Review

Chemical composition and biological activities of *Lysimachia capillipes* Hemsl

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Abstract

***Lysimachia capillipes* (*L. capillipes*) Hemsl, belong to primulaceae pearl vegetables genus, is a treasure in traditional Chinese medicine. It has the effects of invigorating qi and tonifying deficiency, dispelling wind and activating blood, awakening the brain, relieving cough and regulating menstruation. With the development of modern medicine, the active components and therapeutic mechanisms of *L. capillipes* Hemsl have been gradually revealed. The present report systematically reviews the chemical composition and biological activities of *L. capillipes* Hemsl, to provide scientific basis and reference for detailed research on *L. capillipes* Hemsl.**

Keywords: *Lysimachia capillipes* Hemsl; capilliposide; chemical composition; biological activity

1 Introduction

Lysimachia capillipes Hemsl (*L. capillipes* Hemsl), belonging to primulaceae pearl vegetables genus, is a treasure in traditional Chinese medicine with important medicinal value and wide clinical application. It is about 40-60 cm in height and has a strong aroma after drying. In China, it is distributed in Guizhou, Sichuan, Hubei, southern Henan, Hunan, Jiangxi, Guangdong, Fujian, Zhejiang, Taiwan and other provinces. It grows in valley forests and streams at an altitude of 300-2000 m, mainly in acidic soils. In Jiangxi, the whole grass is used to treat influenza. In Sichuan, its fine-stemmed herbs are used as ingredients of hot pot food. In Hunan, it is mixed into bait to attract fish. Therefore, the fine-stemmed herb is a promising medicinal plant and spice plant [1]. Traditional Chinese medicine believes that it has the effects of invigorating qi and tonifying deficiency, dispelling wind and activating blood, awakening the brain, relieving cough and regulating menstruation. It is used to treat cold cough, bronchitis, asthma, irregular menstruation, edema, dysuria and neurasthenia [2]. The compounds isolated from *L. capillipes* Hemsl

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include saponins, flavonoids, aromatic hydrocarbons, aliphatic hydrocarbons and their derivatives. Modern medical studies have demonstrated that *L. capillipes* Hemsl exhibit various pharmacological activities, such as antioxidant, antiviral, antibacterial, anti-inflammatory and anti-tumor effects. This article intends to systematically review the research progress of *L. capillipes* Hemsl from the aspects of chemical composition and biological activity to have a comprehensive understanding of *L. capillipes* Hemsl and lay a foundation for its clinical application.

2 Chemical composition

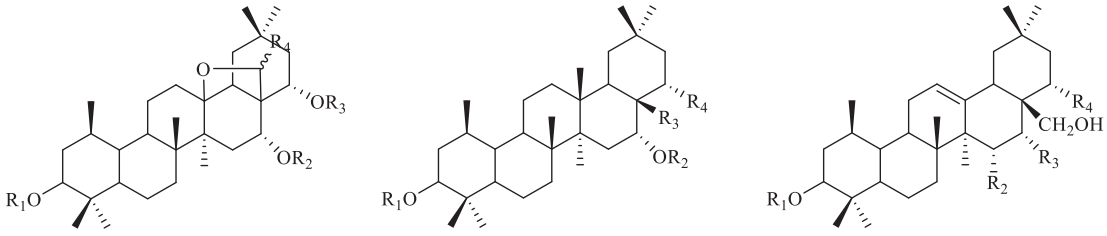
L. capillipes Hemsl contains a variety of compounds, including saponins, flavonoids, aliphatic hydrocarbons and their derivatives, aromatic hydrocarbons and their derivatives, etc.

2.1 Saponins

Saponins are widely found in *L. capillipes* Hemsl, and most of them are oleanane triterpenoid saponins. At present, 13 capilliposides have been identified from *L. capillipes* Hemsl, namely capilliposide A-M. Among them, capilliposide B and capilliposide C have good biological activity and have been studied in depth [3]. The structural formulas of saponins are shown in Table 1 and Fig. 1.

Table 1 Saponins in *L. capillipes* Hemsl

No.	Name	R_1	R_2	R_3	R_4	References
1	capilliposide A	*β*-D-Xyl-(1→2)-*β*-D-Glc-(1→4)-[*β*-D-Glc-(1→2)]-*α*-L-Ara-	H	H	*α*-OH	[3]
2	capilliposide B	*β*-D-Xyl-(1→2)-*β*-D-Glc-(1→4)-[*β*-D-Glc-(1→2)]-*α*-L-Ara-	H	—C(=O)CH$_2$CH$_2$CH$_2$CH$_2$CH$_3$	*α*-OH	[3]
3	capilliposide C	*β*-D-Xyl-(1→2)-*β*-D-Glc-(1→4)-[*β*-D-Glc-(1→2)]-*α*-L-Ara-	H	—C(=O)CH$_2$CH(CH$_3$)$_2$	*α*-OH	[3]
4	capilliposide D	*β*-D-Xyl-(1→2)-*β*-D-Glc-(1→4)-[*β*-D-Glc-(1→2)]-*α*-L-Ara-	H	*β*-D-Glc-	*α*-OH	[3]
5	capilliposide E	*β*-D-Glc-(1→2)-*α*-L-Ara-	Ac	*β*-D-Glc-	O	[3]
6	capilliposide F	*β*-D-Glc-(1→2)-*β*-D-Glc-(1→4)-*α*-L-Ara-	Ac	*β*-D-Glc-	O	[3]
7	capilliposide G	*β*-D-Xyl-(1→2)-*β*-D-Glc-(1→4)-[*β*-D-Glc-(1→2)]-*α*-L-Ara-	Ac	*β*-D-Glc-	O	[3]
8	capilliposide H	*β*-D-Rha-(1→2)-*β*-D-Glc-(1→4)-[*β*-D-Glc-(1→2)]-*α*-L-Ara-	Ac	*β*-D-Glc-	O	[3]
9	capilliposide I	*β*-D-Glc-(1→2)-*α*-L-Ara-	angeloyl oxy	6-acetoxyl-*β*-D-Glc-	O	[3]
10	capilliposide J	*β*-D-Glc-(1→2)-*α*-L-Ara-	Ac	COONa	*β*-D-Glc-O-	[3]
11	capilliposide K	*β*-D-Xyl-(1→2)-*β*-D-Glc-(1→4)-[*β*-D-Glc-(1→2)]-*α*-L-Ara-	H	*α*-OH	*β*-D-Glc-O-	[3]
12	capilliposide L	*β*-D-Xyl-(1→2)-*β*-D-Glc-(1→4)-[*β*-D-Glc-(1→2)]-*α*-L-Ara-	-O-		*β*-D-Glc-O-	[3]
13	capilliposide M	*β*-D-Xyl-(1→2)-*β*-D-Glc-(1→4)-[*β*-D-Glc-(1→2)]-*α*-L-Ara-	H	OH	H	[3]



capilliposide A-I **capilliposide J** **capilliposide K-M**

Fig. 1 The structural formulas of saponins in *L. capillipes* Hemsl

2.2 Flavonoids

Flavonoids are also important active ingredients in *L. capillipes* Hemsl. At present, the isolated flavonoids are mainly flavonols and flavonoid glycosides, including kaempferol, quercetin, isoquercitrin, quercetin-3-*O*-(2,6-*di*-*α*-L-rhamnopyranosyl)-*β*-D-galactopyranoside, capilliposide I, and capilliposide II [4,5]. The structural formulas of flavonoids are shown in Table 2 and Fig. 2.

Table 2 Flavonoids in *L. capillipes* Hemsl

No.	Name	R_1	R_2	References
14	kaempferol	H	H	[4]
15	quercetin	H	OH	[4]
16	isoquercitrin	Glc-	OH	[4]
17	quercetin-3-*O*-(2,6-*di*-*α*-L-rhamnopyranosyl)-*β*-D-galactopyranoside	*α*-L-Rha-(1→6)-[*α*-L-Rha-(1→2)]-*β*-D-Gal-	OH	[5]
18	capilliposide I	*β*-D-Glu-(1→3)-(4-coumaroyl)-*α*-L-Rha-(1→6)-[*α*-L-Rha-(1→2)]-*β*-D-Gal-	H	[5]
19	capilliposide II	*β*-D-Glu-(1→3)-(4-coumaroyl)-*α*-L-Rha-(1→6)-[*α*-L-Rha-(1→2)]-*β*-D-Gal-	OH	[5]

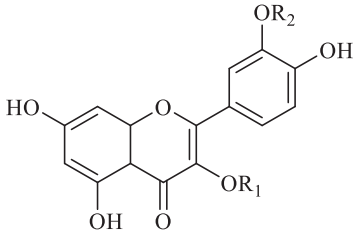


Fig. 2 The structural formulas of flavonoids in *L. capillipes* Hemsl

2.3 Aliphatic hydrocarbons and their derivatives

Aliphatic hydrocarbons and their derivatives have some auxiliary effects, such as anti-tumor and anti-inflammation [6]. The structural formulas of aliphatic hydrocarbons and their derivatives are shown in Table 3 and Fig. 3.

Table 3 Aliphatic hydrocarbons and their derivatives in *L. capillipes* Hemsl

No.	Name	No.	Name
20	2-methylbutanoic acid	75	stearic acid
21	valeric acid	76	nonadecanoic acid
22	2-methylene butanoic acid	77	n-hexanol
23	3-methylvaleric acid	78	2-hydroxymethyl tetrahydropyran
24	caproic acid	79	methyl 3-methylvalerat
25	3-hexenoic acid	80	tert-amyl hydroperoxide
26	*E*-2-hexenoic acid	81	2-ethyl-4-pentenal
27	2-hydroxy-4-methylvaleric acid	82	methyl 3-methyl-2-oxovalerate
28	2-hydroxy-3-methylvaleric acid	83	6-methyl-5-hepten-2-one
29	6-heptenoic acid	84	methyl 2-hydroxy-3-methylvalerate
30	*E*-4-heptenoic acid		
31	enanthic acid	85	2,6-dimethyl-4-heptanol
32	succinic acid	86	linalool
33	methylsuccinic acid	87	6-methyl-3,5-heptadien-2-one
34	*E*-2-heptenoic acid	88	3,5,5-trimethyl-2-cyclohexen-1-one
35	3-octylenic acid		
36	caprylic acid	89	isoborneol
37	*β*-hydroxyvaleric acid	90	safranal
38	2-octylenic acid	91	1,4-dimethyl-2-isobutylcyclohexane
39	2,2-dimethylglutaric acid		
40	6-nonenoic acid	92	verbenone
41	pelargonic acid	93	methyl caprate
42	malie acid	94	*γ*-nonalactone
43	2,6-nonadienoic acid	95	*γ*-ionone
44	2-nonenoic acid	96	*β*-ionone
45	decylenic acid	97	3-(2-pentenyl)-1,2,4-cyclopentanetrione
46	capric acid		
47	pimelie acid	98	*ψ*-ionone
48	4-oxononanoic acid	99	methyl tridecanoate
49	undecenoic acid	100	8-cadinol
50	undecoic acid	101	methyl myristate
51	suberic acid	102	methyl pentadecanoate
52	lauric acid	103	hexahydrofarnesyl acetone
53	azelaic acid	104	nonadecano

(to be continued)

Continued Table 3

No.	Name	No.	Name
54	tridccanoic acid	105	methyl palmitate
55	sebacic acid	106	methyl 15-methylhexadecanoate
56	tetradecenic acid	107	methyl heptadecanoate
57	myristic acid	108	methyl linoleale
58	undecandioic acid	109	methyl oleate
59	pentadecenoic acid	110	phytol
60	pentadecanoic acid	111	methyl stearate
61	2-hydroxytelradecanoic acid	112	*β*-daucosterol
62	dodecandioic acid	113	10-eicosenoic acid
63	3-hydroxytetradecanoic acid	114	2-tridecanone
64	14-methylpentadecanoic acid	115	9(*Z*)-octadecenamide
65	11-hexadecenoic acid	116	erucicamide
66	palmitic acid	117	(10*E*)-heptadec-10-en-1-ol
67	15-methylhexadecanoic acid	118	1-bromo-(8*Z*)-heptadecene
68	14-methylhexadecanoicacid	119	oleamide
69	heptadecenoic acid	120	*cis*-octadec-9-enoic acid
70	margaric acid	121	2-methyltridecane
71	2-hydroxyhexadecanoic acid	122	2-aminoethyl tetradecanoate
72	linoleic acid	123	decan-1-ol
73	linolenic acid	124	17-tritriacontanone
74	oleic acid	125	hentriacontanol

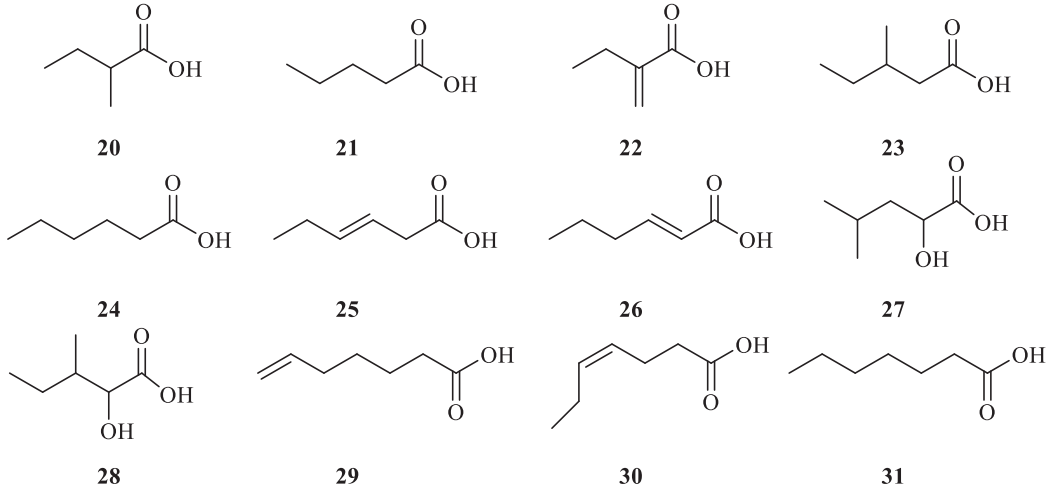


Fig. 3 The structural formulas of aliphatic hydrocarbons and their derivatives in *L. capillipes* Hemsl

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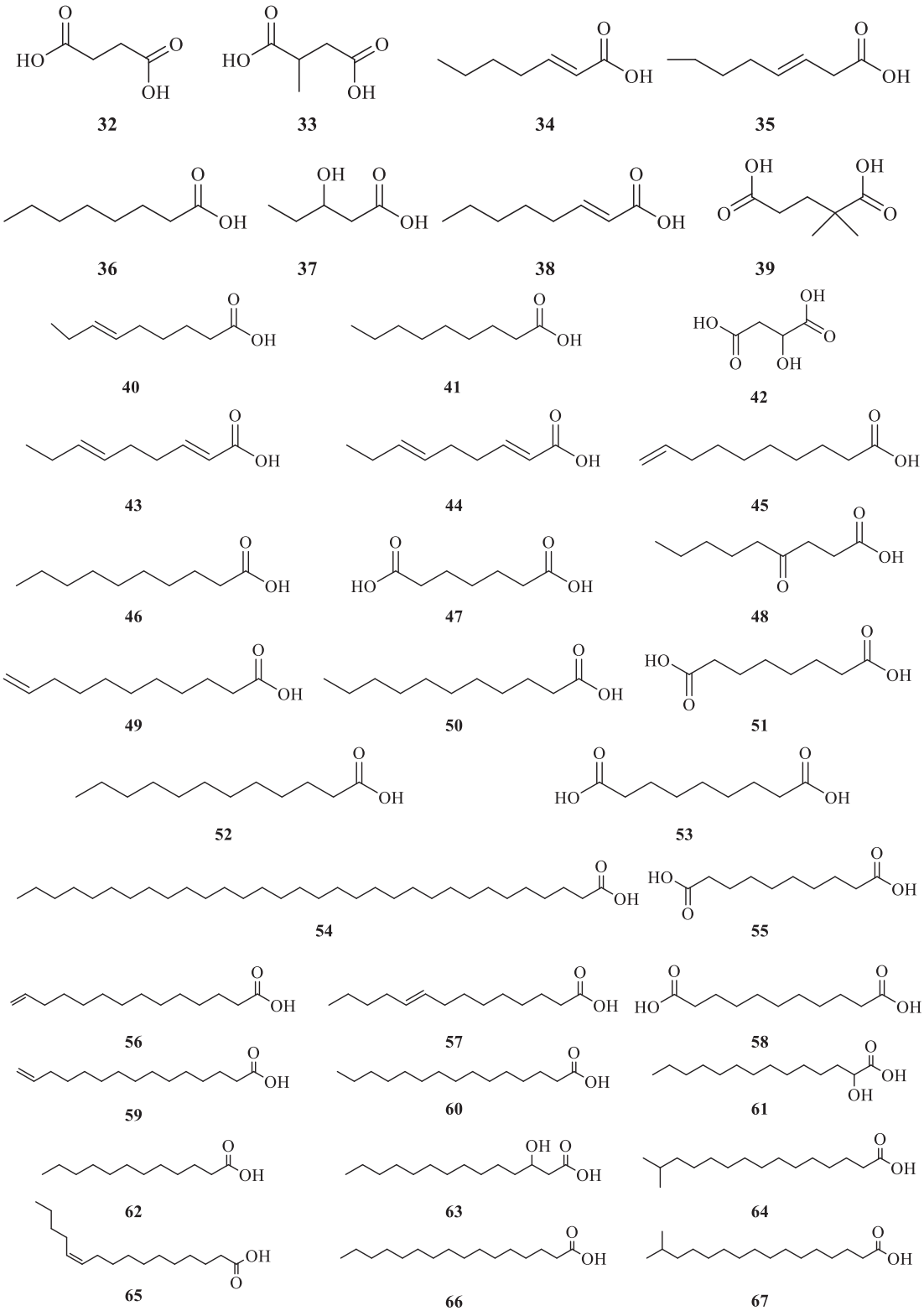

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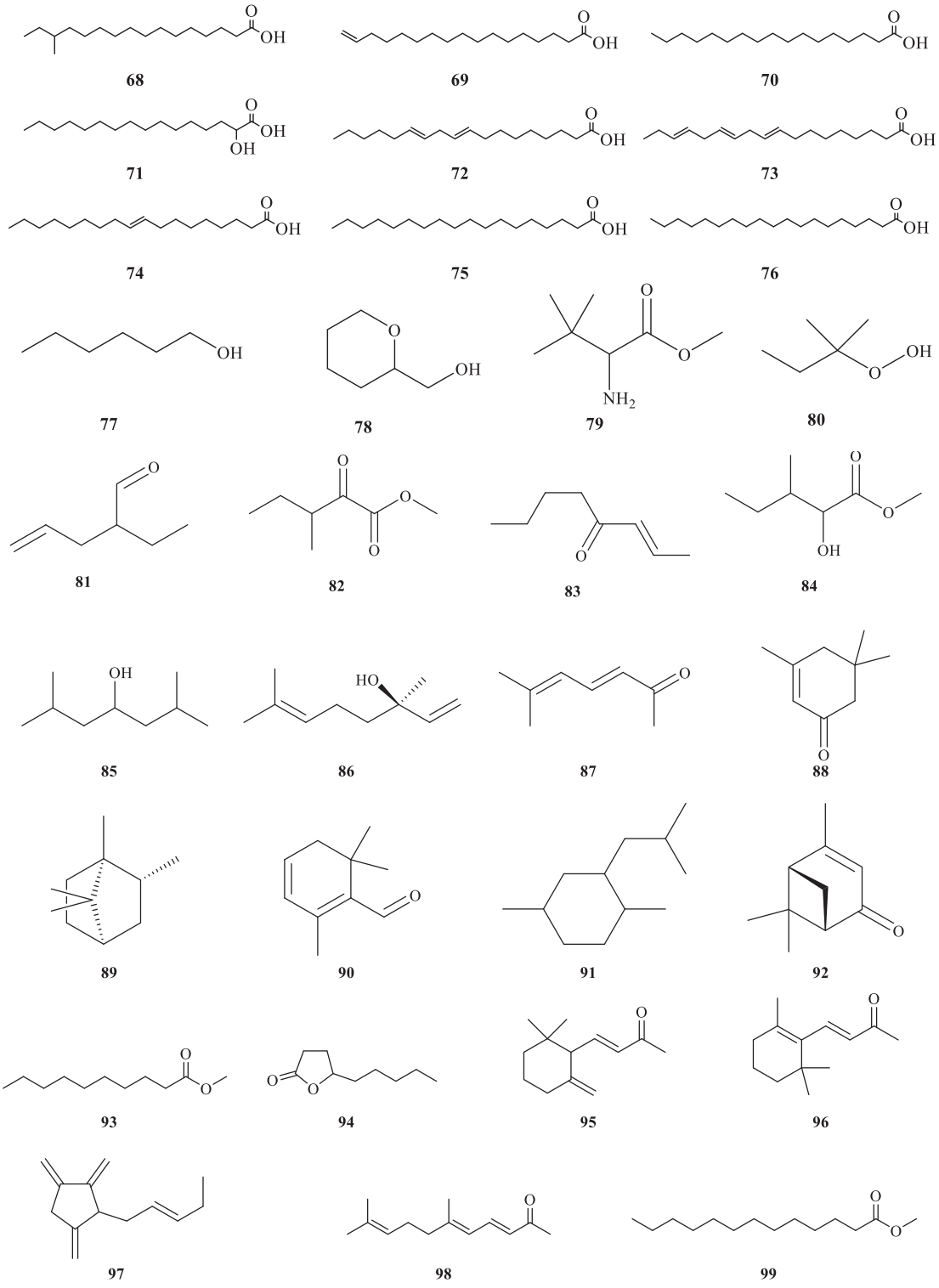

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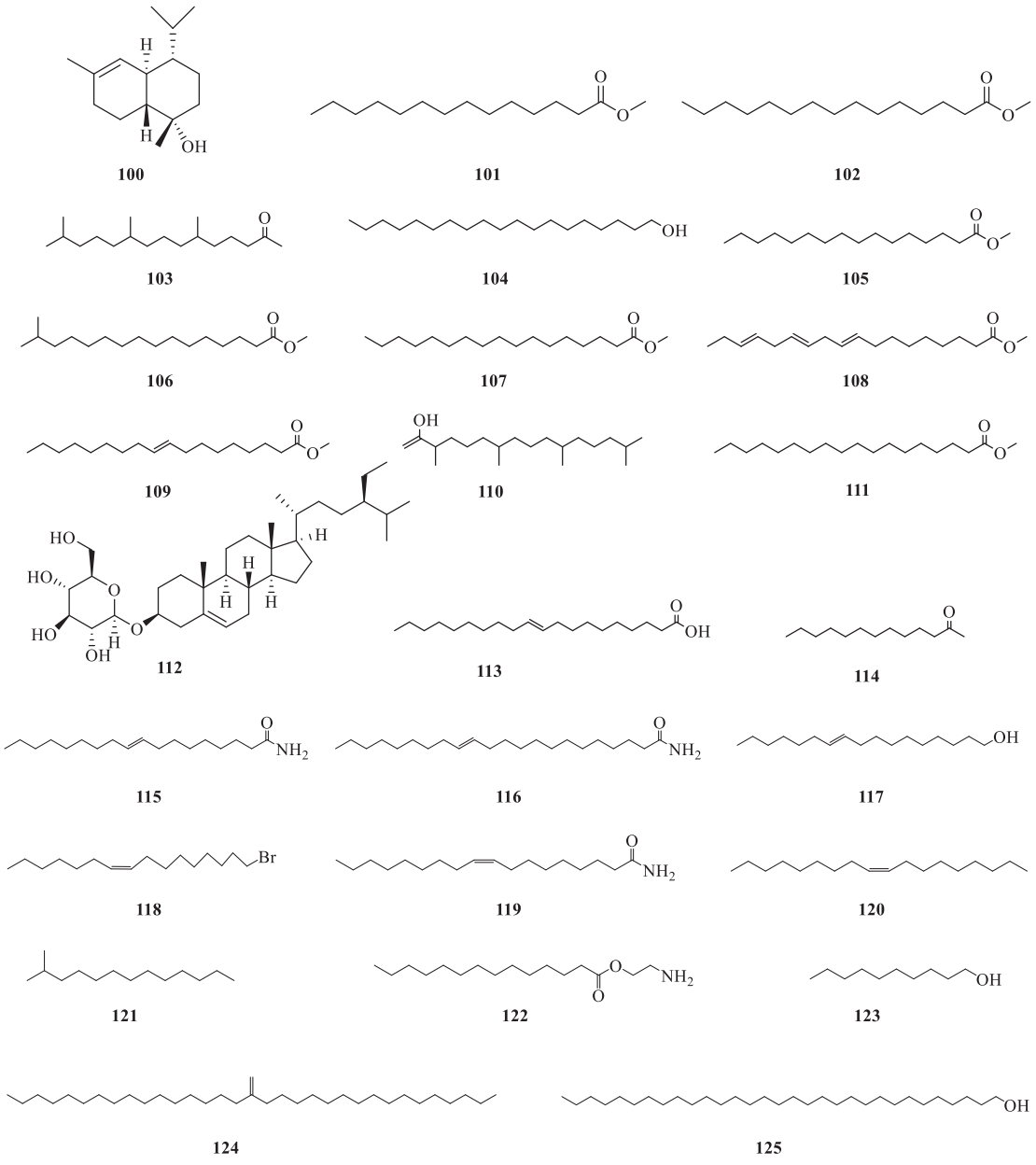


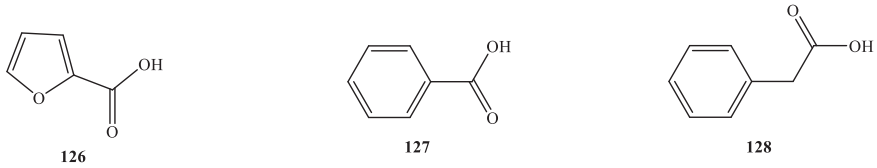
Continued Fig. 3

2.4 Aromatic hydrocarbons and their derivatives

Aromatic hydrocarbons and their derivatives have auxiliary effect such as anti-tumor, anti-bacteria and anti-oxidation [6]. The structural formulas of aromatic hydrocarbons and their derivatives are shown in Table 4 and Fig. 4.

Table 4 Aromatic hydrocarbons and their derivatives in *L. capillipes* Hemsl

No.	Name	No.	Name
126	furancarboxylic acid	152	2,3-dimethyphenol
127	benzoic acid	153	*p*-ethylphenol
128	phenylacetic acid	154	4-ethyl-1,3-benzenediol
129	3-methyibenzoic acid	155	2-ethyl-4-methylphenol
130	phenyipropionic acid	156	2’,4’-Dihydroxyacetophenone
131	2-hydroxy-3-methyibenzoic acid	157	1,2,3-trimethoxybezene
132	*α*-hydroxyphenylpropionic acid	158	3-methoxy-2,5,6-trimethylphenol
133	cinnamic acid	159	3,4-dimethoxyphenol
134	3-hydroxybenzoic acid	160	2-methyl-1,4-benzenedicarboxaldehyde
135	4-hydroxyphenylacetic acid	161	eugenol
136	vanillic acid	162	2-methoxy-4-propylphenol
137	4-gcelyloxy-3-miethoxybcuzoic acid	163	veratric acid
138	*p*-hydroxycinnamic acid	164	3,5-dimethoxy-4-hydroxyacetophenone
139	3,4-dihydroxybenzoic acid	165	2,6-*di*-tert-butyl-4-methylphenol
140	4-acetyloxy-3-methoxycinnamic acid	166	8-hydroxy-3-methylisoconmarin
141	furfural	167	2,4-dimethoxy-1-phenylacetone
142	5-methylfurfural	168	2,6-dimethoxy-4-allylphenol
143	phenol	169	diphenylecetaldehyde
144	2-penlylfuran	170	2,4-dihydroxy-6-methy1-1,3-benzenedicarboxaldehyde
145	benzyl alcohol		
146	*o*-cresol	171	phenanthrene
147	*m*-cresol	172	dibutyl phthalate
148	*o*-methoxyphenol	173	3’,4’,5,5’,7-pentahydroxyflavone
149	phenylethyl alcohol	174	butyl-1*H*-imidazole-4-(8)-carboxylate
150	phlorol	175	*o*-phthalic acid bis-(2-ethyl decyl)-ester
151	1,2-dimethoxybenzene	176	5,5’-dibutoxy-2,2’-bifuran



126 127 128

Fig. 4 The structural formulas of aromatic hydrocarbons and their derivatives in *L. capillipes* Hemsl

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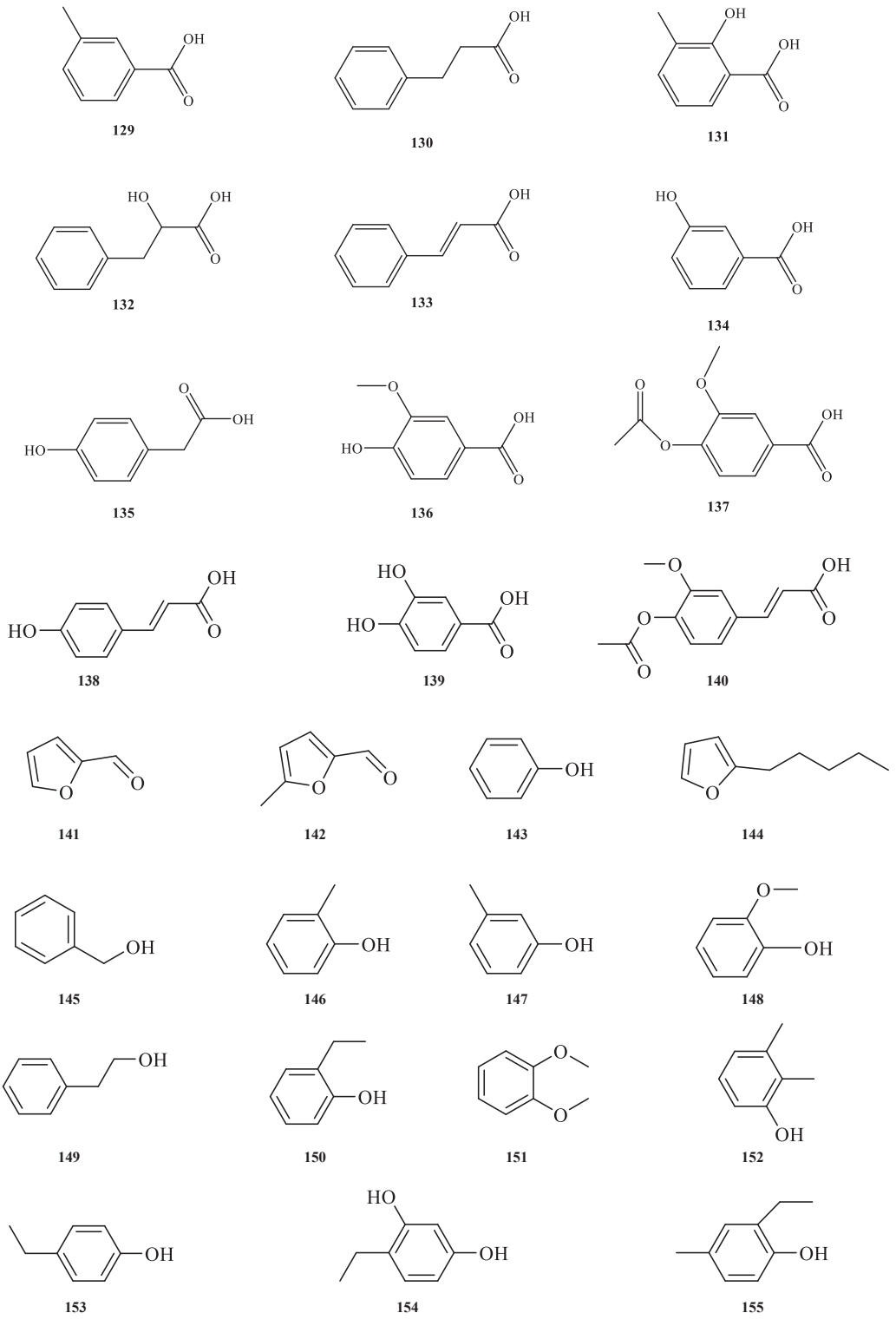

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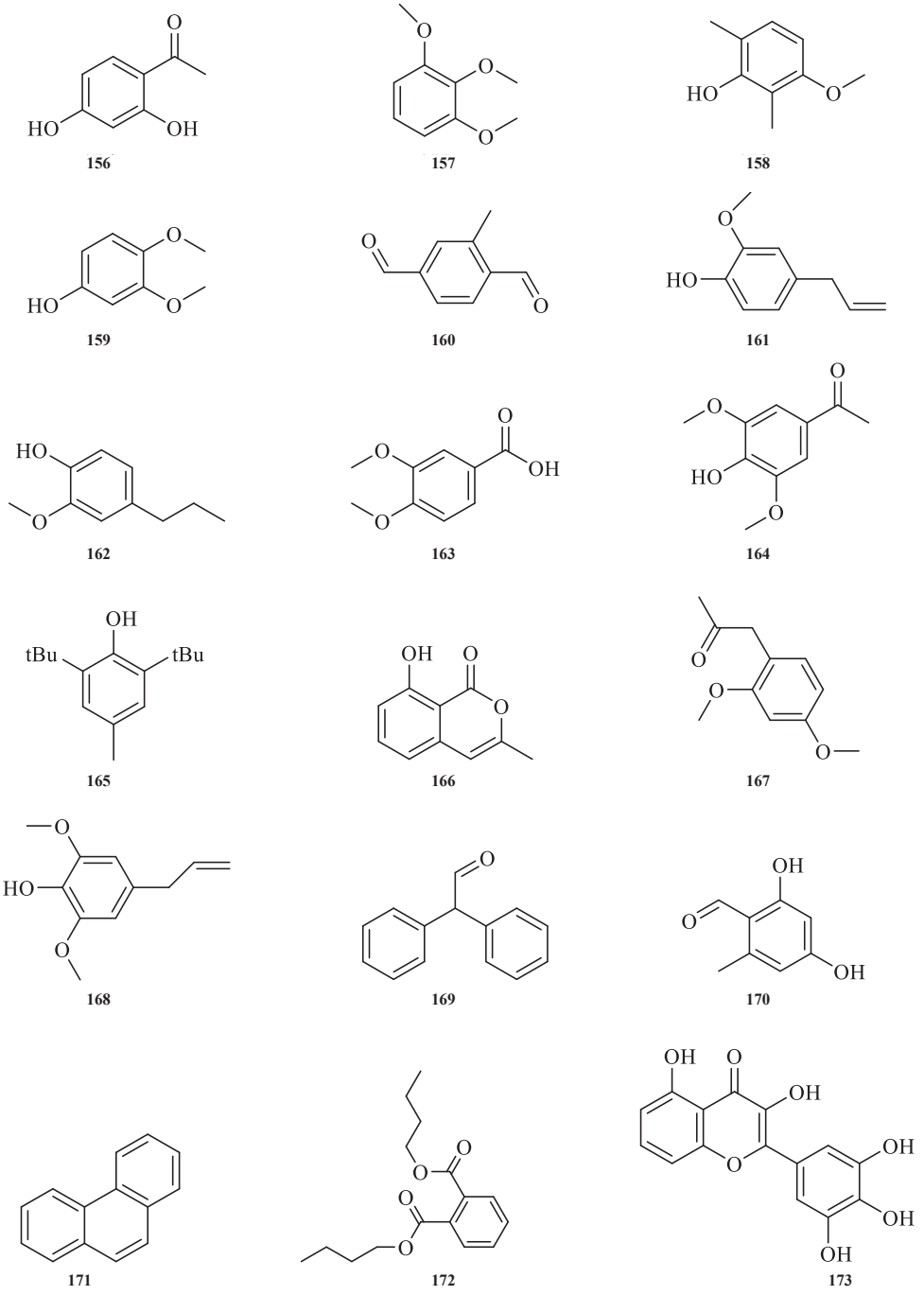

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3 Pharmacological activities of *L. capillipes* Hemsl

At present, the herb has been verified to possess a diverse array of pharmacological activities, with the specific directions being illustrated in Fig. 5.

Fig. 5 Pharmacological activities of *L. capillipes* Hemsl

3.1 Antitumor activity

Capilliposide, a series of saponins or flavonoids in *L. capillipes* Hemsl, is the main active ingredient. It has a good therapeutic effect on prostate cancer, gastric cancer, ovarian cancer, lung cancer, nasopharyngeal carcinoma, breast cancer, esophageal squamous cell carcinoma, cholangiocarcinoma and colorectal cancer. Its mechanism includes inducing apoptosis, inhibiting tumor cell metastasis, tumor cell cycle arrest, gene transcription, inhibiting tumor angiogenesis and enhancing immune activity.

Taking prostate cancer as an example, xenograft tumor models were established by subcutaneous injection of 1×10^6 PC-3 cells in a total volume of 0.1 mL of PBS containing 50% Matrigel. The tumor-bearing mice were divided into 5 groups, 6 in each group, and treated differently: control, docetaxel at 15 mg/kg as positive control, capilliposide-B (**2**) at 20, 40 and 60 mg/kg. Treatment was performed by gavage, 5 d per week. Tumors removed from tumor-bearing mice were quickly frozen in liquid nitrogen and stored at -80 °C for proteomic analysis. The results showed that capilliposide-B (**2**) induced autophagy by activating AMPK and inhibiting mTOR, and AMPK was activated by promoting ROS production in capilliposide-B (**2**)-treated PC-3 cells. With the concentration of 1.25 μM, 2.5 μM and 5 μM, ROS production increased by 5%, 12% and 26%. After capilliposide-B (**2**) treatment, autophagy and epithelial-mesenchymal transition occurred *in vivo*, and ROS accumulation was detected in cells. Among the downstream pathways, LKB1 and AMPK were activated while mTOR was inhibited. The results of Transwell assay showed that capilliposide-B (**2**) inhibited the metastasis of PC-3 cells, and this effect was significantly weakened after pretreatment with chloroquine, indicating that capilliposide-B (**2**) inhibited metastasis by inducing autophagy [7]. Li et al. used DCFH-DA fluorescent probe to detect ROS levels in PC-3 cell lines treated with different concentrations of capilliposide-C (**3**), and the results showed that capilliposide-C (**3**) could promote ROS accumulation [8]. These data suggest that capilliposide-B (**2**) is a potential therapeutic agent for cancer treatment.

Li et al. explored the anti-tumor activity of capilliposide-A (**1**) on colorectal cancer through Xenograft studies, and determined the metabolites in plasma, urine and feces by UPLC-Orbitrap MS analysis for metabolomics. The results showed that capilliposide-A (**1**) could significantly inhibit the proliferation of CRC cells and slow down tumor growth by regulating basal metabolism [9]. Tian et al. detected the cell migration of each group by Transwell, and detected the expression of MMP-2, MMP-9, TNF-α and COX2 in each group by Western blotting. They found that capilliposide-A (**1**) could inhibit the proliferation of CRC cells and inhibit the invasion of CRC cells. Capilliposide-A (**1**) could inhibit the expression of invasion and metastasis-related proteins MMP-2, MMP-9 and NF-κB pathway activators TNF-α and COX2 in CRC cells [10].

In earlier years, Xu et al. proved the anti-ovarian cancer activity of capilliposide [11]. Recently, Zhang et al. found that capilliposide could enhance

paclitaxel-induced A2780T cell apoptosis and inhibit A2780T cell colony formation. Capilliposide exposure reduced the expression of cancer stemness markers, ALDH1, Myd88 and CD44, while promoting that of terminal differentiation markers, such as NFATc1, Cathepsin K and MMP9. RNAseq analysis revealed that the expressions of FOS and JUN were upregulated in capilliposide-C (**3**)-treated A2780T cells [12].

Capilliposide-C (**3**) significantly enhanced the effect of radiation on ionizing radiation (IR)-resistant lung cancer cells *in vitro* and *in vivo*, and ERRFI1 was verified as a candidate downstream gene by RNA-seq. Capilliposide-C (**3**) and ERRFI1 effectively inhibited IR-induced DNA damage repair, and ERRFI1 significantly induced G2/M checkpoint arrest. Additional investigations revealed that down-regulation of EGFR/STAT3 pathway played an important role in radiosensitization between ERRFI1 and capilliposide-C (**3**) [13]. Fei et al. found that capilliposide blocked lung cancer cells in S phase and could not undergo mitosis. The increase of ROS level in lung cancer cells inhibits the NF-κB pathway, promotes the expression of downstream pro-apoptotic protein Bax, inhibits the expression of Bcl-2 protein, initiates the Capase-3 enzyme to execute the apoptosis command, and finally activates the mitochondrial apoptosis pathway [14].

Ying et al. demonstrated the inhibitory effect of capilliposide on the growth of lung cancer A549 cells and breast cancer MCF7 cells by MTT assay [15]. Hua et al. found that after treatment of nasopharyngeal carcinoma CNE-2 cells with capilliposide, the ability of soft agar colony formation decreased and the apoptosis rate increased, indicating that capilliposide has the effect of inhibiting proliferation and inducing apoptosis of nasopharyngeal carcinoma, which is related to the up-regulation of PUMA-Bax pathway [16]. Xu et al. found that the expression of VEGF in the high-dose capilliposide group was significantly lower than that in the model group, indicating that the expression of VEGF in the high-dose capilliposide group was significantly lower than that in the model group [11]. Wang et al. found that capilliposide could inhibit the proliferation of cholangiocarcinoma cells and induce apoptosis of cholangiocarcinoma cells. The mechanism may be related to the up-regulation of caspase-3 expression and the down-regulation of PARP expression, and it has a synergistic effect with 5-Fu. The proportion of apoptotic cells in the combination group was higher than that in the two single drug groups [17]. The combination of capilliposide-C (**3**) and oxaliplatin could significantly reduce the expression of PI3K, phospho-Akt, phospho-mTOR, Bcl-2 and Bcl-XL, and significantly increase the expression of Bax and caspase-3. In addition, capilliposide-C (**3**) significantly enhanced the anticancer effect and apoptosis of oxaliplatin in the xenograft model of esophageal squamous cell carcinoma [18].

3.2 Analgesic and anti-inflammatory activity

Wu et al. 's studies showed that capilliposide at all doses (40, 60 and 90 mg/kg) increased the latency period of paw licking induced by thermal stimulation, and significantly suppressed abdominal writhing episodes of mice induced by intraperitoneal injection of acetic acid at the dose of 40 mg/kg. At the doses of 60 and 90 mg/kg, it suppressed paw edema induced by subcutaneous injection of carrageenan. The inhibition rates of foot swelling were 12.68% and 21.13%. These results show that capilliposide has analgesic and antiinflammatory effects. In terms of mechanism, the anti-inflammatory effect of capilliposide-C (**3**) is related to the inhibition of the production of malondialdehyde (MDA), prostaglandin E2 (PGE2), tumor necrosis factor (TNF-α), cyclooxygenase-1 (COX-1) and cyclooxygenase-2 (COX-2) in paw tissue of carrageenan-injected mice [19]. Yun Gu Gwon et al. investigated the anti-inflammatory activity of *L. capillipes* Hemsl extract in

lipopolysaccharide (LPS)-stimulated RAW264.7 cells. *L. capillipes* Hemsl extract dose-dependently suppressed the production of nitric oxide and the expression of pro-inflammatory cytokines including interleukin (IL)-1β, IL-6 and tumor necrosis factor (TNF)-α in LPS-stimulated RAW264.7 cells, and also significantly inhibited the phosphorylation of MAPKs including p38, JNK and ERK1/2 as well as the expression of phosphorylated NF-κB-p65 in a dose-dependent manner. These results suggest that *L. capillipes* Hemsl extract exhibit anti-inflammatory properties by inhibiting the NF-κB and MAPKs signaling pathway [20].

3.3 Antibacterial activity

Zheng et al. have proved that *L. capillipes* Hemsl extracts have antibacterial activity against *Candida albicans*, *Escherichia coli*, *Staphylococcus aureus* and *Bacillus subtilis* by bacteriostatic circle method. Especially, it has strong antibacterial activity against *Candida albicans* [21]. The study of Xu et al. also confirmed that the extracts had antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*, and found that the extraction of supercritical carbon dioxide fluid extraction (SC-CO2) was better than that of ethanol extraction (EE) [22].

3.4 Antioxidant activity

Capilliposide was prepared into five different concentrations of 5 to 0.3125 mg/mL. 50 μL 6 mmol/L ferrous sulfate and 50 μL 6 mmol/L hydrogen peroxide were added and mixed into 50 μL solution of different concentrations in turn. After 10 min at the room temperature, 50 μL 6 mmol/L salicylic acid was added into the solutions. After reacting at 37 °C for 30 min, the absorbance was measured at 510 nm by a microplate reader. 100 μL 0.2 mmol DPPH· solution was added and mixed into 100 μL of capilliposide solution with different concentrations, and reacted at room temperature in the dark for 30 min. The absorbance was measured at 517 nm. The 2 mmol $ABTS^{+}\cdot$ storage solution and 70 mmol potassium persulfate were mixed at the ratio of 1:4, put at room temperature and in the dark for 16 h, and then diluted 5.5 times with PBS to obtain the $ABTS^{+}\cdot$ working solution. 200 μL $ABTS^{+}\cdot$ working solution was added and mixed into 10 μL of capilliposide solution with different concentrations, and reacted at room temperature in the dark for 10 min. The absorbance was measured at 734 nm. 50 μL PBS and 50 μL 1% potassium ferricyanide were added and mixed in turn into 10 μL of capilliposide solution with different concentrations, and reacted in a water bath at 50 °C for 20 min. After cooling, 50 μL 10% trichloroacetic acid was added to mix well and centrifuged at 3000 r/min for 10 min. 50 μL of supernatant was added with 50 μL of deionized water and 50 μL of 10% ferric chloride. The absorbance was measured at 700 nm after 10 min of reaction. The results showed that capilliposide had strong concentration-dependent antioxidant activity. The scavenging rates of capilliposide on OH, DPPH· and $ABTS^{+}\cdot$ were (68.03±1.93)%, (87.93±4.39)% and 47.19%, respectively. The reducing power of capilliposide on Fe^{3+} was positively correlated with the concentration of capilliposide in a certain range [23]. Xu et al. also used three antioxidant test methods, namely DPPH, ABTS and FRAP, to comprehensively evaluate the antioxidant activity of capilliposide [22].

3.5 Anti-vascular disease activity

Han et al. found that capilliposide specifically inhibited the activation of VEGFR2 and its downstream signaling enzymes Akt and Erk induced by VEGF, and effectively blocked the proliferation, migration and tube formation of HRECs stimulated by VEGF, indicating that capilliposide is a promising drug to prevent angiogenesis-related diseases [24].

3.6 Anti-obesity disease activity

Li et al. found that *L. capillipes* Hemsl extract inhibited the angiogenesis of adipose tissue in transgenic zebrafish Tg (Fli 1: EGFP), and accompanied by decreased Oil Red O staining of the zebrafish. *L. capillipes* Hemsl extract reduced expression of MTP significantly, but modestly reduced expression of Peroxisome proliferator - activated receptor *γ*, FABP10a and CD36 level through ISH, which shows that *L. capillipes* Hemsl has the potential to become a drug for the prevention and treatment of obesity [25].

4 Conclusion

The present report provides a comprehensive review of the chemical composition and pharmacological activities of *L. capillipes* Hemsl. It has the pharmacological effects of anti-tumor, analgesic, anti-inflammatory, antibacterial, anti-oxidation, protection of blood vessels, prevention of ophthalmic diseases, reduction of blood lipids, prevention and treatment of obesity. Saponins and flavonoids extracted from *L. capillipes* Hemsl are the main active substances that exert pharmacological activities. Among them, capilliposide-A, capilliposide-B and capilliposide-C have been studied in depth. They induce apoptosis, inhibit tumor cell metastasis, block tumor cell cycle, gene transcription, inhibit tumor angiogenesis, enhance immune activity and so on. They can not only directly and effectively treat tumors, but also have synergistic effects with many commonly used anti-tumor drugs, so combined drug therapy has become a direction worthy of study. Moreover, the mechanism of synergy is that C can be a sensitive state of cancer cells, so combined targeted chemotherapy and combined radiotherapy have the potential to become mainstream treatment methods. Except for capilliposide-A, B, C, other saponins and flavonoids have not been fully developed, and they also have the potential to become new clinical drugs. The recently screened DM130 macroporous adsorption resin is an excellent purification resin, which can be used to optimize the purification process of total saponins of Lepidium apetalum. After purification, the extract is ground into yellow-green powder, and the particles are loose and will not stick together for a period of time, which provides a new direction for the the production of preparations. The toxicology research of *L. capillipes* Hemsl needs further discussion. In the future, the research on the removal of *L. capillipes* Hemsl and capilliposide will be more in-depth, including mining more active ingredients, exploring the mechanism of action, optimizing the preparation process and improving the quality standards. The application will be further expanded in order to make greater contributions to human health.

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References

[1] Liu Y, Zhang Q, Chen M, et al. Study on Pharmacognosy of Manshanxiang. Lishizhen Med Mater Med Res, 2015, 26: 2178-2180.

[2] Yang F, Wu ZY, Bao S, et al. Determination of the cytotoxicity of lysimachia and the content of luteolin. Pract Pharm Clin Rem, 2018, 21: 419-424.

[3] Tian JK. Studies on the Chemical Constituents of Two Medicinal Plants of *Lysimachia genus*. Peking Union Med Coll and Chin Acad Med Scie, 2002, 1: 1-159.

[4] Xie C, Xu LZ, Zhao BH, et al. Studies on the Chemical Constituents of Hairystalk Loosestrife (*Lysimachia capillipes*). Chin Tradit Herb Drugs, 2000, 31: 3-5.

[5] Tian JK, Zou ZM, Xu LZ, et al. Studies on Chemical

Constituents of *Lysimachia capillipes*. Chin Pharm J, 2006, 3: 171-173.

[6] Ding ZH, Ding JK, Yi YF, et al. The volatile oil components of Lysimachia capillipes Hemsl. Acta Bot Yunnanica, 1989, 11: 209-214.

[7] Wang L, Han H, Feng Y, et al. Capilliposide B inhibits the migration of prostate cancer by inducing autophagy through the ROS/AMPK/mTOR pathway. Phytother Res, 2023, 37: 2902-2914.

[8] Li R, Zhang L, Zhang L, et al. Capilliposide C derived from Lysimachia capillipes Hemsl inhibits growth of human prostate cancer PC3 cells by targeting caspase and MAPK pathways. IntUrol Nephrol, 2014, 46: 1335-1344.

[9] Li W, Zhang X, Feng Y, et al. Deciphering the metabolic profile and anti-colorectal cancer mechanism of Capilliposide A using ultra performance liquid chromatography mass spectrometry combined with non-targeted metabolomics studies. J Pharm Biomed Anal, 2023, 234: 115548.

[10] Tian HQ, Jing XN, Fang JN, et al. The mechanism of LC-A on invasion and migration of human colon cancer SW620 cells. Doct, 2022, 7: 106-109.

[11] Xu Y, Rong YM, Liu XB, et al. Experimental studies on anti-tumor effects of Capilliposide. Chin Pharmacol Bull, 2012, 28: 545-549.

[12] Zhang K, Ying H, Zhao R, et al. Capilliposide from Lysimachia capillipes promotes terminal differentiations and reverses paclitaxel resistance in A2780T cells of human ovarian cancer by regulating Fos/Jun pathway. Chin Herb Med, 2021, 14: 111-116.

[13] Wu K, Chen X, Feng J, et al. Capilliposide C from Lysimachia capillipes Restores Radiosensitivity in Ionizing Radiation-Resistant Lung Cancer Cells Through Regulation of ERRFI1/EGFR/STAT3 Signaling Pathway. Front Oncol, 2021, 11: 644117.

[14] Fei ZH, Wu K, Chen YL, et al. Capilliposide isolated from Lysimachia capillipes Hemsl. induces ROS generation, cell cycle arrest, and apoptosis in human non-small cell lung cancer cell lines. J Evid Based Complement Alternat Med, 2014, 2014: 497456.

[15] Ying HM, Chen RZ, Guo DW, et al. Quantitative Determination and the Related Anti-tumor Research of Saponins in *Lysimachia capillipes*. 2010 China Pharm Congr & 10th Chin Pharm Wkly Collect Pap, 2010, 8: 1-8.

[16] Hua YH, Hu QY, Piao YF, et al. The Antitumor Activity of Capilliposide on Nasopha-ryngeal Cancer Cell Lines CNE-2 in Vitro. China Cancer, 2014, 23: 597-600.

[17] Wang Y, Zhang XF, Wang J, et al. The Anti-Cholangiocarcinoma Effect and Its Mechanism of Lysimachia Capilliposide in Combination with 5-Fluorouracil. J Zhejiang Chin Med Univ, 2018, 42: 989-995.

[18] Shen Z, Xu L, Li J, et al. Capilliposide C Sensitizes Esophageal Squamous Carcinoma Cells to Oxaliplatin by Inducing Apoptosis Through the PI3K/Akt/mTOR Pathway. Med Sci Monit, 2017, 23: 2096-2103.

[19] Wu ZP, Han HT, Xu MT, et al. Analgesic and antiinflammatory activities of the capilliposide derived from *Lysimachia capillipes* Hemsl., a traditional Chinese medicinal herb. Med Sci Monit, 2020, 72: 515-523.

[20] Yun Gu Gwon, Seul Gi Lee, Jeong Un Choi, et al. Anti-inflammatory effect of Lysimachia capillipes extract in LPS-induced macrophages by down-regulating NF-κB and MAPKs signaling pathways. J Korean Soc Food Sci Nutr, 2021, 10: 598.

[21] Zheng LH, Wu QC, Chen QL, et al. Decolorization optimization of saponins from *Lysimachia capillipes* Hemsl by activated carbon and its antimicrobial activity. China Food Addit, 2021, 32: 67-72.

[22] Xu HJ. Study on deep processing and bioactivity of *Lysimachia Capillipes* Hemsl. J Shanghai Inst Chem Technol, 2023, 1: 1-73.

[23] Bi LW, Yu LJ, Qin F, et al. Extraction and Antioxidant Activity of Capilliposide from *Lysimachia Capillipes* Hemsl. Food Sci Technol, 2023, 48: 218-222.

[24] Han H, Yang Y, Wu Z, et al. Capilliposide B blocks VEGF-induced angiogenesis in vitro in primary human retinal microvascular endothelial cells. Biomed Pharmacother, 2021, 133: 110999.

[25] Li XM, Xue Y, Pang L, et al. *Lysimachia Capillipes* Inhibit Adipogenesis via Angiogenesis Inhibition. Drug Res, 2019, 69: 284-290.