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Cytotoxic Activity of Compounds from Vietnamese *Goniothalamus elegans* Ast

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ABSTRACT

Goniothalamus elegans Ast is a plant commonly used in traditional medicine for the treatment of heart disease and diarrhea. Although there has been one published study on its chemical composition, limited research has been conducted on its bioactivity. In this study, the aerial part of *G. elegans* was extracted using the soaking method and further subjected to column chromatography for isolation. The isolated compounds were then evaluated for cytotoxicity using SRB staining. From the aerial part of *G. elegans*, four compounds were successfully isolated and identified as (23*R*)-21,23-epoxy-5α-cycloart-24-en-3β-ol (**1**), stigmasterol (**2**), aristolactam BII (**3**), and piperolactam C (**4**). Among these compounds, aristolactam BII and piperolactam C exhibited moderate cytotoxicity against SW-489, AGS, LU-1, and HepG2 cell lines, with IC_{50} values ranging from 55.55 to 96.21 µg/mL. This study reveals that the phytochemical composition of *G. elegans* and demonstrates its potential cytotoxic activity, indicating promising avenues for further exploration in future research endeavors.

Keywords: *Goniothalamus elegans*, Annonaceae, cytotoxic activity, aristolactam BII

Introduction

Goniothalamus is a large genus within the Annonaceae family, comprising over 160 species that are distributed throughout tropical and subtropical regions of southern Asia.[1,2] These species have long been utilized in Traditional Medicine across various countries for the treatment of ailments such as joint pain, fractures, fever, boils, measles rash, and slow-healing wounds.[3-5] In addition to their traditional uses, modern pharmacological studies have revealed the diverse biological activities exhibited by extracts and isolated compounds derived from *Goniothalamus* sp. Notably, these studies have demonstrated antibacterial and anti-malarial properties, as well as remarkable cytotoxic activity.[6-14]

One specific species of interest is *G. elegans*, which is employed in Traditional Chinese Medicine for the treatment of heart disease and bloody diarrhea.[15,16] Existing literature reports indicate that only one publication has addressed the chemical composition of this species, identifying some isolated compounds primarily belonging to the styryllactone and aristolactam alkaloid groups.[17,18] These extracts and isolated compounds have demonstrated potent anticancer, antimalarial, and antibacterial activities.[17-19]

Previous studies have reported the isolation and evaluation of the cytotoxic activity of four compounds, namely liriodenin, lysicamine, trans-cinnamic acid, and 9-deoxygoniopypyron, from the aerial parts of the Vietnamese *G. elegans*.[20,21]

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This paper aims to expand upon these findings by presenting the extraction process and cytotoxic activity of four known compounds as (23R)-21,23-epoxy-5*α*-cycloart-24-en-3*β*-ol (**1**), stigmasterol (**2**), aristolactam BII (**3**), and piperolactam C (**4**) from *G. elegans*.

Materials and Method

Plant materials

The aboveground portion of the *G. elegans* tree was collected in Huong Hoa district, Quang Tri province, Vietnam in July 2020. The scientific identification of the plant was conducted by Assoc. Prof. Dr. Vu Tien Chinh from the Institute of Ecology and Biological Resources, Vietnam Academy of Science and Technology. The plant specimen has been assigned the identifier code GDTL-001. The collected plant samples are currently stored at the Laboratory of the Department of Medicinal Materials, Faculty of Pharmacy, Hue University of Medicine and Pharmacy.

Chemical reagents

Column chromatography was performed using two different adsorbents: a normal phase adsorbent, specifically silica gel (240-430 mesh, Merck - Germany), and a reverse phase adsorbent (ODS-60-14/63, Fujisilisa - Japan). Gel filtration chromatography utilized Sephadex LH-20 (Dowex 50WX2-100) was purchased from Sigma-Aldrich, USA. Thin-layer chromatography (TLC) was conducted using DC-Alufolien 60 F_{254} and RP18 F_{254} plates obtained from Merck, Germany. Substances were detected using an ultraviolet lamp with wavelengths of 254 nm and 365 nm. Nuclear magnetic resonance spectroscopy (1D- and 2D-NMR) measurements were carried out on a Bruker AM500 FT-NMR Spectrometer (Bruker, Massachusetts, USA). TMS (tetramethylsilane) served as the internal standard during NMR analysis. These experiments were conducted at the Institute of Chemistry, Vietnam Academy of Science and Technology.

Extraction and isolation

The raw powder weighing 4.5 kg was subjected to 10 L of methanol extraction at room temperature, repeated three times at a frequency of

once per week. The combined extracts resulted in a total solvent yield of 375 g. The total extract was then dispersed in water and partitioned with n-hexane, dichloromethane (CH_2Cl_2), and ethyl acetate (EtOAc) successively, yielding fractions of each solvent and residual water. The obtained solvent fractions were as follows: n-hexane (H, 117.6 g), CH_2Cl_2 (D, 91.2 g), EtOAc (E, 83.3 g), and residual water (W, 74.7 g). The CH_2Cl_2 fraction (D, 91.2 g) was subjected to further separation using Sephadex LH-20 column chromatography, eluted with a CH_2Cl_2-MeOH (1:1, v/v) solvent system, resulting in the isolation of eight subfractions (D1–D8). Subfraction D3 was subsequently subjected to normal phase silica gel chromatography, using an *n*-hexane-CH_2Cl_2-MeOH (3:1:0.1, v/v/v) solvent system, leading to the formation of four fractions (D3A–D3D). Fraction D3B underwent reverse-phase column chromatography using an acetone-H_2O (5:1, v/v) solvent system, resulting in the generation of five fractions (D3B1–D3B5). Compound **1** (5.6 mg) was obtained through the purification of fraction D3B4 using Sephadex LH-20 column chromatography eluted with MeOH. Fraction D3B3 was subjected to normal phase column chromatography, using a CH_2Cl_2-EtOAc (10:1, v/v) solvent system, yielding six fractions (D3B3A–D3B3F), and compound **2** (14.6 mg) was isolated from the washed crystals in fraction D3B3C. On the other hand, the EtOAc fraction (E, 83.3 g) underwent separation using a normal phase silica gel column with gradient elution of n-hexane-EtOAc (100:0 x 0:100, v/v), resulting in six fractions (E1–E6). Fraction E4 was subjected to normal phase column chromatography, eluted with n-hexane-EtOAc (5:1, v/v), leading to the generation of six fractions (E4A–E4F). Fraction E4B was further isolated using reverse-phase column chromatography with an acetone-H_2O (2:1, v/v) solvent system, yielding five fractions (E4B1–E4B5). The E4B4 fraction was isolated using normal phase column chromatography with the solvent system *n*-hexane-CH_2Cl_2-EtOAc (10:1:1, v/v/v), resulting in five fractions (E4B4A−E4B4E). Compound **3** (14 mg) was purified from the E4B4C fraction using a Sephadex LH-20 column with 100% MeOH as the solvent. The E4B4D fraction was purified by reverse-phase chromatography using a MeOH-H_2O (1:1, v/v) solvent system, yielding compound **4** (8 mg). The chemical structures of isolated compounds (**1**-**4**) were in Figure 1.

Cancer cell

The cell lines employed for the cytotoxicity assessment in this study included human lung cancer (SK-LU-1), human breast cancer (MCF-7), human gastric cancer (AGS), human liver cancer (HepG2), and human colon cancer (SW-480). Additionally, the study also utilized the human benign embryonic kidney cell line (HEK-293) for comparative analysis.

Methods for assessing cytotoxicity

The cytotoxicity assessment of the total methanol (MeOH) extract, as well as the individual extracts and isolated compounds from G. elegans, was conducted using the sulforhodamine B (SRB) dye method, following Monks' protocol.[20] The human liver cancer cell line HepG2 was cultivated in a medium comprising 50 mL of DMEM (Dulbecco's Modified Eagle Medium) containing 2 mM L-glutamine, 1.5 g/L sodium bicarbonate, 4.5 g/L glucose, 10 mM HEPES, and 1.0 mM sodium pyruvate, supplemented with 10% fetal bovine serum (FBS). The cells were cultured in a CO2 incubator at 37°C, with the medium being refreshed every 48 hours. Cell dissociation was performed using 0.05% trypsin-EDTA solution, and subculturing was carried out every 3-5 days at a ratio of 1:3. To determine the percentage of viable cells, the SRB dye was employed for quantifying cellular protein. Live cells were seeded overnight in 96-well plates at a density of 4×10^4 cells in 180 µL of the culture medium per well. Test samples, at various concentrations, were added to each well containing the cells. The culture was maintained under constant conditions for 72 hours. Following the removal of the medium, the cells were fixed with 20% (w/v) trichloroacetic acid (TCA) at 4°C for 1 hour. Subsequently, the cells were stained with SRB at room temperature for 30 minutes. The bound SRB was then eliminated by washing with 1% (v/v) acetic acid. Finally, a 10 mM Tris solution was utilized to dissolve the SRB bound to the protein molecules and stain them. The absorbance of the resulting solution was measured at 515 nm using an ELISA reader (BioTek, Washington, USA). The experiments were repeated three times to ensure accuracy. For the positive control, ellipticine was employed at test concentrations of 10, 2, 0.4, and 0.08 µg/mL. A 10% solution of dimethyl sulfoxide (DMSO) was consistently used as the negative control. The IC_{50} value, representing the concentration at which 50% inhibition of cell growth occurs, was determined using TableCurve 2Dv4 computer software (Systat Software, Inc., USA). The percentage of inhibition (I) was calculated according to the formula:

$$I\% = 100\% - (ODt-OD0)/(ODc-OD0) \times 100$$

Where, ODt: average optical density value at day 3; OD0: average optical density value at time 0; ODc: average optical density value of the blank.

Results and Discussion

Compound **1** was isolated as a white powder, well soluble in $CHCl_3$. The ^{1}H-NMR spectrum reveals several characteristic signals, including an olefin proton signal at δ_H 5.18 (td, J = 8.4, 1.2 Hz, H-24), two oxymethylene protons at δ_H 3.93 (t, J = 8.4 Hz, H-21a) and 3.38 (t, J = 8.4 Hz, H-21b), oxymethine protons at δ_H 4.52 (m, H-23), and 3.28 (m, H-3) (Table 1). Additionally, six methyl groups are observed at δ_H 0.81 (s, H3-29), 0.89 (s, H3-30), 0.96 (s, H3-28), 0.97 (s, H3-18), 1.72 (d, J = 1.2 Hz, H3-27), and 1.68 (d, J = 1.2 Hz, H3-26). The ^{13}C-NMR and HMQC spectra provide information on the carbon signals, confirming the presence of 30 carbons, including 6 methyl groups, 12 methylene groups, 6 methine groups, and 6 non-hydrogenous carbons, a typical cycloartane triterpene skeleton.[21,22] Notably, the presence of a three-substituted double bond is indicated by two olefin carbons at δ_C 126.3 (C-24) and 135.7 (C-25). The carbon signals for the oxymethin group are observed at δ_C 78.8 (C-3) and 75.2 (C-23), while the oxymethylene carbon is found at δ_C 71.4 (C-21). The HMBC spectrum reveals key interactions, such as H3-28 (δ_H 0.96) and H3-29 (δ_H 0.81) with C-3 (δ_C 78.8), confirming the assignment of the oxymethine group to C-3. The interaction between H3-26 (δ_H 1.68)/H3-27 (δ_H 1.72) and C-24 (δ_C 126.3)/C-25 (δ_C 135.7) supports the location of the double bond at C-24/C-25. Additionally, the HMBC interaction between H-21 (δ_H 3.93; 3.38) and C-23 (δ_C 75.2), along with the chemical shift values of C-21 (δ_C 71.4) and C-23 (δ_C 75.2), suggests the presence of a tetrahydrofuran ring in the cycloartane triterpene skeleton.[21,22] Furthermore, the COSY interaction between H-21 (δ_H 3.93; 3.38), H-20 (δ_H 2.22), H-22 (δ_H 1.24), H-23 (δ_H 4.52), and H-24 (δ_H 5.18) suggests a fragment of the sec-but-2-enyl structure at C-23. Overall, based on the analysis of the ^{1}H- and ^{13}C-NMR spectral data, **1** is identified as (23R)-21,23-epoxy-5α-cycloart-24-en-3β-ol.[23,24]

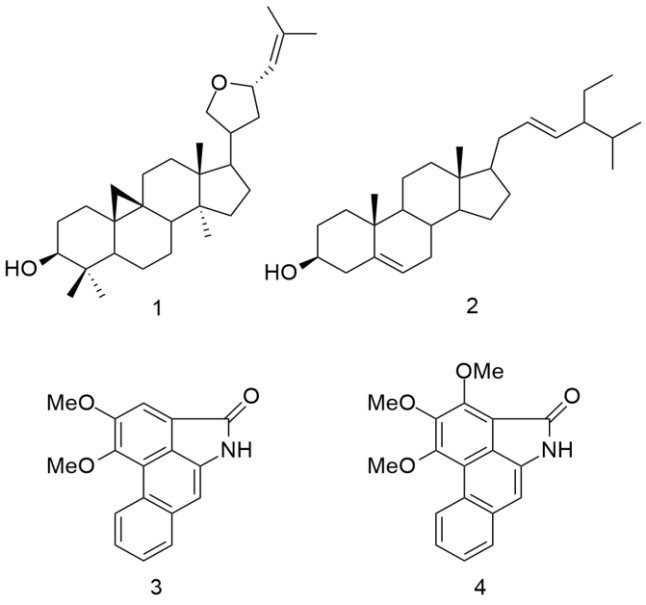

Figure 1: Chemical structures of isolated compounds (**1**–**4**)
Table 1: NMR spectroscopic data of compound 1 in $CDCl_3$

No	Compound 1	
	δ_C (125 MHz)	δ_H (600 MHz, *J* in Hz)
1	31.9	1.26*; 1.57*
2	30.4	1.57*; 1.74*
3	78.8	3.28 m
4	40.5	–
5	47.0	1.29*
6	21.0	1.60*; 0.80*
7	26.0	1.15*; 1.35*
8	47.8	1.49*
9	20.0	–
10	25.8	–
11	26.4	1.12*; 1.97 sept (5.4)
12	31.3	–
13	45.5	–
14	48.4	–
15	35.8	1.36*
16	27.9	1.37*; 1.88*
17	51.0	1.73*
18	18.8	0.97 s
19	30.0	0.57 d (4.2); 0.32 d (4.2)
20	43.7	2.22 m
21	71.4	3.93 t (8.4); 3.38 t (8.4)
22	40.5	2.10 quin (6.0); 1.24*
23	75.2	4.52 m
24	126.3	5.18 td (8.4; 1.2)
25	135.7	–
26	18.1	1.68 d (1.2)
27	26.3	1.72 d (1.2)
28	25.5	0.96 s
29	14.0	0.81 s
30	19.3	0.89 s

* Chemical shifts may be interechangeable.

Compound **2** was isolated as a white powder, well soluble in $CHCl_3$. The ^{1}H-NMR spectrum of **2** reveals several characteristic signals, these include an olefin proton signal at δH 5.35 (brd, J = 5.4 Hz, H-6), two trans olefin protons at δH 5.16 (dd, J = 15.3, 9.0 Hz, H-22) and 5.02 (dd, J = 15.3, 8.4 Hz, H-23), and one oxymethine proton at δH 3.52 (m, H-3). In the high field region of the spectrum, signals for various methyl groups are observed. These include two tertiary methyl groups at δ_H 0.70 (s, H3-18) and 1.01 (s, H3-19), three secondary methyl groups at δH 0.81 (d, J = 6.0 Hz, H3-27), 0.85 (d, J = 6.0 Hz, H3-26), and 1.02 (d, J = 6.6 Hz, H3-21), and one primary methyl group at δH 0.81 (t, J = 7.2 Hz, H3-29). Based on these spectral data, **2** is identified as stigmasterol,[25] which is a common sterol found in various plants.

Compound **3** was obtained as a pale-yellow powder, and it is well soluble in $CHCl_3$ and MeOH. The ^{1}H-NMR spectrum of **3** shows characteristic signals, including four aromatic protons at δ_H 9.24 (1H, m, H-5), 7.81 (1H, m, H-8), 7.57 (2H, m, H-6/H-7), and two singlet signals of non-interacting aromatic protons at δ_H 7.83 (H-2) and 7.08 (H-9). Additionally, two methoxy groups attached to the aromatic nucleus resonate at δH 4.12 (3-OCH_3) and 4.03 (4-OCH_3) as singlets of high intensity. The ^{13}C-NMR and HSQC spectra of **3** reveal resonance signals of 17 carbons, including one amide carbon (δ_C 169.3), two oxygen-carrying aromatic carbons (δ_C 151.7 and 154.6), and two methoxy carbons (δ_C 57.0 and 40.4). The signals in the range δ_C 105.7-134.8 are assigned to the carbons of the aromatic nucleus (Table 2). Based on the ^{1}H and ^{13}C-NMR spectral data, **3** possesses an aporphinoid skeleton containing the phenanthrene-bearing group.[26,27] The HMBC spectrum confirms interactions between specific protons and carbons, such as H-2 (δ_H 7.83) with C-4 (δ_C 151.7)/C-10a (δ_C 124.5), H-5 (δ_H 9.24) with C-7 (δ_C 127.6)/C-4a (δ_C 121.1)/C-8a (δ_C 134.8), H-6 (δH 7.57) with C-8 (δ_C 129), H-7 (δ_H 7.57) with C-5 (δ_C 127.6)/C-8a (δ_C 134.8), H-8 (δ_H 7.81) with C-6 (δ_C 126)/C-9 (δC 105.7)/C-4b (δ_C 127.1), and H-9 (δ_H 7.08) with C-4b (δ_C 127.1)/C-10a (δ_C 124.5). These interactions confirm the presence of a 1,3,4,10-substituted phenanthrene framework. Furthermore, the HMBC spectrum confirms the binding sites of the two methoxy groups at C-3 and C-4. Interactions between H-12 (δ_H 4.08) and C-3 (δ_C 154.6), as well as between H-13 (δ_H 4.13) and C-4 (δ_C 151.7), indicate the attachment of the methoxy groups. The lower resonance of C-3 compared to C-4 is attributed to the non-planar structure of the methoxy group at C-4. Based on the spectral data and comparison with references, **3** is identified as 10-amino-3,4-dimethylphenanthrene-1-carboxylic acid lactam, also known as aristolactam BII.[28,29]

Compound **4** was obtained as a pale yellow powder and is well soluble in $CHCl_3$ and MeOH. The ^{1}H and ^{13}C-NMR spectral data of **4** reveal a structure similar to **3** (Table 2), possessing an aporphinoid skeleton containing a phenanthrene-colored group. However, **4** contains a methoxy group at C-2 of the main skeleton. The presence of the methoxy group at C-2 in 4 is confirmed by the HMBC interaction between H-12 (δ_H 4.20) and C-2 (δ_C 157.3). The low magnetic shift of C-2 in **4** compared to the spectral data of C-2 in **3** further supports this finding. Based on the spectral data and comparison with references, compound **4** is identified as 10-amino-2,3,4-trimethylphenanthrene-1-carboxylic acid lactam, also known as piperolactam C.[28,29]

Cytotoxicity results

Among the isolated compounds, (23R)-21,23-epoxy-5α-cycloart-24-en-3β-ol (**1**), aristolactam BII (**3**) and piperolactam C (**4**) were used to evaluate the cytotoxicity activity using SRB dye on human lung cancer (SK-LU-1), human breast cancer (MCF-7), gastric cancer cell lines, human colon cancer (AGS), human liver cancer (HepG2), human colon cancer (SW-480) and human embryonic renal cell line (HEK-293). Compound **1**, (23R)-21,23-epoxy-5α-cycloart-24-en-3β-ol, did not exhibit cytotoxic activity against any of the tested cell lines. Compound **3**, aristolactam BII, showed moderate cytotoxic activity against the following cell lines SW-480 (IC_{50} = 68.3 ± 1.91 µg/mL), AGS (55.44 ± 5.04 µg/mL), SK-LU-1 (96.21 ± 4.79 µg/mL), and HepG2 (82.14 ± 2.72 µg/mL). Compound **4**, piperolactam C exhibited cytotoxic activity against the following cell lines SW-480 (IC_{50} = 78.03 ± 1.88 µg/mL), AGS (63.80 ± 3.81 µg/mL), SK-LU-1 (94.46 ± 2.51 µg/mL), and HepG2 (87.35 ± 4.21 µg/mL). However, neither aristolactam BII (**3**) nor piperolactam C (**4**) showed cytotoxic effects on the MCF-7 and HEK-293 cancer cell lines. Ellipticine, the positive control, demonstrated cytotoxic activity against all tested cancer cell lines with IC_{50} values ranging from 0.34 to 1.50 µg/mL. These results indicate that aristolactam BII (**3**) and piperolactam C (**4**) have some cytotoxic activity against certain cancer cell lines, while compound 1 does not exhibit cytotoxic effects in the tested cell lines (Table 3).

Compound **1** was identified as (23R)-21,23-epoxy-5α-cycloart-24-en-3β-ol. It is indeed interesting that **1**, belonging to the cycloartane structure, has been identified in the *Goniothalamus* genus for the first time. The presence of this compound expands the known chemical diversity within this plant genus. Aristolactam BII, also known as cepharanone B, has a history of being discovered in various species, including *Aristolochia argentina* and some other different *Goniothalamus* species such as *G. velutius*, *G. chinensis*, *G. amuyon*, *G. griffithii*, *G. andersonii*, *G. malayanus*, and *G. tenuifolius*. Its classification as an alkaloid with a phenanthrene lactam framework is notable. Aristolactam BII exhibits diverse biological activities, including antioxidant, anti-inflammatory, antiplatelet, antibacterial, antifungal, neuroprotective, and antitumor properties.[28,29] Piperolactam C, a derivative of aristolactam BII, is structurally similar but contains

an additional methoxy substituent at the C-2 position. This slight modification may influence its biological activities. Aristolactams, including piperolactam C, are of significant interest due to their potential pharmacological properties and have been studied for their antioxidant, anti-inflammatory, and anticancer effects.[30]

In this study, the cytotoxic activities of aristolactam BII (**3**) and piperolactam C (**4**) on various cancer cell lines have been studied, revealing their potential as anticancer agents. Aristolactam BII showed strong and selective cytotoxic activity against the NCI-H187 cell line with an IC_{50} of 0.072 µg/mL, which was even stronger than the positive control ellipticine. Importantly, aristolactam BII exhibited low toxicity toward normal Vero cell lines. Moreover, aristolactam BII demonstrated significant activity against human CNS carcinoma XF-498 cells, L1210, and HeLa cells,[8,9,31] and P-388, A-549, and HT-29 cells.[32]

The anti-tumor activity of this alkaloid was associated with the downregulation of cell cycle-related proteins such as cyclin E, cyclin A, CDK2, and CDC2 (CDK1), as well as upregulation of proteins such as p21Cip1, p27Kip1, and p53. Furthermore, aristolactam BII increased the expression of caspase 3, caspase 8, and Bax, while decreasing the expression of Bcl-2 protein, leading to late apoptosis.[9-11]

Regarding piperolactam C (**4**), which shares a similar phenanthrene-bearing structure with aristolactam BII, its cytotoxic activity has been found to be relatively weak, and it has not been extensively studied. Piperolactam C exhibited toxicity against cancer cell lines P-388, HT-29, and A549.[33] It has been suggested that the lower inhibitory activity of piperolactam C may be attributed to the absence of oxygen-containing substituents in the D-ring, which play a crucial role in its inhibitory activity against P-388 and A549 cells, as noted by Tsai et al.[34]

Overall, aristolactam BII and piperolactam C demonstrate promising cytotoxic activities against certain cancer cell lines, and further research is warranted to explore their mechanisms of action and potential as anticancer agents.

Table 2: NMR spectroscopic data of compounds **3** and **4**

C	Compound 3[a]		Compound 4[b]	
	δ_C (600 MHz)	δ_H (150 MHz, *J* in Hz)	δ_C (600 MHz)	δ_H (150 MHz, *J* in Hz)
1	121.1	–	109.0	–
2	109.6	7.83 s	157.3	–
3	154.6	–	154.2	–
4	151.7	–	146.4	–
4a	121.1	–	116.5	–
4b	127.1	–	126.5	–
5	127.6	9.24 m	126.7	9.20 m
6	126.0	7.57 m	126.0	7.55 m
7	127.6	7.57 m	126.8	7.55 m
8	129.0	7.81 m	128.7	7.83 m
8a	134.8	–	133.4	–
9	105.7	7.08 s	106.2	7.20 s
10	133.9	–	133.4	–
10a	124.5	–	125.7	–
11	169.3	–	167.4	–
12	57.0	4.08 s	60.9	4.20 s
13	60.4	4.13 s	61.6	4.54 s
-NH	–	7.99 br s	63.0	4.00 s

[a] in $CDCl_3$, [b] in pyridine-d_5

Table 3: Cytotoxic activity of compounds **1**, **3**, and **4**

Cancer cells	IC_{50}[a]			
	1	3	4	Ellipticine[b]
SW-480	>100	68.3 ± 1.91	78.03 ± 1.88	0.34 ± 0.05
AGS	>100	55.44 ± 5.04	63.80 ± 3.81	0.38 ± 0.03
SK-LU-1	>100	96.21 ± 4.79	94.46 ± 2.51	0.38 ± 0.04
MCF-7	>100	>100	>100	1.50 ± 0.16
HepG2	>100	82.14 ± 2.72	87.35 ± 4.21	0.38 ± 0.04
HEK-293	>100	> 100	> 100	0.40 ± 0.04

[a] Results are expressed as IC_{50} in µg/mL, and the cytotoxicity effect was expressed as the mean ± standard deviation (SD) of three replicates. Statistical significance was accessed by Duncan's multiple range tests (* $p < 0.01$; ** $p < 0.05$); [b] Positive control.

Conclusion

In conclusion, the aboveground part of Vietnamese *Goniothalamus elegans* yielded four compounds, (23R)-21,23-epoxy-5*α*-cycloart-24-en-3*β*-ol (**1**), stigmasterol (**2**), aristolactam BII (**3**), and piperolactam C (**4**). Among these compounds, aristolactam BII and piperolactam C exhibited moderate cytotoxicity against SW-480, AGS, SK-LU-1, and HepG2 cancer cell lines, with IC_{50} values ranging from 55.55 to 96.21 µg/mL. These findings highlight the importance of further exploring the phytochemistry and biological activities of the *Goniothalamus elegans*. Additional research is needed to uncover the full potential of these compounds and their potential applications in cancer treatment.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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