

## A New Chromanone Derivative from *Calophyllum inophyllum* Resin and Its Antibacterial Activity

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**Abstract:** A new chromanone derivative, calophylloidal acid B (2), was isolated from *Calophyllum inophyllum* resin in Lombok, Indonesia. The structure of the new compound was elucidated as a structural isomer of calophylloidal acid A (1), which we had previously isolated from Indonesian *C. inophyllum* resin. It exhibited potent antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*.

**Keywords:** Chromanone; *Calophyllum inophyllum*; calophylloidal acid; Indonesia; antibacterial activity.  
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### 1. Plant Source

In October 2019, *Calophyllum inophyllum* resin was collected from the arboretum of the Research and Development Institute of Non-Timber Forest Product Technology, Lombok Barat District, West Nusa Tenggara Barat Province, Indonesia, and was identified by taxonomists at the Herbarium Bogoriense, Indonesia. The voucher specimen (accession number: BO-1994333) is preserved in the arboretum of the Research and Development Institute of Non-Timber Forest Product Technology, Lombok Barat District, West Nusa Tenggara Barat Province, Indonesia.

### 2. Previous Studies

The genus *Calophyllum* is predominantly distributed in the tropical regions of the world, such as India, Malaysia, Indonesia, and Madagascar, where > 130 species have been reported [1-3]. The plant species produce various secondary metabolites to resist tropical environmental factors, such as

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pests, microorganisms, and ultraviolet radiation. Chromanones, coumarins, and xanthenes have been previously isolated from *Calophyllum* genus as key secondary metabolites [4-6]. Due to rich secondary metabolite profile of the genus, *Calophyllum* sp. seed oils as well as trunk bark, root, and leaf decoctions have been used as traditional medicines since ancient times owing to their beneficial biological effects, such as antibacterial [4], anti-human immunodeficiency virus [5], and antitumor [6] activities.

In our previous study, we isolated a new compound, calophylloidic acid A (**1**), which is the main component of *Calophyllum inophyllum* resin from Lombok, Indonesia (Figure 1) [7]. We found that *C. inophyllum* resin and **1** exhibited strong antibacterial activity. In that study, LC-MS analysis revealed the molecular ions showing the same  $m/z$  value as that of **1**, suggesting the presence of other structural isomers of **1** in the resin. To effectively use *C. inophyllum* resin, further component analysis and biological evaluations are required. Therefore, we performed compositional analysis of *C. inophyllum* resin using chiral column chromatography and assessed the antibacterial activity of the isolated compounds.

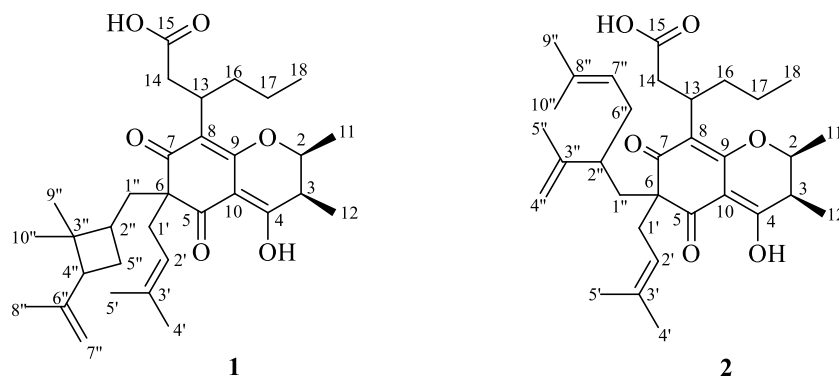
### 3. Present Study

The EtOH extracts of *C. inophyllum* resin from our previous study were used [7]. These extracts (15.4 g) were analyzed using silica gel (n-hexane/ethyl acetate 3:1, 0.1% acetic acid) via open column chromatography to obtain 10 fractions (Frs.1–10). Fr. 3 (46.3 mg of 2.2 g) was separated via chiral column chromatography (Daicel CHIRALPAK IG, 5  $\mu$ m, 10  $\times$  250 mm; H<sub>2</sub>O/acetonitrile 33:67, 0.1% formic acid) to obtain four fractions. Further, Fr. 3-1 (24.9 mg) was separated via chiral column chromatography (CHIRALPAK IG, H<sub>2</sub>O/acetonitrile 33:67, 0.1% formic acid) to isolate calophylloidic acid B (**2**) (10.8 mg).

*Calophylloidic acid B (2)*: Yellow gum;  $[\alpha]_D^{28} = -23.6^\circ$  ( $c = 0.23$ , CHCl<sub>3</sub>); UV (acetonitrile):  $\lambda_{\max}$  (log  $\epsilon$ ): 263 (3.66), 309 (3.98); IR  $\nu_{\max}$  (KBr): = 3333, 3110, 2961, 2360, 1704, 1647, 1542, 1488, 1286, 1240 cm<sup>-1</sup>; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>):  $\delta$  (ppm) = 0.88 (3H, t,  $J = 7.3$  Hz, H-18), 1.16 (3H, d,  $J = 7.2$  Hz, H-12), 1.24 (2H, m, H-17), 1.34 (3H, d,  $J = 6.5$  Hz, H-11), 1.46 (3H, s, H-5'), 1.46 (1H, m, H-16a), 1.50 (3H, s, H-5''), 1.52 (3H, s, H-4'), 1.54 (3H, s, H-10''), 1.65 (3H, s, H-9''), 1.78 (1H, m, H-16b), 1.88 (2H, m, H-6''), 1.98 (1H, m, H-2''), 2.10 (2H, m, H-1'), 2.50 (2H, m, H-1'), 2.60 (1H, dq,  $J = 3.6, 7.2$  Hz, H-3), 2.72 (1H, dd,  $J = 6.6, 15.8$  Hz, H-14a), 2.85 (1H, dd,  $J = 8.2, 15.8$  Hz, H-14b), 3.51 (1H, m, H-13), 4.38 (1H, dq,  $J = 3.6, 6.5$  Hz, H-2), 4.41 (1H, m, H-4a''), 4.48 (1H, m, H-4b''), 4.78 (1H, t,  $J = 7.9$  Hz, H-2'), 4.89 (1H, t,  $J = 6.7$  Hz, H-7''), 16.27 (1H, s, 4-OH); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>):  $\delta$  (ppm) = 9.9 (CH<sub>3</sub>, C-12), 14.1 (CH<sub>3</sub>, C-18), 16.3 (CH<sub>3</sub>, C-11), 17.2 (CH<sub>3</sub>, C-5''), 17.7 (CH<sub>3</sub>, C-5'), 17.9 (CH<sub>3</sub>, C-10''), 20.9 (CH<sub>2</sub>, C-17), 25.7 (CH<sub>3</sub>, C-4'), 25.7 (CH<sub>3</sub>, C-9''), 30.7 (CH, C-13), 33.1 (CH<sub>2</sub>, C-6''), 34.9 (CH<sub>2</sub>, C-16), 37.9 (CH<sub>2</sub>, C-14), 39.9 (CH, C-3), 40.5 (CH<sub>2</sub>, C-1''), 42.7 (CH<sub>2</sub>, C-1'), 45.1 (CH, C-2''), 59.8 (C, C-6), 74.3 (CH, C-2), 103.2 (C, C-10), 113.1 (CH<sub>2</sub>, C-4''), 114.1 (C, C-8), 117.1 (CH, C-2'), 122.3 (CH, C-7''), 132.1 (C, C-8''), 135.3 (C, C-3'), 147.3 (C, C-3''), 164.4 (C, C-9), 177.1 (C, C-15), 188.7 (C, C-4), 196.6 (C, C-7), 200.4 (C, C-5); HRESIMS:  $m/z$  527.3369 [M + H]<sup>+</sup> (calcd. 527.3367 for C<sub>32</sub>H<sub>47</sub>O<sub>6</sub>).

Antibacterial activities of **2** against *Staphylococcus aureus* and *Escherichia coli* were evaluated as previously described [7]. Minimal inhibitory concentration (MIC) was also determined. Briefly, **2** at a concentration of 5–2560  $\mu$ g/mL prepared in DMSO was diluted with each bacterial solution and incubated at 37 °C for 24 h. Subsequently, bacterial growth was assessed based on turbidity. MIC was defined as the lowest concentration at which no turbidity was observed. Compound **2** exhibited potent antibacterial activity against *S. aureus* and *E. coli* with MIC values of 16 and 8  $\mu$ g/mL, respectively, which were the same activity as **1**. Recently, we have reported the improvement of water solubility and antibacterial activity of **1** via inclusion complexation with cyclodextrins [11]. Compound **2** is also expected to improve the water solubility and antibacterial activity through the formation of the inclusion complex with cyclodextrins.

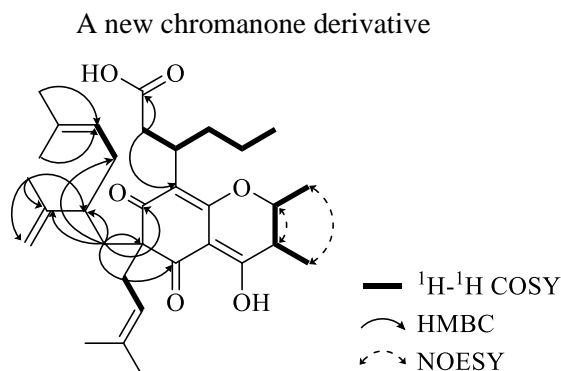
Compound **2** was isolated via preparative HPLC using chiral stationary phases column (Figure 1). The  $^{13}\text{C}$  NMR spectroscopic data revealed that **2** possessed 32 carbon atoms, and its HSQC correlations indicated the presence of eight methyl, seven methylene, six methine, and 11 quaternary carbons.



**Figure 1.** Structures of calophylloidic acid A (**1**) and B (**2**)

The molecular formula of **2** was determined to be  $\text{C}_{32}\text{H}_{46}\text{O}_6$  using HRESIMS ( $[\text{M} + \text{H}]^+$  at  $m/z$  527.3369 and  $[\text{M} - \text{H}]^-$  at  $m/z$  525.3223) (Figure S10). Further, 1D and 2D NMR spectroscopic data of **2** were found to be similar to compound **1** and its structural analogs [4,7]. Upon comparing the  $^{13}\text{C}$  NMR data of **1** and **2**, we revealed that C-9'' ( $\delta_{\text{C}}$  24.7) and C-10'' ( $\delta_{\text{C}}$  24.0) of **1**, which are the characteristic features of the four-membered ring structure, were not observed in **2**. Meanwhile, the NMR signals of H-4'' ( $\delta_{\text{H}}$  4.41, 4.48) were assigned to two terminal methylene protons from the double bond. The presence of an isopropenyl group from H-5'' ( $\delta_{\text{H}}$  1.50) to C-2'' ( $\delta_{\text{C}}$  45.1), C-3'' ( $\delta_{\text{C}}$  147.3), and C-4'' ( $\delta_{\text{C}}$  113.1) was confirmed based on HMBC correlation. The signals of two methyl groups H-9'' ( $\delta_{\text{H}}$  1.65) and H-10'' ( $\delta_{\text{H}}$  1.54) and the vinyl proton H-7'' ( $\delta_{\text{H}}$  4.89) suggested the presence of a prenyl group. The presence of a prenyl group was also confirmed based on HMBC correlation from H-9'' and H-10'' to C-7'' ( $\delta_{\text{C}}$  122.3). The HMBC correlations from H-1'' ( $\delta_{\text{H}}$  2.10) to C-5 ( $\delta_{\text{C}}$  200.4), C-6 ( $\delta_{\text{C}}$  59.8), C-7 ( $\delta_{\text{C}}$  196.6), C-2'' ( $\delta_{\text{C}}$  45.1), C-3'' ( $\delta_{\text{C}}$  147.3), and C-6'' ( $\delta_{\text{C}}$  33.1) indicated that the lavandulyl group is bound at C-6. The  $^1\text{H}$ - $^1\text{H}$  COSY, HSQC, and HMBC experiments of **2** enabled the allocation of all signals and determination of the planar structure (Figure 2).

The relative structures of dimethyl chromanone were identified as *cis*-isomers by comparing the chemical shifts of **2** ( $\delta_{\text{C-2}}$  74.3,  $\delta_{\text{C-3}}$  39.9,  $\delta_{\text{C-11}}$  16.3, and  $\delta_{\text{C-12}}$  9.9) and **1** ( $\delta_{\text{C-2}}$  74.4,  $\delta_{\text{C-3}}$  40.6,  $\delta_{\text{C-11}}$  16.3, and  $\delta_{\text{C-12}}$  9.8) [7], J value (3.6 Hz) between H-2 and H-3 of **2**, and NOESY correlations of H-2/H-3 and H-11/H-12 (Figure 2). In our previous study, we determined the absolute configuration of C-2 and C-3 of **1** as (2*S*, 3*R*) using time-dependent density functional theory and electronic circular dichroism (ECD) calculations [7]. In the current study, the absolute configuration of C-2 and C-3 of **2** was determined as (2*S*, 3*R*) in a similar manner by comparing the ECD data of **1** and **2** (Figure S11). However, the absolute configurations of C-6, C-13, and C-2'' are unknown. Therefore, **2** was identified as a new chromanone derivative and named as “calophylloidic acid B”. Several chromanone derivatives have been isolated from *Calophyllum* species [3-5, 8-10]. They contain an isoprene unit and a monoterpene group at C-6 position of the unique coumarin ring system. The synthetic pathway for these compounds, including calophylloidic acids (**1** and **2**), is unknown yet.



**Figure 2.** Key  $^1\text{H}$ - $^1\text{H}$ -COSY, HMBC, and NOESY correlations for calophylloidic acid B (**2**)

In conclusion, a new chromanone derivative, calophylloidic acid B (**2**), was isolated and its chemical structure elucidated by 1D and 2D NMR techniques and Mass spectral data for the first time. The compound **2** and its derivatives might be considered as potential antibacterial agents against *S. aureus* and *E. coli*.

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## Supporting Information

Supporting Information accompanies this paper on <http://www.acgpubs.org/journal/records-of-natural-products>

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## References

- [1] M. Govindasamy, S. Ramalingam, R. Dhairiyasamy and S. Rajendran (2022). Investigation on thermal and storage stability of the *Calophyllum inophyllum* ester with natural leaf extract as antioxidant additive, *Energy* **253**, 124117.
- [2] V. Vigneshwar, S.Y. Krishnan, R.S. Kishna, R. Srinath, B. Ashok and K. Nanthagopal (2019). Comprehensive review of *Calophyllum inophyllum* as a feasible alternate energy for CI engine applications, *Renew. Sustain. Energ. Rev.* **115**, 109397.
- [3] H. Wang, Q.Y. Sun, F.M. Yang, C.L. Long, Y.H. Wang, G.H. Tang, F.W. Zhao, H.M. Niu, Q.Q. Huang, J.J. Xu, Y. Wataya and L.J. Ma (2010). Chromanone derivatives from the pericarps of *Calophyllum polyanthum*, *Helv. Chim. Acta* **93**, 2183-2188.
- [4] F. Cottiglia, B. Dhanapal, O. Sticher and J. Heilmann (2004). New chromanone acids with antibacterial activity from *Calophyllum brasiliense*, *J. Nat. Prod.* **67**, 537-541.
- [5] Y. Kashman, K. R. Gustafson, R.W. Fuller, J.H. Cardellina 2nd, J.B. McMahon, M.J. Currens, R.W. Buckheit Jr, S.H. Hughes, G.M. Cragg and M.R. Boyd (1992). The calanolides, a novel HIV-inhibitory class of coumarin derivatives from the tropical rainforest tree, *Calophyllum lanigerum*, *J. Med. Chem.* **35**, 2735-2743.
- [6] M.C. Yimdjo, A.G. Azebaze, A.E. Nkengfack, A.M. Meyer, B. Bodo and Z.T. Fomum (2004). Antimicrobial and cytotoxic agents from *Calophyllum inophyllum*, *Phytochemistry* **65**, 2789-2795.

Mizuno *et al.*, *Rec. Nat. Prod.* (202X) X:X XX-XX

- [7] S. Mizuno, R. Miyata, K. Mukaide, S. Honda, A. Sukito, M. Sahlan, T. Taniguchi and S. Kumazawa (2022). New compound from the plant origin of propolis from Lombok, Indonesia and its antibacterial activity, *Results Chem.* **4**, 100276.
- [8] Y.-C. Shen, M.-C. Hung, L.-T. Wang and C.-Y. Chen (2003). Inocalophyllins A, B and their methyl esters from the seeds of *Calophyllum inophyllum*, *Chem. Pharm. Bull.* **51**, 802-806.
- [9] L.M. Lemos, R.B. Oliveira, B.L. Sampaio, G.V. Ccana-Ccapatinta, F.B. Da Costa and D.T.O. Martins (2016). Brasiliensic and isobrasiliensic acids: isolation from *Calophyllum Brasiliense* Cambess. And anti-*Helicobacter pylori* activity, *Nat. Prod. Res.* **30**, 2720-2725.
- [10] S. Tip-pyang and J. Sichaem (2021). Two new chromanone acid derivatives from *Calophyllum inophyllum*, *Chem. Nat. Compd.* **57**, 265-268.

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