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RESEARCH ARTICLE

Chemical profile and antibacterial activity of acetone extract of *Homalomena cochinchinensis* Engl. (Araceae)

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ABSTRACT

Homalomena cochinchinensis Engl. is a rare species which is found in Southern China, Cambodia, Laos and Vietnam and its chemical constituents and bioactivity have not been determined yet. In this study, we identified 32 and 38 compounds in acetone extracts of *H. cochinchinensis* aerial part and rhizome, respectively via gas chromatography mass spectrometry (GC/MS). The main constituents of acetone extract of the aerial part were 3-((4Z,7Z)-Heptadeca-4,7-dien-1-yl)phenol (18.73%); cis-9,cis-12-Octadecadienoic acid (12.04%); linolenic acid (11.08%); n-Hexadecanoic acid (10.13%); (Z)-3-(Heptadec-10-en-1-yl)phenol (7.09%); γ-Sitosterol (5.58%) and linalool (5.56%). On the other hand, acetone extract of rhizome contained linalool (28.42%); 1,2,3-Propanetriol, 1-acetate (10.13%); 3-((4Z,7Z)-Heptadeca-4,7-dien-1-yl)phenol (5.28%); 3-Buten-2-one, 3-methyl-4-(1,3,3-trimethyl-7-oxabicyclo[4.1.0]heptan-1-yl)- (5.28%) and 4-(2,6,6-Trimethyl-cyclohex-1-enyl)-butyric acid (4.54%). Furthermore, this study has also proved the antibacterial activity of acetone extracts from the aerial part and the rhizome of this species for the first time using disk diffusion method. The results showed that the extract of the aerial part could inhibit the growth of 5 out of a total 6 bacterial strains, including *Bacillus cereus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella enteritidis* and *Staphylococcus aureus*; while the susceptible strains to the rhizome extract were 5 strains, such as *B. cereus*, *E. coli*, *P. aeruginosa*, *Salmonella typhimurium* and *S. aureus*. The findings suggest the further application of this species in pharmacology and medicine.

Introduction

Medicinal herbs and their uses have been recorded since early times, ever from prehistoric times. Hundreds of biochemical compounds which exert many functions such as defense against bacteria, fungi, insects, herbivors are synthesized by plants. Phytochemicals and potential bioactivities of several medicinal plants have been determined (1). However, only phytochemical composition of a small percentage of the plants have been clarified among the estimated number of 500000 species (2). Therefore, the potential uses of several plants have still not been investigated.

The genus *Homalomena* Schott belongs to the Araceae family with 250 species which are largely distributed in tropical and subtropical regions (3). There are five species of this genus have been found in Vietnam viz. *H. pierreana, H. vietnamensis, H. occulta, H. pendula* and *H. cochinchinensis* (4, 5). Several species of the *Homalomena* are remedies used in Vietnam and other Asian countries in traditional medicines (5). Chemical characterization and bioactivity studies on some species of *Homalomena* has proved its medicinal values (5-8).

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H. conchinchinensis was found in Southern China, Cambodia, Laos and some areas in Southern Vietnam, including Bu Gia Map National Park, Binh Phuoc Province and Vinh Cuu Natural and Historical Reserve, Dong Nai Province (4). Its chemical composition and bioactivity have not been elucidated. Hence, this study was primarily implemented to determine the phytochemical composition and antibacterial activity of acetone extract from *H. conchinchinensis* aerial parts and rhizomes.

Materials and Methods

Plant specimens

The aerial parts and rhizomes of *H. cochinchinensis* were collected from Bu Gia Map National Park, Bu Gia Map District, Binh Phuoc Province, Vietnam in June 2020, location of about 12°15'03"N; 107°09'05"E, 432 m in elevation (Fig. 1). The vouchered specimen numbers were Vo 315 and Vo 316. All the specimens were deposited in the Herbarium of Bu Gia Map National Park.

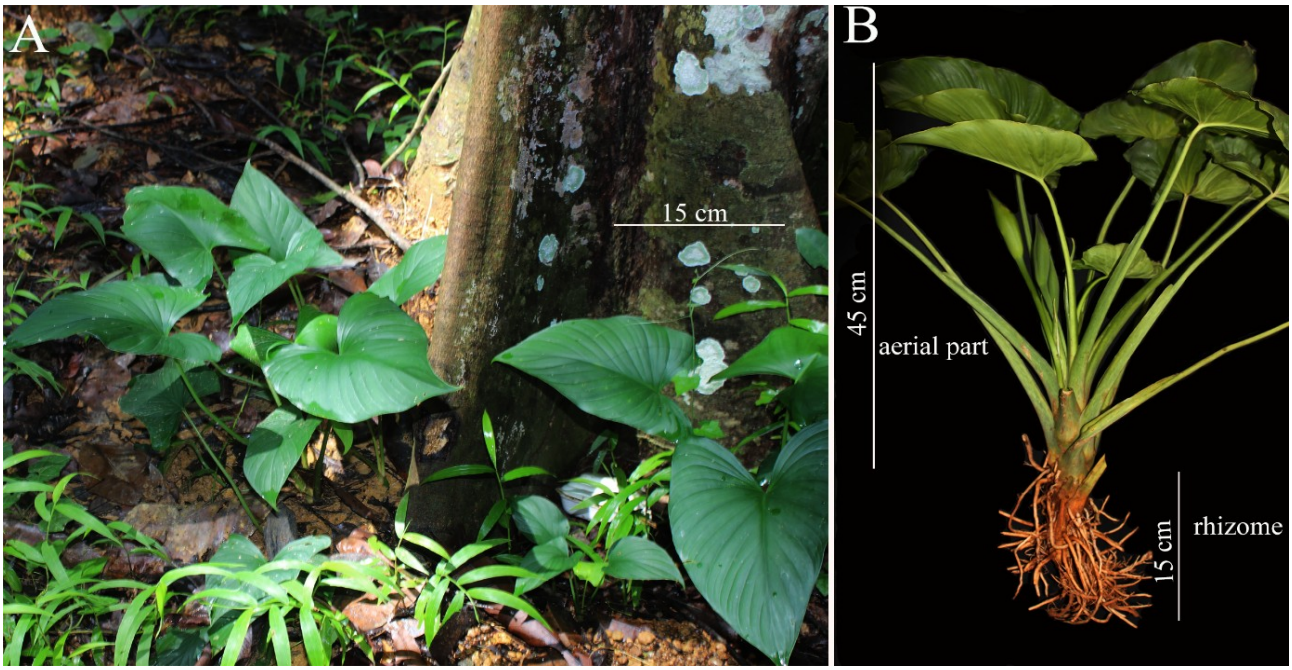

Fig. 1. *Homalomena cochinchinensis*. A. Habitat, B. Aerial part and rhizome.

Microorganisms

To clarify the antibacterial activity of acetone extract of rhizomes and aerial parts of *H. cochinchinensis*, six bacterial strains, including *Escherichia coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC 27853), *Salmonella enteritidis* (ATCC 13076), *Salmonella typhimurium* (ATCC 13311), *Bacillus cereus* (ATCC 11774), *Staphylococcus aureus* (ATCC 25923). These bacterial strains were stored in 20% glycerol medium at -20 °C. All the bacterial strains were re-activated by culturing in Luria-Bertani broth at 37 °C for 24 hours before using in further experiments.

Extraction procedures

The aerial parts and rhizome were moderately dried at 50 °C until their weights were unchanged. The dried samples were ground into powder by electric grinder. 100 mg of the dried samples were subsequently macerated in 500 ml of 80% acetone solution at room temperature for 72 hrs. The extracts were obtained by filtration of the mixture via filter paper and subsequently concentrated in reduced pressure at 60 °C to obtain the brown extract. The residual acetone was eliminated from the resulting extract by sublimation dryer. The final extracts were stored in 4 °C before further experiments (9).

Gas chromatography-mass spectrometry (GC/MS) analysis

To identify the chemical composition of acetone extracts, the GC/MS analysis was performed on the TRACE™ 1310 Gas Chromatograph (Thermo Fisher Scientific Inc., Waltham, MA, USA) coupled with ISQ 7000 single quadrupole mass spectrometer. The DB-5MS column (30 m x 0.25 mm X 0.25 µm) was used as the stationary phase and Helium at a flow rate 1.2 ml/min was used as the carrier gas. Samples were injected into the GC system by splitting method with split ratio of 30:1, splitless time 1 min, at 250 °C in the flow rate 36 ml/min. The transfer line temperature was set at 250 °C. The oven temperature was set at 80 °C for 5 min, and was increased 20 °C/min until reached 280 °C, the oven was subsequently held at 280 °C for 10 min. The electron impact ionization was set as 70 eV and the filament source temperature was set at 250 °C. The acquisitions scan mass range of MS was 29-650 m/z with the scanning frequency of 2 scans/sec. The chemical constituents were identified on the basis of comparison between their mass spectra with the internal library, NIST 2017 library and the Wiley 8th edition libraries.

Antibacterial activity

The antibacterial assay of the acetone extracts from *H. conchinchinensis* aerial parts and rhizomes was

determined using the agar diffusion method in accordance with the CLSI guideline (10). The bacteria were cultured in Mueller Hinton Broth for growing until the turbidity of the cultures reached 0.5 McFarland Standard. 0.1 ml of bacterial culture was inoculated onto the surface of Muller Hinton Agar plate. The paper discs were impregnated with 10 µl of acetone extracts and the plates were kept at 4 °C for 2 hrs to fully diffuse the extract. The Gentamycin containing discs (Nam Khoa BioTek Company, Vietnam) (10 µg/ml) were used as positive controls and negative controls were sterilized distilled water containing paper discs. Then, the plates were incubated at 37 °C for 24 hrs, and the diameters of the inhibition zones of extract against tested bacteria were recorded.

Statistical analysis

The antibacterial activity experiment was performed in triplicates. The results were expressed at the form mean ± standard deviation (SD). The data about mean and standard deviation were obtained using the Excel 2016 software, and the differences among the groups were evaluated by the one-way analysis of variance (ANOVA) method and Fisher's least significant difference using the Stagraphics Centurion XV software (Statpoint Technologies Inc., Warrenton, Virginia, USA) with $p < 0.05$.

Results and Discussion

Chemical composition

The data from GC/MS revealed that there were 32 and 38 compounds found in acetone extracts of *H. cochinchinensis* aerial part and rhizome, respectively (Table 1 and 2, Fig. 2 and 3). The main constituents of the aerial part extract were 3-((4Z,7Z)-Heptadeca-4,7-dien-1-yl)phenol (18.73%); cis-9,cis-12-Octadecadienoic acid (12.04%); linolenic acid (11.08%); n-Hexadecanoic acid (10.13%); (Z)-3-(Heptadec-10-en-1-yl)phenol (7.09%); γ-Sitosterol (5.58%) and linalool (5.56%) (Table 1). On the other hand, acetone extract of the rhizome contained linalool (28.42%); 1,2,3-Propanetriol, 1-acetate (10.13%); 3-((4Z,7Z)-Heptadeca-4,7-dien-1-yl)phenol (5.28%); 3-Buten-2-one, 3-methyl-4-(1,3,3-trimethyl-7-oxabicyclo[4.1.0]heptan-1-yl)- (5.28%) and 4-(2,6,6-Trimethyl-cyclohex-1-enyl)-butyric acid (4.54%). Among them, 10 compounds were identified in both aerial parts and rhizomes, such as linalool; 3,5-Dihydroxy-6-methyl-2,3-dihydro-4H-pyran-4-one; 5-Hydroxymethylfurfural; 2-Methoxy-4-vinylphenol; Cadina-1(10),4-diene; Phenol, m-pentadecyl; 3-((4Z,7Z)-Heptadeca-4,7-dien-1-yl)phenol; (Z)-3-(Heptadec-10-en-1-yl)phenol; 3-Heptadecylphenol and Stigmasterol.

Of note, some compounds found in both aerial parts and rhizome possess the bioactivity and health benefits. For example, linalool, which accounted for 28.24% in rhizome extract and 5.56% in the aerial extract, is the monoterpene alcohol exerting many bioactivities such as anti-hyperlipidemic, antimicrobial, anti-inflammatory, antinociceptive, antidepressive, analgesic and neuroprotective effects (11). Terpinen 4-ol, the other monoterpene found in rhizome of *H. cochinchinensis*, possesses many biological and pharmacological properties such as antiviral, anti-biofilm, anti-cancer, anti-inflammatory activities (12). It was also indicated that terpinen-4-ol could inhibit the growth of range of cancer cells, such as colorectal, gastric, pancreatic and prostate cancer cell lines in dose dependent manner (13). Furthermore, n-hexadecanoic acid, one of the bioactive compounds found in aerial part extract of *H. cochinchinensis* with 10.13%, has been suggested as the inflammatory agent (14). Anti-nociceptive and antioxidant effects of phytol, one of the components of aerial extract, have also been proved in previous study (15). In addition, another study proved that γ-sitosterol, the compound identified in aerial parts of *H. cochinchinensis* with 5.58%, had antidiabetic activity in streptozotocin induced diabetic mice, not only increasing the plasma insulin level but also anti-hyperlipidemic and anti-hyperglycemic effects (16). Stigmasterol, the bioactive compounds existing in both aerial parts (2.76%) and rhizomes (0.54%) of *H. cochinchinensis*, has the anti-osteoarthritic effect and cholesterol-lowering as well as human red blood cell membrane stabilizing activities (17-19). The presence of these bioactive compounds provides the scientific basis for further exploitation of this species in medicine and suggests it as the source to isolate more precious bioactive compounds.

Antibacterial activity of H. cochinchinensis acetone extract

As shown in Table 3 and Fig. 4, acetone extract of *H. cochinchinensis* aerial part could inhibit the growth of 5 out of 6 tested microorganisms, such as *B. cereus, E. coli, P. aeruginosa, S. enteritidis* and *S. aureus*, whereas the growth of *S. typhimurium* was not hindered by the extract. The antibacterial activity of extract against *E. coli* was the highest with the diameter of inhibition zone about 14.5 ± 0.5 mm, followed by *P. aeruginosa* (13.5 ± 1.3 mm), *B. cereus* (11.3 ± 0.6 mm), *S. aureus* (9.8 ± 0.8 mm), *S. enteritidis* (8.3 ± 0.6 mm). The results indicated that the aerial part extract had the strong antibacterial activity against some bacteria including *E. coli* and *P. aeruginosa* (14.5 ± 0.5 and 13.5 ± 1.3 mm, respectively), but it is still weaker than positive control (19.1±0.6 and 16.2±0.6 mm respectively).

The data of antibacterial activity of acetone extract of *H. cochinchinensis* rhizome were presented in Table 4 and Fig. 4. Among 6 tested microorganisms, the extract showed the antibacterial activity against 5 bacterial strains, including *B. cereus, E. coli, P. aeruginosa, S. typhimurium* and *S. aureus* except for *S. enteritidis*. The extract exhibited the strongest antimicrobial effect against *B. cereus* with the diameter of inhibition zone about 24.6 ± 1.2 mm followed by *S. typhimurium* (15.3 ± 0.6 mm), *S. aureus* (14.6 ± 1.2 mm), *E. coli* and *P. aeruginosa* (8.3 ± 0.6 mm and 8.6 ± 0.2 mm respectively). The findings suggest the potential application of acetone extract of rhizome as the antimicrobial agent, because the diameter of inhibition zone of rhizome extract against *B. cereus* are higher than that of positive controls (24.6 ± 1.2 mm versus 20.6 ± 1.2 mm respectively).

Table 1. Phytochemical composition of acetone extracts from the aerial parts of *H. cochinchinensis*

No.	RT	Compounds	%	Formula
1	4.89	m-Mentha-6,8-diene, (R)-(+)-	0.76	$C_{10}H_{16}$
2	5.27	Benzeneacetaldehyde	0.78	C_8H_8O
3	6.43	Linalool	5.56	$C_{10}H_{18}O$
4	7.1	3,5-Dihydroxy-6-methyl-2,3-dihydro-4H-pyran-4-one	0.85	$C_6H_8O_4$
5	7.67	p-Menth-1-en-4-ol, (R)-(-)-	0.74	$C_{10}H_{18}O$
6	8.13	5-Hydroxymethylfurfural	1.77	$C_6H_6O_3$
7	8.42	Linalool, formate	0.33	$C_{11}H_{18}O_2$
8	9.04	2-Methoxy-4-vinylphenol	0.38	$C_9H_{10}O_2$
9	9.75	2,4-Diisopropenyl-1-methyl-1-vinylcyclohexane	0.24	$C_{15}H_{24}$
10	10.48	Methyl (10E)-10-heptadecen-8-ynoate	0.27	$C_{18}H_{30}O_2$
11	10.7	Cadina-1(10),4-diene	0.32	$C_{15}H_{24}$
12	11.67	2-Cyclohexen-3-ol-1-one, 2-dodecanoyl	0.80	$C_{18}H_{30}O_3$
13	12.14	Olivetol	0.43	$C_{11}H_{16}O_2$
14	12.57	Neophytadiene	3.91	$C_{20}H_{38}$
15	12.71	3,7,11,15-Tetramethyl-2-hexadecen-1-ol	0.70	$C_{20}H_{40}O$
16	13.21	n-Hexadecanoic acid	10.13	$C_{16}H_{32}O_2$
17	13.99	Phytol	4.20	$C_{20}H_{40}O$
18	14.08	cis-9,cis-12-Octadecadienoic acid	12.04	$C_{18}H_{32}O_2$
19	14.11	Linolenic acid	11.08	$C_{18}H_{30}O_2$
20	14.2	Stearic acid	1.61	$C_{18}H_{36}O2$
21	15.79	Phenol, m-pentadecyl	0.50	$C_{21}H_{36}O$
22	16.09	n-Docosanoic acid	1.45	$C_{22}H_{44}O_2$
23	16.82	3-((4Z,7Z)-Heptadeca-4,7-dien-1-yl)phenol	18.73	$C_{23}H_{36}O$
24	16.87	(Z)-3-(Heptadec-10-en-1-yl)phenol	7.09	$C_{23}H_{38}O$
25	17.01	3-Heptadecylphenol	0.88	$C_{23}H_{40}O$
26	20.34	γ-Tocopherol	0.69	$C_{28}H_{48}O_2$
27	20.96	Clionasterol acetate	0.42	$C_{31}H_{52}O_2$
28	21.32	2(3H)-Furanone, dihydro-3,4-dipiperonyl-, trans-(-)-	0.30	$C_{20}H_{18}O_6$
29	21.48	DL-α-Tocopherol	3.33	$C_{29}H_{50}O_2$
30	23.22	Ergost-5-en-3α-ol	1.35	$C_{28}H_{48}O$
31	23.7	Stigmasterol	2.76	$C_{29}H_{48}O$
32	24.97	γ-Sitosterol	5.58	$C_{29}H_{50}O$
		Total	99.98	

Table 2. Phytochemical composition of acetone extracts from the rhizomes of *H. cochinchinensis*

No.	RT	Compounds	%	Formula
1	3.64	1-Isopropyl-4-methylenebicyclo[3.1.0]hexane	1.49	$C_{10}H_{16}$
2	4.41	3-Carene	0.51	$C_{10}H_{16}$
3	4.8	o-Cymene	0.16	$C_{10}H_{14}$
4	4.93	D-Limonene	0.44	$C_{10}H_{16}$
5	5.05	Eucalyptol	0.61	$C_{10}H_{18}O$
6	5.64	γ-Terpinene	0.28	$C_{10}H_{16}$
7	5.92	3,4-Dimethyl-3-hexen-2-one	1.01	$C_8H_{14}O$
8	6.21	trans-Linalool oxide (furanoid)	0.40	$C_{10}H_{18}O_2$
9	6.45	Linalool	28.42	$C_{10}H_{18}O$
10	7.1	3,5-Dihydroxy-6-methyl-2,3-dihydro-4H-pyran-4-one	1.19	C_6H_8O4
11	7.24	Glycerin	2.22	C_3H_8O3
12	7.67	Terpinen-4-ol	3.20	$C_{10}H_{18}O$
13	7.73	1,5-Octadiene-3,7-diol, 3,7-dimethyl	1.56	$C_{10}H_{18}O_2$
14	7.84	3-Cyclohexene-1-methanol, α, α,4-trimethyl-, (R)-	0.64	$C_{10}H_{18}O$
15	8.00	2-Norpinanol, 3,6,6-trimethyl	0.81	$C_{10}H_{18}O$
16	8.15	5-Hydroxymethylfurfural	2.20	$C_6H_6O_3$
17	8.32	Linalyl acetate	2.25	$C_{12}H_{20}O_2$
18	8.41	1,2,3-Propanetriol, 1-acetate	13.73	$C_5H_{10}O_4$
19	8.66	1,7-Octadiene-3,6-diol, 2,6-dimethyl	0.45	$C_{10}H_{18}O_2$
20	9.04	3,5-Heptadienal, 2-ethylidene-6-methyl	0.40	$C_{10}H_{14}O$
21	10.7	Cadina-1(10),4-diene	1.08	$C_{15}H_{24}$
22	11.12	Germacrene D-4-ol	2.29	$C_{15}H_{26}O$
23	11.54	tau.-Muurolol	1.15	$C_{15}H_{26}O$
24	11.61	α-Cadinol	1.70	$C_{15}H_{26}O$
25	12.1	Oplopanone	4.76	$C_{15}H_{26}O_2$

26	12.33	Ledene oxide-(I)	2.67	$C_{15}H_{24}O$
27	12.51	5,6,6-Trimethyl-5-(3-oxobut-1-enyl)-1-oxaspiro[2.5]octan-4-one	1.12	$C_{14}H_{20}O_3$
28	12.57	Isospathulenol	1.47	$C_{15}H_{24}O$
29	12.63	Aromadendrane-4,10-diol	2.96	$C_{15}H_{26}O_2$
30	13.41	3-Buten-2-one, 3-methyl-4-(1,3,3-trimethyl-7-oxabicyclo[4.1.0]heptan-1-yl)-	5.28	$C_{14}H_{22}O_2$
31	13.65	4-(2,6,6-Trimethyl-cyclohex-1-enyl)-butyric acid	4.54	$C_{13}H_{22}O_2$
32	15.76	Phenol, 3-pentadecyl	0.14	$C_{21}H_{36}O$
33	15.92	1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester	0.15	$C_{24}H_{38}O4$
34	16.81	3-((4Z,7Z)-Heptadeca-4,7-dien-1-yl)phenol	5.28	$C_{23}H_{36}O$
35	16.88	(Z)-3-(Heptadec-10-en-1-yl)phenol	2.38	$C_{23}H_{38}O$
36	17.00	3-Heptadecylphenol	0.28	$C_{23}H_{40}O$
37	23.17	Ergost-5-en-3á-ol	0.21	$C_{28}H_{48}O$
38	23.67	Stigmasterol	0.54	$C_{29}H_{48}O$
		Total	99.97	

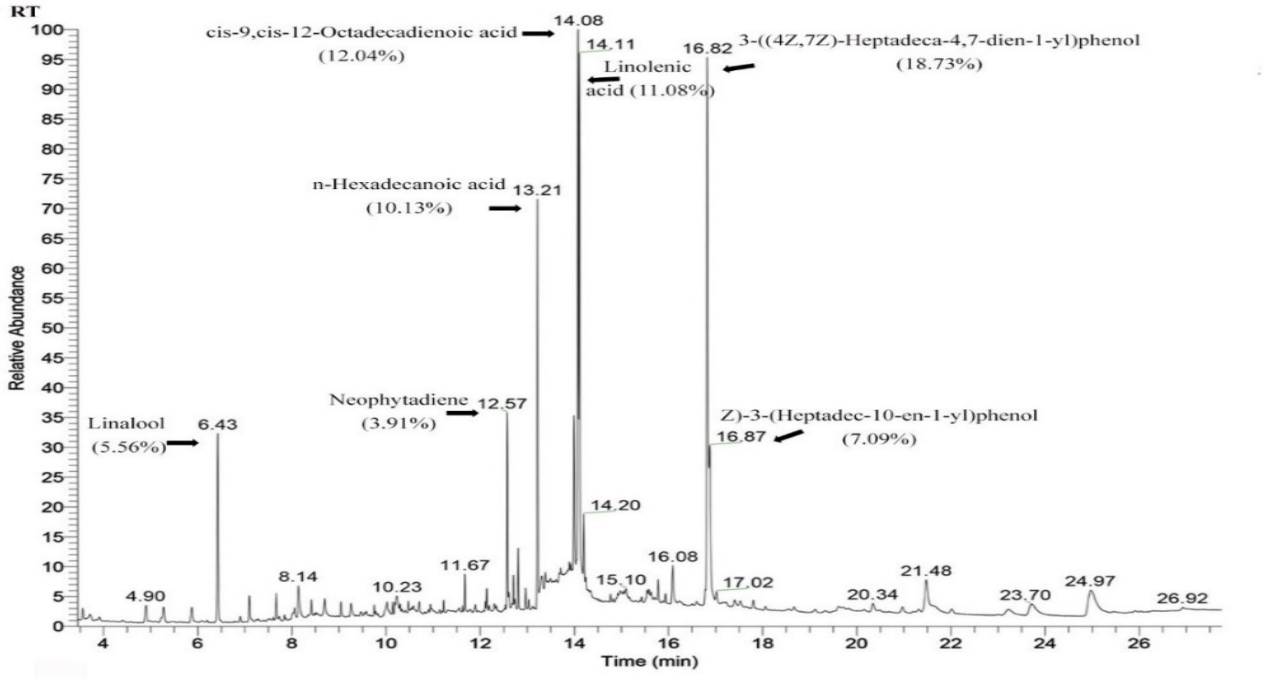

Fig. 2. Gas chromatogram of acetone extract from *H. cochinchinensis* aerial part with major components.

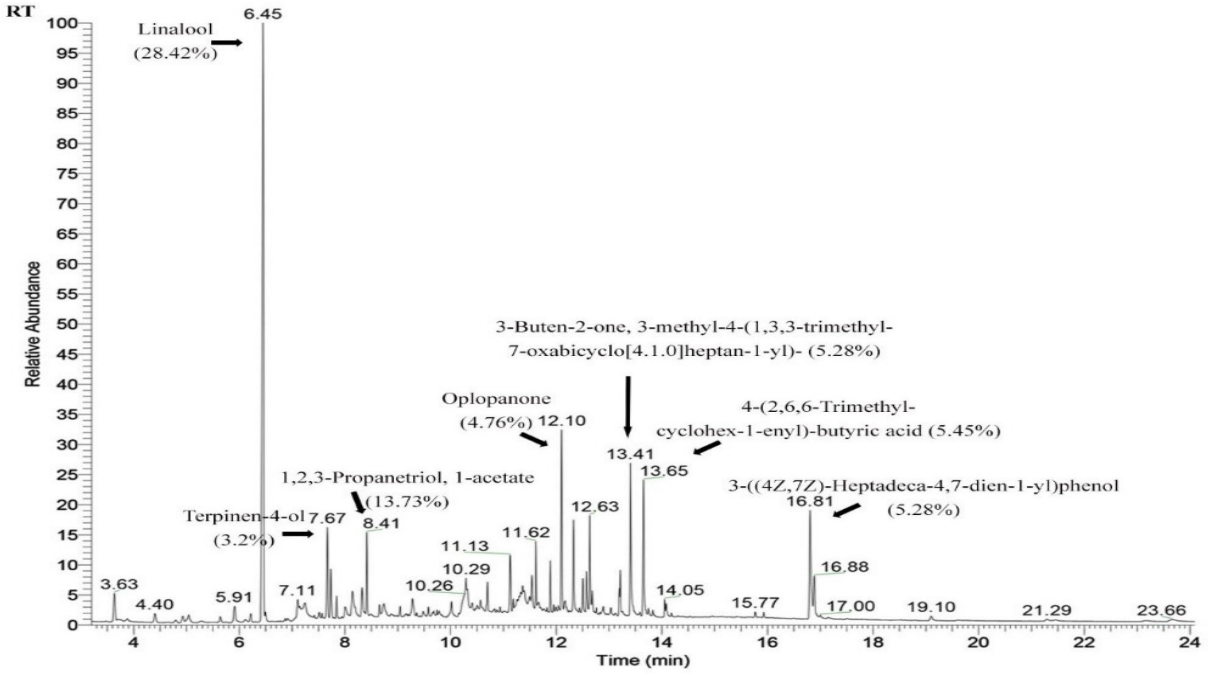

Fig. 3. Gas chromatogram of acetone extract from *H. cochinchinensis* rhizome with major components.

Table 3. Inhibition zone of acetone extract isolated from the aerial parts of *H. cochinchinensis* against five bacterial strains

Tested bacteria	Growth inhibition zone (mm)	
	Studied sample	Positive control
Bacillus cereus	11.3±0.6[a]	19.6±0.6[b]
Escherichia coli	14.5±0.5[a]	19.1±0.6[b]
Pseudomonas aeruginosa	13.5±1.3[a]	16.2±0.6[b]
Salmonella enteritidis	8.3±0.6[a]	17.2±0.3[b]
Salmonella typhimurium	-	16.5±0.5
Staphylococcus aureus		9.8±0.8[a]

a,b Different superscript lower-case letters in the same row denote significant difference (p<0.05).

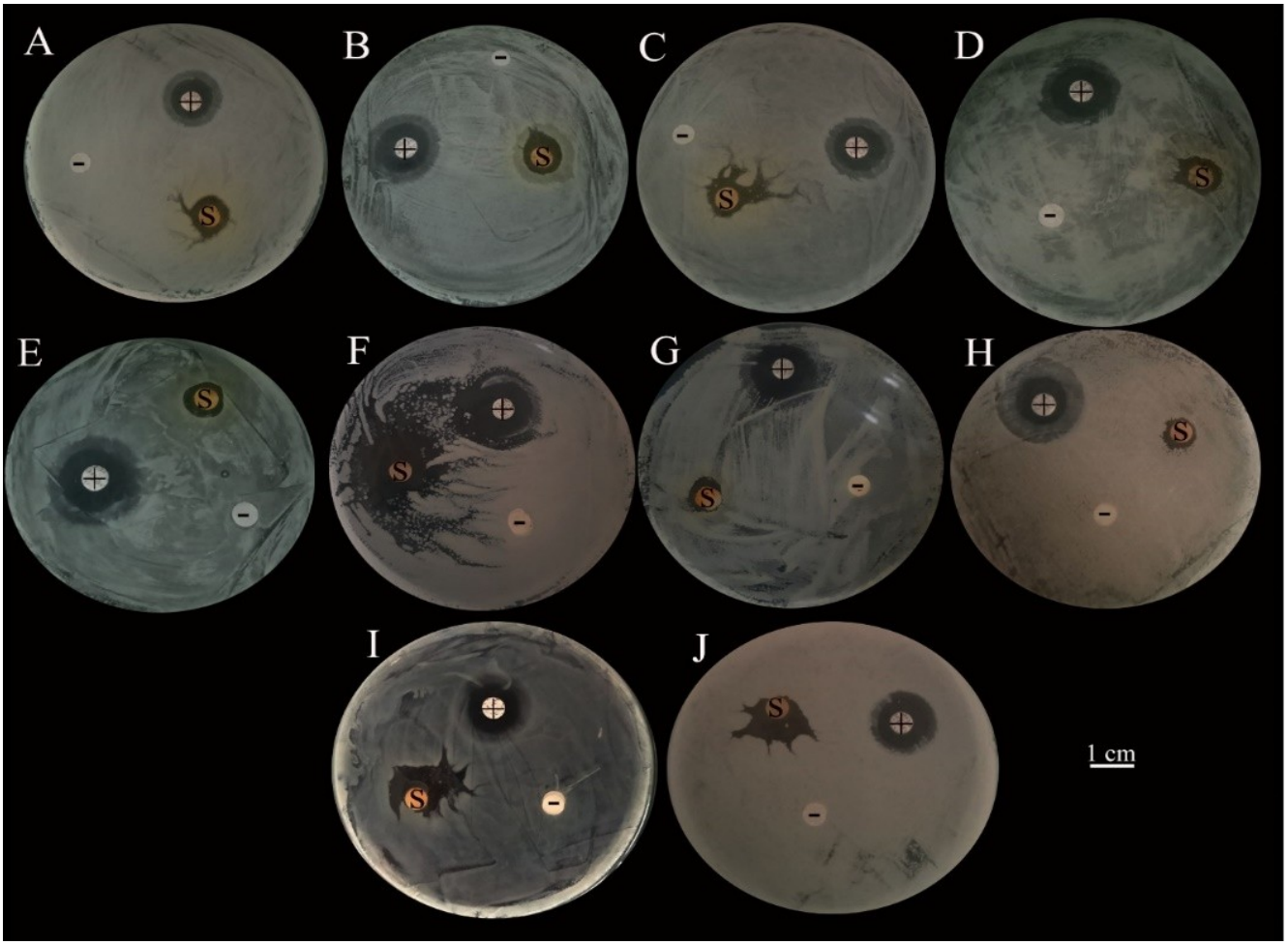

Fig. 4. Antibacterial activity of the acetone extract from the aerial part and rhizome of *H. cochinchinensis* against 6 bacterial strains. The areial part: A. *Bacillus cereus,* B. *Escherichia coli*, C. *Pseudomonas aeruginosa*, D. *Salmonella enteritidis*, E. *Staphylococcus aureus*. The rhizome: F. *Bacillus cereus,* G. *Escherichia coli*, H. *Pseudomonas aeruginosa*, I. *Salmonella typhimurium*, J. *Staphylococcus aureus*. (-) Negative control with sterilized distilled water, (+) Positive control with discs containing gentamicin

The antibacterial activity of many compounds found in acetone extracts of *H. cochinchinensis* aerial part and rhizome have been proven in previous studies. For example, it was also found that linalool possessed the antimicrobial effect against many pathogenic bacteria and fungi such as *P. aeruginosa, E. coli, S. aureus*, *Candida albicans* and *Aspergillus brasiliensis* (20). Moreover, in a study proved that linalool, the bioactive compounds existing in both aerial part and rhizome extracts could effectively hinder the growth of *Pasteurella multocida*, the pathogenic bacterium which causes range of diseases in mammals and birds, especially pneumonia or bovine respiratory disease in cattle (21). Linolenic acid, the other main constituent of aerial part extract with 11.08%, exerts the antimicrobial effect against some pathogenic bacteria and fungi, including *Streptococcus mutans*, *C. albicans*, *Aggregatibacter actinomycetemcomitans*, *Fusobacterium nucleatum* and *Porphyromonas gingivalis* (22). Additionally, cis-9,cis-12-Octadecadienoic acid and n-Hexadecanoic acid, two compounds found in aerial part extract of *H. cochinchinensis*, also exhibited the antibacterial effect against *E. coli* with minimum inhibition quantity (MIQ) of 1 µg (14, 23). The antimicrobial effect of Terpinen-4-ol, the compound existing in acetone extract of *H. cochinchinensis* rhizome and essential oils in many species of Lamiaceae and

Table 4. Inhibition zone of acetone extract isolated from the rhizomes of *H. cochinchinensis* against five bacterial strains

Tested bacteria	Growth inhibition zone (mm)	
	Studied sample	Positive control
Bacillus cereus	24.6±1.2[b]	20.6±1.2[a]
Escherichia coli	8.3±0.6[a]	19.3±0.6[b]
Pseudomonas aeruginosa	8.6±0.2[a]	16.3±0.6[b]
Salmonella enteritidis	-	18.3±0.6
Salmonella typhimurium	15.3±0.6[a]	16.6±0.8[b]
Staphylococcus aureus	14.6±1.2[a]	16.0±1.7[a]

a,b Different superscript lower-case letters in the same row denote significant difference (p<0.05).

Myrtaceae against some pathogens in human, including *S. aureus, S. epidermidis, E. coli* and *Botrytis cinerea* also was documented in previous study (12).

As mentioned above, *H. cochinchinensis* is a rare species; as a consequence, antibacterial activity of this species has not been elucidated yet. There are only some published data for antibacterial activity of other member of the *Homalomena* genus in previous studies. For instance, it was observed that methanol extract of *H. propinque* rhizome collected from Pahang Forest Reserve, Malaysia had antibacterial activity against *E. coli, Bacillus subtilis* and *S. aureus* (24). Moreover, the ethanolic extract from *H. sagittifolia* rhizome exhibited the inhibition of the growth against 2 Gram positive bacterial strains, including *B. subtilis* and *S. aureus* as well as some Gram negative bacterial strains, such as *E. coli, Klebsiella pneumoniae* and *Pseudomonas stutzeri* (25). On the other hand, essential oil from *H. aromatica* rhizomes showed high antimicrobial activity against *Trichophyton rubrum, T. mentagrophytes, Microsporum fulvum, M. gypseum, Trichosporon beigelii, Candida albicans Epidermophyton floccosum* (6, 7). Furthermore, the essential oils isolated from *H. pineodora* also exhibited against 4 Gram positive bacteria (*Staphylococcus aureus*, *Bacillus cereus* and *B. subtilis*), 5 Gram negative bacteria (*Proteus mirabilis, Yersinia* sp., *Shigella boydii, Acinetobacter anitratus* and *Pseudomonas aeruginosa*) and 1 yeast (*Candida albicans*) (26).

Conclusion

In present study, thirty-two and thirty-eight compounds of acetone extracts of *H. cochinchinensis* aerial part and rhizome were investigated for the first time. Accordingly, acetone extract of rhizome contained linalool (28.42%); 1,2,3-Propanetriol, 1-acetate (10.13%); 3-((4Z,7Z)-Heptadeca-4,7-dien-1-yl)phenol (5.28%); 3-Buten-2-one, 3-methyl-4-(1,3,3-trimethyl-7-oxabicyclo[4.1.0]heptan-1-yl)- (5.28%) and 4-(2,6,6-Trimethyl-cyclohex-1-enyl)-butyric acid (4.54%) as main compounds whereas 3-((4Z,7Z)-Heptadeca-4,7-dien-1-yl)phenol (18.73%); cis-9,cis-12-Octadecadienoic acid (12.04%); linolenic acid (11.08%); n-Hexadecanoic acid (10.13%); (Z)-3-(Heptadec-10-en-1-yl)phenol (7.09%); γ-Sitosterol (5.58%) and linalool (5.56%) were major constituents isolated from the aerial parts. Furthermore, the extract of the aerial part could inhibit the growth of 5 out of a total 6 bacterial strains, including *Bacillus cereus, Escherichia coli, Pseudomonas aeruginosa, Salmonella enteritidis* and *Staphylococcus aureus*; while the susceptible strains to the rhizome extract were 5 strains such as *Bacillus cereus, Escherichia coli, Pseudomonas aeruginosa, Salmonella typhimurium* and *Staphylococcus aureus.*

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Authors' contributions

The present study was designed by Hong Thien Van. The samples were collected by Huy Sang Vo, a staff of Bu Gia Map National Park. All authors performed experiments and handled the research data. Data analysis was conducted by Hong Thien Van. Hong Thien Van drafted the manuscript and resolved all the queries of reviewers.

Conflict of interests

No conflict of interest was declared by the authors.

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