inflammation-related diseases. The inhibitory influence of all fractions was assessed the anti-inflammatory effect in LPS-stimulated RAW 264.7 cells as an in vitro model. Cells were simultaneously treated with LPS and different concentrations of BPFs. The concentration of NO in the cell culture supernatants was determined by measuring the accumulation of nitrite using the Griess reaction. As displayed in Figure 2, all the fractions appreciably inhibited the LPS-induced NO production in a concentration-dependent manner. Among them, the fraction BP5 exhibited a significant reduction of NO production to 14.12 μM at a concentration of 100 μg/mL as compared with the LPS-treated cells.

3.3. Effect of BPFs on α-Glucosidase Inhibition. α-Glucosidase is an intestinal enzyme that breaks the polysaccharides-linked α-1,4 down to α-glucose which leads to a high blood sugar level. The development of an α-glucosidase inhibitor derived from natural products is an important contribution to the treatment of diabetes. The crude extract and its fractions from B. parviflora leaves were evaluated for their α-glucosidase inhibitory activity. It was observed that four fractions BP1, BP2, BP8, and BP9 exhibited 31.5, 66.8, 57.8, and 26.8% inhibitory activities at 200 μg/mL, respectively (Table 1). Meanwhile, fractions BP4, BP5, and BP6 exhibited strong inhibitory activities with 88.1, 98.8, and 83.8%, respectively, better than the one of the positive control (acarbose) with 79.1% inhibition at 200 μg/mL. Among them, the fraction BP5 (IC_{50} value of 44.3 ± 0.2 μg/mL) showed the best. As a result, the increase in the α-glucosidase inhibitory activity shown by different BPFs would be due to their chemical components such as flavonoids, terpenoids, steroids, alkaloids, and glycosidic compounds. These suggested that the fraction BP5 was a remarkable inhibition potential against the α-glucosidase.

3.4. Isolation and Identification of the Potentially Bioactive Compounds. In the present study, the fraction BP5 demonstrated the highest α-glucosidase inhibitory as well as anti-inflammatory activities compared to other fractions. Therefore, BP5 was selected for further isolation and elucidation of the potential bioactive compounds. The fraction BP5 was subjected to a silica gel column and Sephadex LH-20 for fractionation. Repeated column chromatography was performed for subfractions to yield eight compounds. The chemical structures of the isolated compounds were identified by 1D and 2D NMR spectroscopic analysis as well as compared with the reported data in the literature. They were five flavonoids, taxifolin (1) [17], quercetin (2) [18], myricetin (3) [19], rutin (4) [20], and kaempferol (5) [21], and three triterpenoids, lupeol (6) [22], betulinic acid (7) [23], and corosolic acid (8) [24]. Among these compounds, taxifolin (2) and corosolic acid (8) have not yet been previously reported from the Bruguiera genus. Especially, all compounds were isolated for the first time from B. parviflora. Their spectral data (Figure S1–S25 in supplementary file) were described in detail in published data, and their structures are shown in Figure 3.

Compound 1 (quercetin). Yellow amorphous powder; m.p. 313–315 °C. ESI-MS m/z 301.04 [M-H]–, calcd. for C_{15}H_{10}O_{7}-H, 301.24

\[
^1H\text{ NMR (500 MHz, DMSO-d}_{6}): 6.18 (1H, d, 2.0 Hz, H-6), 6.41 (1H, d, 1.5 Hz, H-8), 7.67 (1H, d, 2.0 Hz, H-2), 6.88 (1H, d, 8.5 Hz, H-5), 7.54 (1H, dd, 8.5, 2.0 Hz, H-6), 12.48 (1H, s, 5-OH)
\]

\[
^13C\text{ NMR (125 MHz, DMSO-d}_{6}): 147.7 (C-2), 135.8 (C-3), 175.9 (C-4), 160.7 (C-5), 98.2 (C-6), 164.0 (C-7), 93.4 (C-8), 156.2 (C-9), 103.0 (C-10), 122.0 (C-1), 115.1 (C-2'), 145.1 (C-3'), 146.8 (C-4'), 115.6 (C-5'), 120.0 (C-6').
\]

Compound 2 (taxifolin). Pale yellow powder; m.p. 230–232 °C; [α]_{D}^{20} +44.0 (c 1.3, Acetone). ESI-MS m/z 303.30 [M-H]–, calcd. for C_{13}H_{12}O_{7}-H, 303.25

\[
^1H\text{ NMR (500 MHz, DMSO-d}_{6}): 4.96 (1H, d, 11.0 Hz, H-2), 4.48 (1H, d, 11.0 Hz, H-3), 5.84 (1H, d, 2.0 Hz, H-6), 5.89 (1H, d,}
\]
Figure 1: The effect of BPFs on the survival rate of RAW 264.7 macrophages cells. The cells were pretreated with concentrations (25, 50, 75, and 100 μg/mL) of BPFs for 24 hours. The data show the mean ± SD of three independent experiments performed in triplicates. *p < 0.05 versus the LPS-treated group, #p < 0.05 compared to Dexan (positive control).

Figure 2: The effect of BPFs on the production of NO in LPS-induced RAW 264.7 macrophages. The cells were pretreated for 30 minutes with concentrations (25, 50, 75, and 100 μg/mL) of BPFs and then stimulated with LPS (100 μg/mL) for 24 hours. The data show the mean ± SD of three independent experiments performed in triplicates. *p < 0.05 versus the LPS-treated group, #p < 0.05 compared to Dexan (positive control).
Table 1: α-Glucosidase inhibitory activity of Bruguiera parviflora extracts.

| Fraction | Concentration (µg/mL) | IC₅₀ (µg/mL) |
|----------|-----------------------|-------------|
|          | 25                    | 50          | 100         | 150         | 200         |
| BP1      | 1.0 ± 0.1             | 7.9 ± 0.5   | 13.0 ± 0.1  | 23.2 ± 0.2  | 31.5 ± 0.4  | —           |
| BP2      | 12.6 ± 0.1            | 20.8 ± 0.1  | 28.5 ± 0.1  | 55.5 ± 0.1  | 66.8 ± 0.1  | 146.2 ± 0.1b |
| BP3      | 26.9 ± 0.2            | 39.8 ± 0.1  | 48.4 ± 0.1  | 63.3 ± 0.3  | 69.8 ± 0.2  | 106.5 ± 0.3c |
| BP4      | 30.3 ± 0.1            | 44.6 ± 0.2  | 66.3 ± 0.1  | 77.7 ± 0.3  | 88.1 ± 0.3  | 69.8 ± 0.2c  |
| BP5      | 36.6 ± 0.1            | 55.5 ± 0.3  | 74.2 ± 0.2  | 89.7 ± 0.1  | 98.8 ± 0.3  | 44.3 ± 0.2a  |
| BP6      | 38.8 ± 0.2            | 54.6 ± 0.1  | 63.8 ± 0.1  | 76.7 ± 0.1  | 83.8 ± 0.1  | 49.4 ± 0.1b  |
| BP7      | 20.2 ± 0.1            | 31.6 ± 0.2  | 54.0 ± 0.1  | 63.8 ± 0.1  | 80.2 ± 0.1  | 102.5 ± 0.1c |
| BP8      | 30.1 ± 0.3            | 37.2 ± 0.1  | 47.0 ± 0.2  | 49.8 ± 0.1  | 57.8 ± 0.2  | 150.8 ± 0.1c |
| BP9      | 2.7 ± 0.1             | 3.6 ± 0.6   | 8.8 ± 0.3   | 15.5 ± 0.1  | 26.8 ± 0.2  | —           |
| The crude| 35.3 ± 0.3            | 44.0 ± 0.1  | 54.1 ± 0.5  | 63.3 ± 0.2  | 79.8 ± 0.1  | 83.0 ± 0.4d  |
| Acarbose | 4.7 ± 0.4             | 10.5 ± 0.2  | 39.5 ± 0.3  | 62.4 ± 0.1  | 79.1 ± 0.3  | 127.7 ± 0.2e |

Values are presented as the mean ± SD values of triplicate determinations. Means with lower cases in the same column indicate significant differences at a 5% statistical level; -: inactive.

1.5 Hz, H-8), 6.87 (1H, s, H-2'), 6.73 (1H, d, 8.0 Hz, H-5'), 6.75 (1H, d, 9.5 Hz, H-6'), 5.73 (1H, brs, 3-OH), 11.88 (1H, s, 5-OH), 8.98 (2H, s, 3',4'-OH).

13C NMR (125 MHz, DMSO-d₆): 83.1 (C-2), 71.6 (C-3), 197.6 (C-4), 163.4 (C-5), 96.1 (C-6), 167.1 (C-7), 95.1 (C-8), 162.6 (C-9), 100.4 (C-10), 128.1 (C-1'), 115.2 (C-2'), 145.8 (C-3'), 145.0 (C-4'), 115.4 (C-5'), 119.4 (C-6').

**Compound 3** (myricetin). Yellow amorphous powder; m.p. 213–215 °C. ESI-MS m/z 317.22 [M-H]⁻, calcld. for C₁₅H₁₀O₇-H, 317.24.

**Compound 4** (quercetin 3-O-rutinoside, rutin). Yellow amorphous powder; m.p. 190–192 °C.

1H NMR (500 MHz, DMSO-d₆): 6.19 (1H, s, H-5), 6.38 (1H, s, H-2'), 7.54 (2H, dd, 8.0, 2.0 Hz, H-2',6'), 6.84 (1H, d, 7.0 Hz, H-5'), 5.34 (1H, d, 6.0 Hz, H-1'), 4.38 (1H, brs, H-1''), 12.59 (1H, s, 5-OH), 0.99 (3H, d, 5.0 Hz, H-6'').

13C NMR (125 MHz, DMSO-d₆): 146.9 (C-2), 135.9 (C-3), 175.8 (C-4), 160.8 (C-5), 98.2 (C-6), 163.9 (C-7), 93.2 (C-8), 103.0 (C-10), 120.8 (C-1'), 107.2 (C-2'), 145.8 (C-3'), 135.9 (C-4'), 145.8 (C-5'), 107.2 (C-6').

**Figure 3:** The chemical structures of isolated compounds from Bruguiera parviflora.
Figure 4: The effect of the isolated compounds on the production of NO in LPS-induced RAW 264.7 macrophages. The cells were pretreated for 30 minutes with concentrations (25, 50, 75, and 100 µg/mL) of compounds 1–8 and then stimulated with LPS (100 µg/mL) for 24 hours. The data show the mean ± SD of three independent experiments performed in triplicates. *p < 0.05 versus the LPS-treated group. †p < 0.05 compared to Dexan (positive control).

| Concentration (µg/mL) | Cell viability (%) |
|-----------------------|-------------------|
| 25                    | #                 |
| 50                    | #                 |
| 75                    | #                 |
| 100                   | #                 |

**Compound 1 (kaempferol).** White powder; m.p. 315–317 °C.

**Compound 2 (dihydroquercitrin).** White amorphous powder; m.p. 230–233 °C.

**Compound 3 (kaempferol-3′-O-glucoside).** Yellow amorphous powder; m.p. 212–214 °C.

**Compound 4 (quercetin-3′-O-glucoside).** Yellow amorphous powder; m.p. 214 °C.

**Compound 5 (kaempferol).** Yellow amorphous powder; m.p. 315–317 °C. APCLI-MS m/z 455.38 [M-H]−, calcd. for C_{30}H_{50}O_{6}H, 455.69

**Compound 7 (betulinic acid).** White powder; m.p. 315–317 °C. APCLI-MS m/z 455.38 [M-H]−, calcd. for C_{30}H_{50}O_{6}H, 455.69

**Compound 8 (corosolic acid).** White powder; m.p. 250–252 °C. APCLI-MS m/z 471.43 [M-H]−, calcd. for C_{30}H_{48}O_{2}H, 471.69

**Compound 6 (quercetin-3′-O-glucoside).** White amorphous powder; m.p. 212–214 °C. APCLI-MS m/z 490.49 [M-H]−, calcd. for C_{30}H_{50}O_{6}H, 490.72

**Compound 9 (quercetin-3′-O-glucoside).** White amorphous powder; m.p. 315–317 °C. APCLI-MS m/z 490.49 [M-H]−, calcd. for C_{30}H_{50}O_{6}H, 490.72

**Compound 10 (kaempferol-3′-O-glucoside).** Yellow amorphous powder; m.p. 214 °C.
12), 138.3 (C-13), 41.7 (C-14), 27.5 (C-15), 25.6 (C-16), 47.1 (C-17), 52.4 (C-18), 38.5 (C-19), 38.5 (C-20), 30.2 (C-21), 36.3 (C-22), 28.8 (C-23), 16.4 (C-24), 16.9 (C-25), 17.0 (C-26), 23.3 (C-27), 178.4 (C-28), 17.2 (C-29), 21.1 (C-30)

3.5. Effects of Isolated Compounds 1–8 on NO Production in LPS-Induced RAW 264.7 Cells. All isolated compounds 1–8 were evaluated for their inhibition of NO production in LPS-stimulated RAW 264.7 cells using the Griess assay with dexamethasone (Dexan) as a positive control. The anti-inflammatory activities of the tested compounds increased in accordance with the increased concentration. As shown in Figure 4, compounds 1–5 displayed a potential inhibition with NO production from 11.77 to 13.92 µM at a concentration of 100 µg/mL as compared with the LPS-treated cells, in which all of them belonged to flavonoids. Therefore, it was possible to indicate that the anti-inflammatory activity of B. parviflora would be derived from its flavonoid compounds. Among these flavonoids, compounds 1, 2, and 5 showed good anti-inflammatory effects with NO production to 12.32, 11.77, and 12.50 µM, respectively, at the concentration of 100 µg/mL.

Besides, the effects of the tested compounds on cell viability were evaluated to determine whether their anti-inflammatory activities were due to the cytotoxicity. As the results in Figure 5 show, these compounds did not show any significant cytotoxicity with LPS treatment for 24 hours up to 100 µg/mL. Based on all the above-mentioned data, the flavonoids from B. parviflora leaves would play an important role in inhibiting LPS-stimulated NO release.

Figure 5: The effect of the isolated compounds on the survival rate of RAW 264.7 macrophages cells. The cells were pretreated with concentrations (25, 50, 75, and 100 µg/mL) of compounds 1–8 for 24 hours. The data show the mean ± SD of three independent experiments performed in triplicates. *p < 0.05 versus the LPS-treated group, #p < 0.05 compared to Dexan (positive control).

3.6. Effects of Isolated Compounds 1–8 on α-Glucosidase Inhibition. The chemical constituents 1–8 isolated from B. parviflora leaves were tested for α-glucosidase inhibitory activity and acarbose was used as a standard with an IC_{50} value of 127.7 ± 0.2 µg/mL. As presented in Table 2, all tested compounds 1–8 possessed significant inhibitory activities with IC_{50} values from 3.4 to 98.0 µg/mL, and these inhibitions were better than acarbose. Among the flavonoids, the most effective one was compound 2 with an IC_{50} value of 3.4 ± 0.5 µg/mL, while compound 8 showed the strongest inhibition among the tested triterpenoids with an IC_{50} value of 17.9 ± 0.4 µg/mL. These results indicated that the diversity of the structural skeleton, the substituent groups, and their positions on the skeleton could have a significant impact on α-glucosidase inhibition. From the structures of flavonoids 1–5, it would be said that the α-glucosidase inhibitory activity is strengthened by the presence of hydroxy groups directly attached to the flavonoid skeleton, because it could have the ability to make flavonoids binding into the pocket of α-glucosidase by constructing the hydrogen bond [25]. The comparison of activities of compound 2 (IC_{50} = 3.4 ± 0.5 µg/mL) and its glycosidic derivative, compound 4 (IC_{50} = 74.1 ± 0.4 µg/mL), showed that the O-glycosylation of the -OH group at the C-3 position weakened the α-glucosidase inhibitory activities. These results showed good compatibility with the structure–activity relationship studies on flavonoids as inhibitors of α-glucosidase enzyme done by Söhrêtoğlu and Sari [26] and Carina et al. [27]. Furthermore, compound 7 (IC_{50} = 28.1 ± 0.4 µg/mL) exhibited stronger inhibition than compound 6 (IC_{50} = 98.0 ± 0.6 µg/mL).
suggesting that the replacement of the methyl group by the carboxyl group at C-28 could enhance the inhibition of α-glucosidase. Besides, the weaker inhibition of compound 7 compared to compound 8 (IC_{50} = 17.9 ± 0.4 μg/mL) indicated that the six-membered E ring would be important for the inhibition of triterpenoids. These results demonstrated that flavonoids and triterpenoids isolated from *B. parviflora* leaves were potential inhibitors against α-glucosidase.

### 4. Conclusions

The bioactive guided investigation of *B. parviflora* led to isolation and elucidation of the structures of eight compounds, including five flavonoids and three triterpenoids. Among them, flavonoids such as taxifolin (1), quercetin (2), myricetin (3), rutin (4), and kaempferol (5) exhibited the potent anti-inflammatory as well as α-glucosidase inhibitory activities. Quercetin (2) showed the most potent inhibitory effect against α-glucosidase activity with an IC_{50} value of 3.4 ± 0.5 μg/mL and the LPS-induced NO production of 11.8 μM at the concentration 100 μg/mL. The obtained result suggested that *B. parviflora* leaves are a potential natural source for the prevention of inflammation and diabetes which would be due to its bioactive compounds.

### Abbreviations

| Abbreviation | Definition |
|--------------|------------|
| DMEM | Dulbecco’s modified Eagle’s medium |
| DMSO | Dimethyl sulfoxide |
| DPPH | 2,2-Diphenyl-1-picryl-hydrazyl-hydrate |
| IC_{50} | The half-maximal inhibitory concentration |
| LPS | Lipopolysaccharide |
| BPF | *Bruguiera parviflora* fraction |
| TLC | Thin layer chromatography |
| pNPG | para-Nitro-4-hydroxybenzene α-D-glucopyranoside |

## Data Availability

The data used to support the findings of this study are included within the article.

### Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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### Supplementary Materials

Figure S1: the ESI–MS spectrum of quercetin. Figure S2: the 1H–NMR spectrum of quercetin (500 MHz, DMSO–d_{6}). Figure S3: the 13C–NMR spectrum of quercetin (125 MHz, DMSO–d_{6}). Figure S4: the ESI-MS spectrum of taxifolin. Figure S5: the 1H–NMR spectrum of taxifolin (500 MHz, DMSO–d_{6}). Figure S6: the 13C–NMR spectrum of taxifolin (125 MHz, DMSO–d_{6}). Figure S7: the APCI-MS spectrum of myricetin. Figure S8: the 1H–NMR spectrum of myricetin (500 MHz, DMSO–d_{6}). Figure S9: the 13C–NMR spectrum of myricetin (125 MHz, DMSO–d_{6}). Figure S10: the 1H–NMR spectrum of rutin (500 MHz, DMSO–d_{6}). Figure S11: the 13C–NMR spectrum of rutin (125 MHz, DMSO–d_{6}). Figure S12: the HMBC spectrum of rutin (500 MHz, DMSO–d_{6}). Figure S13: the 1H–NMR spectrum of kaempferol (500 MHz, DMSO–d_{6}). Figure S14: the 13C–NMR spectrum of kaempferol (125 MHz, DMSO–d_{6}). Figure S15: the HSQC spectrum of kaempferol (500 MHz, DMSO–d_{6}). Figure S16: the HSQC spectrum of kaempferol (500 MHz, DMSO–d_{6}). Figure S17: the APCI-MS spectrum of lupeol. Figure S18: the 1H–NMR spectrum of lupeol (500 MHz, CDCl_{3}). Figure S19: the 13C–NMR spectrum of lupeol (125 MHz, CDCl_{3}). Figure S20: the APCI-MS spectrum of corosolic acid. Figure S21: the 1H–NMR spectrum of betulinic acid (500 MHz, CDCl_{3}). Figure S22: the 13C–NMR spectrum of betulinic acid (125 MHz, CDCl_{3}). Figure S23: the APCI-MS spectrum of corosolic acid. Figure S24: the 1H–NMR spectrum of corosolic acid (500 MHz, DMSO–d_{6}). Figure S25: the 13C–NMR spectrum of corosolic acid (125 MHz, DMSO–d_{6}). (Supplementary Materials)
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