CHEMICAL COMPOSITION AND CYTOTOXIC ACTIVITY OF THE METHANOL EXTRACT FROM *POLYCARPAEA CORYMBOSA* (L.) LAM ROOTS

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Abstract - *Polycarpaea corymbosa* (L.) Lam, a traditional medicinal plant known for its cooling and diuretic properties, is commonly used in folk medicine for both internal and topical applications. The methanol root extract of *Polycarpaea corymbosa* (L.) Lam was prepared using ultrasound-assisted extraction. Phytochemical screening indicated the presence of alkaloids, coumarins, flavonoids, polyphenols, reducing sugars, carboxylic acids, and steroids. GC-MS analysis of the volatile constituents of the methanol extract identified 17 compounds, with carboxylic acids and their derivatives constituting the major components. Furthermore, the extract exhibited notable cytotoxicity against HepG2 and MCF-7 cell lines, with IC_{50} values (µg/mL) of 14.81 ± 0.77 and 25.89 ± 2.02, respectively. The results suggest that the methanolic root extract of *Polycarpaea corymbosa* (L.) Lam shows potential as an adjunct anticancer agent against HepG2 and MCF-7 cell lines.

Keywords - *Polycarpaea corymbosa* (L.) Lam; root; methanolic extract; HepG2; MCF-7.

1. Introduction

Polycarpaea corymbosa (L.) Lam. is a herbaceous species belonging to the family Caryophyllaceae, commonly found across tropical and subtropical regions, particularly in South and Southeast Asia. The plant commonly grows in dry, nutrient-deficient habitats such as sandy areas, roadsides, and wastelands, indicating a strong adaptability to harsh environmental conditions. In Vietnam, *Polycarpaea corymbosa* is frequently found on coastal sandy soils extending from Hai Phong to Binh Thuan provinces [1, 2]. In traditional medicine, *Polycarpaea corymbosa* has traditionally been employed for the management of respiratory ailments, jaundice, snakebite, boils, and inflammatory conditions [3, 4]. Pharmacological investigations have revealed that this species possesses multiple bioactive properties, such as antioxidant [5, 6], anti-inflammatory [7, 8], antibacterial [9, 10], analgesic [11], hepatoprotective [12], and inhibitory effects on cancer cell lines [13-15]. Phytochemical investigations have revealed the presence of several constituents in whole-plant extracts, including camelliagenin A, A1-barrigenol, stigmastanol, apoanagallosaponin IV, *n*-hexadecanoic acid, and 5-hydroxymethylfurfural, as well as flavonoids, phenolic compounds, saponins, fatty acids, and other classes of secondary metabolites [16-19]. However, reports on the chemical composition and cytotoxic activity of *Polycarpaea corymbosa* specimens collected in Vietnam remain scarce. In addition, root tissues often accumulate higher concentrations of defensive and bioactive compounds than aerial parts [20]. In the present study, the phytochemical profile and cytotoxic effects of the methanolic root extract of *Polycarpaea corymbosa* collected in Hue City, Vietnam, were examined against HepG2 hepatoma and MCF-7 breast cancer cells.

2. Materials and methods

2.1. Plant materials, chemicals, and equipment

2.1.1. Plant materials

The roots of *Polycarpaea corymbosa* (L.) Lam. were collected from coastal sandy areas in Phong Quang Ward, Hue City, in June 2024. The plant material was taxonomically identified by Dr. Tran Quang Dan (The University of Danang - University of Science and Education) according to references [1] and [2], and a voucher specimen (PCC001) was deposited at the Faculty of Physics and Chemistry, The University of Danang - University of Science and Education. The collected roots were free from fungal contamination and insect damage, undamaged, and of uniform quality. After collection, the roots were thoroughly cleaned, air-dried, oven-dried, and subsequently ground into powder. The brown root powder was stored in a cool, well-ventilated place for subsequent use in experiments.

2.1.2. Chemicals

Analytical-grade reagents and solvents, including CH_3OH, DMSO, SRB, CCl_3COOH, CH_3COOH, Tris base, and phytochemical screening reagents, were obtained from commercial suppliers in China.

2.1.3. Equipment

Laboratory apparatus used in this work comprised glassware, pipettes, filter paper, an analytical balance, a digital ultrasonic cleaner, a rotary evaporator, a Bio-Rad Mark Pro microplate reader, and an Agilent 7890A/5975C gas chromatograph coupled with a mass spectrometer.

2.2. Methods

2.2.1. Determination of Physicochemical parameters

Moisture content, total ash, and heavy metal content were determined according to the Vietnamese Pharmacopeia V.

Moisture content: The root powder of *Polycarpaea corymbosa* was placed in a porcelain dish and dried at 105 °C until a constant weight was obtained.

Total ash: The dried root powder, obtained after moisture determination, was incinerated at 500 °C for 6 hours to yield white ash.

Heavy metal content: The obtained ash was dissolved in 10% nitric acid (HNO_3) and diluted to volume with distilled water for subsequent analysis using atomic absorption spectroscopy (AAS).

2.2.2. Preparation of Extract

The powdered roots of *Polycarpaea corymbosa* were extracted twice with methanol (1:15, w/v) under ultrasonic conditions (40 kHz, 50 °C, 40 min). The pooled extracts were vacuum-concentrated at 50 °C to obtain the crude methanolic fraction (yield: 36.2%) [21].

2.2.3. Qualitative phytochemical screening and chemical constituent analysis

* The presence of major phytochemical classes in the methanolic extract was assessed using standard chemical tests with characteristic reagents [22]:

- Alkaloids: Detected using Mayer's, Wagner's, and Dragendorff's reagents. Positive reactions were indicated by the appearance of white/yellow, brown, and orange precipitates, respectively.

- Flavonoids: Detected using a combination of sodium nitrite ($NaNO_2$), aluminum chloride ($AlCl_3$), and sodium hydroxide (NaOH). The appearance of an orange-yellow color indicated the presence of flavonoids.

- Coumarins: Detected using 10% NaOH solution. Formation of turbidity indicated the presence of coumarins.

- Polyphenols: Detected using ferric chloride ($FeCl_3$). A dark green reaction product was considered indicative of the presence of polyphenols.

- Reducing sugars: Detected using Fehling's A and B solutions. Formation of a brick-red precipitate indicated the presence of reducing sugars.

- Steroids: Detected using Liebermann–Burchard reagent. Steroids were identified based on the formation of a green-colored reaction product.

- Carboxylic acids: Detected using sodium carbonate (Na_2CO_3). Formation of effervescence indicated the presence of carboxylic acids.

* Chemical constituents analysis: The phytochemical composition of the root-derived methanolic fraction from *Polycarpaea corymbosa* was determined through GC-MS analysis carried out on an Agilent 7890A/5975C apparatus.

- Gas Chromatography (GC) conditions: The GC oven was operated within a temperature range of 35-450 °C with a resolution of 1 °C. Heating was conducted at programmable rates between 0.1 and 120 °C/min, and the maximum analytical duration was set at 999.99 min. The system allowed a split ratio up to 7500:1 under operating pressures ranging from 0 to 100 psi, while helium was employed as the carrier gas at flow rates of 1-13 mL/min. Separation was achieved using an HP-5MS fused-silica capillary column (30 m × 0.25 mm, film thickness 0.25 µm).

- Mass Spectrometry (MS) conditions: Electron ionization was employed for mass analysis within a scan range of m/z 20-500. Instrument performance showed retention time variation below 0.0012 min and peak area repeatability under 2.0 RSD. The analyzer supported masses up to 1050 amu with ionization energies ranging from 5 to 241.5 eV.

2.2.4. Evaluation of the cytotoxic activity

HepG2 human liver cancer and MCF-7 breast cancer cell lines were kindly supplied by Prof. J. M. Pezzuto from Long Island University (USA) and Prof. Chi-Ying Huang from National Yang Ming Chiao Tung University (Taiwan), respectively. The cells were maintained as adherent monolayer cultures in DMEM supplemented with 2 mM L-glutamine, 1.5 g/L $NaHCO_3$, 4.5 g/L glucose, 10 mM HEPES, 1.0 mM sodium pyruvate, and 10% fetal bovine serum (Gibco). Cell cultivation was carried out at 37 °C in a humidified atmosphere containing 5% CO_2 for 3-5 days.

In vitro cytotoxic evaluation was conducted according to the standard screening protocol recommended by the National Cancer Institute (NCI) for the identification of compounds with anticancer potential. Cytotoxicity was assessed using the method described by Monks *et al*. [23]. This assay estimates total cellular protein based on optical density measurements obtained after staining viable cells with sulforhodamine B (SRB). Since the absorbance intensity correlates with the amount of SRB bound to cellular proteins, higher OD values reflect greater cell density. The experimental procedure was performed under the following conditions:

- The research sample was prepared as a stock solution in 100% DMSO in a microcentrifuge tube, with a stock concentration of 20 mg/mL. Subsequently, the stock solution was diluted tenfold to 2 mg/mL (2000 µg/mL) by transferring 100 µL of the stock solution into a second microcentrifuge tube containing 900 µL of cell culture medium (without FBS). Finally, a dilution plate was prepared by transferring 50 µL of the solution from the second microcentrifuge tube into well A1 of a 96-well plate to perform the second dilution step. Then, 10 µL of the sample from well A1 was transferred into well B1, which already contained 90 µL of cell culture medium (without FBS), and the dilution was continued in the same manner to obtain a series of four concentrations in descending order (A1, B1, C1, and D1). At this stage, the samples were diluted, and the resulting concentration series was 2000, 400, 80, and 16 µg/mL. Cells were detached using trypsin, quantified with a counting chamber, and diluted to obtain a final density of 3×10^4 cells/mL. Aliquots of 190 µL were then transferred into individual wells followed by incubation for 3-5 days.

- In the experiment, 10 µL of the prepared solution from the dilution plate was transferred into the experimental plate containing 190 µL of the cell. Accordingly, the final concentrations to which the cells were exposed with the sample were 100, 20, 4, and 0.8 µg/mL.

- For the day 0 reference, an additional 96-well plate containing only cancer cells (190 µL/well) without treatment was established in three columns. Following 1 h

incubation, cells were fixed using TCA. This control plate was handled separately but subjected to the same analytical procedure as the treated experimental plates.

- Following incubation in a CO_2 atmosphere, the cells were fixed to the plate surface using TCA for 30 min and subsequently stained with SRB at 37 °C for 1 h. Excess dye was removed, and the wells were rinsed three times with 5% acetic acid before being air-dried at room temperature.

- The SRB attached to cellular proteins was released with 10 mM Tris(hydroxymethyl)aminomethane solution, followed by gentle agitation for 10 min. Optical density was recorded within the wavelength range of 515-540 nm using an ELISA microplate reader (Bio-Rad). The inhibitory effect of the samples on cell proliferation was expressed as percentage inhibition calculated from Equation (1) [24]:

$$\%\,Cell\ inhibited = 100\% - \frac{OD\,(reagents) - OD\,(day\ 0)}{OD\,(negative\ control) - OD\,(day\ 0)} \quad (1)$$

Cytotoxic experiments were independently repeated three times for reproducibility. Ellipticine obtained from Sigma-Aldrich (USA) was utilized as the positive standard at concentrations ranging from 0.08 to 10 µg/mL. DMSO (1%) served as the negative control, and its final concentration in the assay system was maintained at 0.05%. IC_{50} values, defined as the concentration causing 50% inhibition of cell growth, were estimated using TableCurve 2Dv4 software. In accordance with NCI guidelines, extracts exhibiting IC_{50} values of 20 µg/mL or lower were classified as cytotoxic [25]. The experimental work was conducted at the Institute of Biotechnology, Vietnam Academy of Science and Technology.

3. Results and discussions

3.1. Physicochemical parameters

The results of selected physicochemical parameters of *Polycarpaea corymbosa* root powder:

- Moisture content: 6.73%

- Total ash: 4.20%

- The heavy metal contents are presented in Table 1.

According to the "Regulations on Biological and Chemical Contaminant Limits in Food" issued by the Ministry of Health, the contents of selected heavy metals in *Polycarpaea corymbosa* root powder were well below the maximum permissible limits [26].

Table 1. *Content of selected heavy metals*

Metal	Metal content (mg/kg dry weight)	Permissible content (mg/kg)
Pb	$0.857.10^{-4}$	≤ 0.05
Cu	$1.574.10^{-3}$	≤ 30
Zn	$5.435.10^{-4}$	≤ 40
Cd	$0.059.10^{-3}$	≤ 0.05

3.2. Qualitative phytochemical screening and chemical constituent analysis

The results of the qualitative screening of major phytochemical classes in the methanolic extract of *Polycarpaea corymbosa* roots are presented in Table 2.

Table 2. *Phytochemical classes*

Phytochemical class	Reagent	Observation	Result
Alkaloids	Mayer	Pale yellow precipitate	Present
	Wagner	Brown precipitate	Present
	Dragendroff	Orange precipitate	Present
Courmarins	NaOH	Turbidity	Present
Flavonoids	$NaNO_2$ + $AlCl_3$ + NaOH	Orange-yellow color	Present
Polyphenols	$FeCl_3$	Dark green precipitate	Present
Reducing sugars	Fehling A + Fehling B	Brick-red precipitate	Present
Steroids	Liebermann-Burchard	Green color	Present
Carboxylic acids	Na_2CO_3	Effervescence	Present

Table 2 summarizes the phytochemical constituents detected in the methanolic extract of *Polycarpaea corymbosa* roots, including alkaloids, coumarins, flavonoids, polyphenols, reducing sugars, steroids, and carboxylic acids. These findings are consistent with previous reports by S. Sindhu and S. Manorama [9] and K. Modi and M. B. Shah [19]. Studies have demonstrated that alkaloids, flavonoids, polyphenols, and steroids exhibit significant cytotoxicity against liver and breast cancer cell lines [27-30].

The chemical composition of volatile compounds in the methanolic extract of *Polycarpaea corymbosa* roots, as determined by GC-MS analysis, is shown in Figure 1 and Table 3.

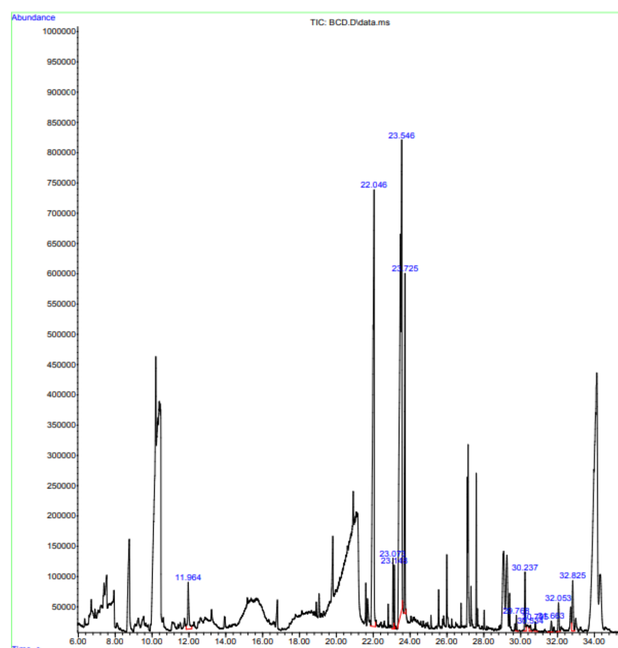

Figure 1. *GC-MS chromatogram*

The results presented in Figure 1 and Table 3 indicate that 17 compounds were identified in the methanolic extract of *Polycarpaea corymbosa* roots. Among these, compounds belonging to the carboxylic acid and derivative

class accounted for the highest proportion (22.62%), followed by phytosterols (1.04%), phenolics (0.86%), lignans (0.63%), and other organic compounds (0.32%). Similar findings have also been documented in previous reports [17, 18]. Numerous studies have demonstrated that phytosterols possess antiproliferative potential against a variety of tumor cell lines, particularly liver and breast cancers [31].

Table 3. *Chemical composition*

No.	Retention time (min)	Compound	Peak area (%)
1	11.964	2-Methoxy-4-vinylphenol	0.64
2	18.912	Coniferyl aldehyde	0.10
3	19.062	4-((1*E*)-3-Hydroxy-1-propenyl)-2-methoxyphenol	0.22
4	22.046	*n*-Hexadecanoic acid	7.13
5	22.813	Heptadecanoic acid	0.14
6	23.073	9,12-Octadecadienoic acid, methyl ester	0.43
7	23.148	9-Octadecenoic acid (*Z*)-, methyl ester	0.29
8	23.477	(*Z*, *Z*)-9,12-Octadecadienoic acid	6.49
9	23.546	Oleic acid	5.12
10	23.726	Octadecanoic acid	3.02
11	29.768	*γ*-Tocopherol	0.12
12	30.237	Sesamin	0.53
13	30.534	Vitamin E	0.10
14	30.795	Sesamolin	0.10
15	31.663	Campesterol	0.13
16	32.053	Stigmasterol	0.31
17	32.825	*γ*-Sitosterol	0.60

3.3. Evaluation of the cytotoxic activity

Table 4 presents the anticancer potential of the methanolic root-derived extract of *Polycarpaea corymbosa* against human liver and breast cancer cell lines (HepG2 and MCF-7).

Table 4. *Cytotoxic effects on HepG2 and MCF-7 cancer cells*

Methanol extract						
Concentration (μg/mL)	HepG2		MCF-7		Ellipticine	
	Percentage of inhibition	SD	Percentage of inhibition	SD	Percentage of inhibition	SD
100	89.11	1.94	75.87	2.26	90.91	2.08
20	56.90	1.03	44.66	1.73	72.16	2.12
4	15.74	1.58	8.20	0.47	49.89	1.59
0.8	5.69	0.51	3.22	0.35	21.73	1.04
IC_{50}	**14.81±0.77**		**25.89±2.02**		**0.40±0.02**	

Ellipticine was tested at concentrations of 10-2-0.4-0.08 μg/mL

According to NCI guidelines, extracts are considered cytotoxically active when the IC_{50} value is ≤ 20 μg/mL. The data in Table 4 revealed that the methanolic extract derived from *Polycarpaea corymbosa* roots exerted potent activity against HepG2 hepatoma cells with an IC_{50} of 14.81 ± 0.77 μg/mL, while only moderate inhibition was detected for MCF-7 breast cancer cells (IC_{50} = 25.89 ± 2.02 μg/mL). These results are consistent with the chemical constituents identified in the methanolic extract. Previous reports by M. S. Abirami and P. Muthusamy [14] demonstrated that ethanol extracts from the whole plant of *P. corymbosa* showed significant cytotoxicity against HepG2 and MCF-7 cells, with IC_{50} values of 10.00 ± 0.02 and 6.80 ± 0.05 μg/mL, respectively. Ethyl acetate extracts exhibited moderate cytotoxicity against MCF-7 cells (IC_{50} = 28.05 ± 0.02 μg/mL) and weak cytotoxicity against HepG2 cells (IC_{50} = 85.55 ± 0.71 μg/mL), whereas petroleum ether extracts showed no cytotoxic activity against either cell line. These findings suggest that the methanolic extract from *Polycarpaea corymbosa* roots possesses promising anticancer potential toward HepG2 liver cancer and MCF-7 breast cancer cells.

4. Conclusions

In summary, the methanolic extract from *Polycarpaea corymbosa* roots was found to contain bioactive phytochemical classes, including alkaloids, coumarins, flavonoids, polyphenols, reducing sugars, steroids, and carboxylic acids, as determined by reactions with specific chemical reagents. Furthermore, GC-MS analysis identified 17 volatile compounds in the extract, with carboxylic acids and their derivatives representing the predominant class. In addition, the methanolic extract exhibited strong cytotoxicity against human hepatocellular carcinoma (HepG2) cells (IC_{50} = 14.81 ± 0.77 μg/mL) and moderate cytotoxicity against breast adenocarcinoma (MCF-7) cells (IC_{50} = 25.89 ± 2.02 μg/mL).

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