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NATURAL PRODUCTS: FROM CHEMISTRY TO PHARMACOLOGY (C HO, SECTION EDITOR)

Chemical Constituents and Pharmacological Effects of Genus *Patrinia*: a Review

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Abstract

Purpose of Review To provide references for further research and for the application of the genus *Patrinia*, recent studies concerning the phytochemistry and pharmacology of the genus *Patrinia* were summarized.

Recent Findings There are about 20 species of *Patrinia* genus around the world which is mainly distributed throughout East Asia and North America, and about 10 species, 3 subspecies, and 2 variant species in China which have been used as traditional Chinese medicine in controlling fever and inflammation along with detoxication, mobilization of blood circulation, and treatment for stasis, among others. The tender leaves of some species could be used for food. The main chemical constituents are triterpenoids, iridoids, flavonoids, anthraquinone, coumarin, lignans, steroids organic acids, and alkaloids in *Patrinia*. Pharmacology researches showed that *Patrinia* possesses sedative, antibacterial, antivirus, anti-tumor activities, and protective effects of liver and gallbladder. It can be used in the treatment of neurasthenia, hepatitis, and pneumonia.

Summary The plant resources of genus *Patrinia* are rich; at the same time, the genus has complex chemical constituents and abundant pharmacological activities.

Keywords Genus *Patrinia* · Chemical constituents · Pharmacology · Triterpenoids

Introduction

There are about 20 species of genus *Patrinia* all over the world which are mainly distributed in East Asia and North America. Therein, about 10 species, 3 subspecies, and 2 variant species are native to China. According to the Chinese traditional pharmaceutical books, 9 species and 2 subspecies have been used as medicinal herbs in China [1], which are widely distributed in the entire country. The *Patrinia* species in China include *Patrinia scabiosaefolia* Fisch. ex Trevir.; *Patrinia sibirica* (Linn.) Juss.; *Patrinia glabrifolia* Yamamoto et Sasaki; *Patrinia speciosa* Hand. Mazz; *Patrinia intermedia* (Horn.) Roem. et Sehult; *Patrinia rupestris* (Pall.) Juss.; *subsp. rupestris; subsp. scabra* (Bunge) H. J. Wang; *Patrinia heterophylla* Bunge; *subsp. heterophylla*; *subsp. angustifolia* (Hemsl.) H. J. Wang; *Patrinia villosa* (Thunb.) Juss.; *subsp. punctifolia* H. J. Wang; *Patrinia punctiflora* Hsu et H. J. Wang; *var. punctiflora*; *var. robusta* Hsu et H. J. Wang; *monandra* C.B.Clarke; *var. monandra*; and *var. formosana* (Kitam.) H. J. Wang.

The main chemical constituents of genus *Patrinia* are triterpenoids, followed by iridoids, flavonoids, anthraquinones, coumarins, lignans, organic acids, and alkaloids. Moreover, the difference among *Patrinia* plants, about their species and skeleton of terpenoids, flavonoids, and glycosides, can be used as the basis of chemical taxonomy among species [2].

In China, there is a long application story of the genus *Patrinia*. *P. scabiosaefolia* and *P. villosa* are colloquially

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named "*Bai Jiang Cao*" recorded in the "*Sheng Nong's Herbal Classic*", and they were ranked as "Middle grade" herbs. According to the "*Compendium of Materia Medica*", *Bai Jiang Cao* is often used to treat gynecopathy. Many species of this genus, for example, *P. scabiosaefolia*, *P. villosa*, and *P. heterophylla* have been used as folk medicine with the effects of anti-inflammation, detoxification, antibacterial, sedation, and antispasmodic in China [3]. Besides, the young leaves and/or flower buds of some *Patrinia* species such as *P. scabiosaefolia*, *P. villosa*, *P. punctiflora*, and *P. glabrifolia* are also used as vegetables in some areas of China.

The important research value of genus *Patrinia* is its significant clinical effect in the treatment of neurasthenia and postpartum diseases. However, only a few species of this genus were studied, including *P. scabiosaefolia*, *P. villosa*, and *P. scabra*, which were focused on the chemical components, less published reports concerning their pharmacology, and no comprehensive research combining the components and pharmacology together [4]. In this paper, we comprehensively summarized the chemical constituents (Table 1) and pharmacological activities of *Patrinia*.

Chemical Constituents

Triterpenoids

Eighty-two compounds (Compounds 1–82 in Figs. 1,2,3) have been obtained from 5 species of *Patrinia*. Based on the skeleton of sapogenin, saponins can be divided into three types: oleanane, hederagenin, and ursane. The main glycosyls are xylose, rhamnose, arabinose, and glucose.

Iridoids

Studies on iridoids in *Patrinia* were reported as early as the 1970s. Villoside and loganin (Compounds 91–92 in Fig. 4) were isolated from *P. villosa* by Heihachiro Taguchi [37]. Furthermore, the C_1–OH of iridoid compounds was easily combined with sugar as glycosides; C7 and C8 are sometimes substituted by hydroxyl groups and combined with sugar as glycosides. In addition, C4 is often attached by carbonyl group derivatives. Until now, there were 71 iridoids isolated from *Patrinia* (Compounds 83–153 in Fig. 4) with the main skeletons such as iridoids and secoiridoids.

Flavonoids

There were 32 flavonoid compounds (Compounds 154–186 in Fig. 5) isolated from *P. rupestris*, *P. villosa*, *P. heterophylla*, *P. scabra*, and *P. scabiosaefaolia*. Their skeletons were mainly composed of flavonoids, flavonols, dihydroflavonoids, and their glycosides as well as a small amount of chalcones. The main glycosyls were rhamnose and glucose.

Anthraquinones

Liu et al. [47] isolated compounds 187–192 from *P. scabra* in 2010 (Fig. 6). The main glycosyls are rhamnose and glucose.

Phenylpropanoid Derivatives

Coumarins

There are few reports which have been published concerning coumarins (Compounds 193–197 in Fig. 7).

Lignans

Lignans usually existed in the form of glycosides. Twenty-two lignans and their glycosides (Compounds 198–219 in Fig. 8) have been identified from the genus *Patrinia*. Up to now, most lignans from *Patrinia* are mainly concentrated in *P. scabra*, while a few in *P. villosa* and *P. scabiosaefaolia.*

Phenylpropionic Acids

To date, five coumarins (Compounds 220–224 in Fig. 9) were isolated and identified from the roots and rhizomes of the genus *Patrinia*.

Steroids

Eight steroids (Compounds 225–232 in Fig. 10) have been isolated from the whole plants of the genus *Patrinia*. Therein, compounds 225–229 were isolated from *P. scabiosaefaolia*, compounds 230–231 from *P. rupestris* and compound 232 from *P. villosa.*

Essential Oils

Based on the supercritical CO_2 extraction and GC-MS, Yang et al. extracted and identified 41 chemical components from *P. scabiosaefaolia*, mainly including monoterpenes, sesquiterpenes and the corresponding oxygen-containing derivatives, and caryophyllene is the highest (25%) among them [72]. Tian et al. identified 9 compounds from *P. scabiosaefaolia* and 6 compounds from *P. heterophylla* [73]. Ma et al. analyzed extracts of *P. villosa* by GC-MS and

Table 1 Chemical constituents of genus *Patrinia*

Number	Compounds	Source	Ref.
Triterpenoids and saponins			
Hederagenin-type triterpenoid saponins 1–21			
1	2α,3β,23-Trihydroxyolean-12-en-28-oic acid	*P. scabiosaefaolia*	[5]
2	2α,3β,19α,23-Trihydroxyolean-12-en-28-oic acid	*P. scabiosaefaolia*	[5]
3	Scabioside A	*P. scabiosaefaolia*	[6]
4	Scabioside C	*P. scabiosaefaolia*	[6]
5	Hederagenin	*P. scabiosaefaolia*	[7]
6	2'-*O*-Acetyl-3-*O*-α-L-ara-hederagenin	*P. scabiosaefaolia*	[7]
7	28-*O*-β-*D*-Glc-(1 → 6)-β-*D*-glc hederagenin ester	*P. scabiosaefaolia*	[8]
8	3-*O*-α-L-Ara-(1 → 3)-β-*D*-xyl hederagenin	*P. scabiosaefaolia*	[9]
9	*3-O-β-D-Glc-(1 → 3')-(2'-O-acetyl)-α-L-ara hederagenin*	*P. scabiosaefaolia*	[10]
10	α-Hederin	*P. scabiosaefaolia*	[11]
11	3-*O*-(2'-Acetate)α-L-ara hederagenin 28-*O*-β-*D*-Glc-(1 → 6)-β-*D*-glucopyranoside	*P. scabiosaefaolia*	[12]
12	3-*O*-α-L-Ara hederagenin 28-*O*-β-*D*-glc-(1 → 6)-β-*D*-glucopyranoside	*P. scabiosaefaolia*	[12]
13	Prosapogenine CP_3	*P. scabiosaefaolia*	[13]
14	Sieboldianaside A	*P. scabiosaefaolia*	[13]
15	Kalopanax saponin B	*P. scabiosaefaolia*	[14]
16	Patrinia saponin H_3	*P. scabiosaefaolia*	[15]
17	3-*O*-α-L-Rha(1 → 2)-α-L-ara-hederagenin-28-*O*-α-L-ara-(1 → 4)-β-*D*-glc-(1 → 6)-β-*D*-glucopyranoside	*P. scabiosaefaolia*	[16]
18	3-*O*-β-*D*-Xyl-(1 → 3)-α-L-rha-(1 → 2)-α-L-ara hederagenin-28-*O*-α-L-ara-(1 → 4)-β-*D*-glc-(1 → 6)-β-*D*-glucopyranoside	*P. scabiosaefaolia*	[16]
19	Sibiroside A	*P. sibrica*	[17]
20	Sibiroside B	*P. sibrica*	[17]
21	Sibiroside C	*P. sibrica*	[17]
Oleanane-type triterpenoid saponins 22–71			
22	Patrirupin A	*P. scabiosaefaolia*	[4]
23	Oleanolic acid	*P. scabiosaefaolia*	[6]
24	3-*O*-α-L-Ara oleanolic acid	*P. scabiosaefaolia*	[7]
25	28-*O*-β-*D*-Glc oleanolic acid	*P. scabiosaefaolia*	[9]
26	3-*O*-α-L-Rha-(1 → 2)-α-L-ara oleanolic acid	*P. scabiosaefaolia*	[11]
27	3-O-β-D-Glc-(1 → 3)-α-L-rha-(1 → 2)-α-L-ara oleanolic acid	*P. scabiosaefaolia*	[12]
28	3-*O*-β-*D*-Xyl-(1 → 3)-α-L- rha-(1 → 2)-α-L-ara oleanolic acid-28-*O*-β-*D*-glucopyranosyl ester	*P. scabiosaefaolia*	[13]
29	3-*O*-β-*D*-Glc-(1 → 3)-α-L- rha-(1 → 2)-α-L-ara-oleanolic acid-28-*O*-β-*D*-glc-(1 → 6)-β-*D*- glucopyranosyl ester	*P. scabiosaefaolia*	[12]
30	3-*O*-β-*D*-Glc-(1 → 3)-α-L- ara oleanolic acid	*P. scabiosaefaolia*	[18]
31	Patrinia-glycoside B-II	*P. scabiosaefaolia*	[18]

Table 1 (continued)

Number	Compounds	Source	Ref.
32	Patrinoside C	*P. intermedia*	[19]
33	PatrinosideC_1	*P. intermedia*	[20]
34	Patrinoside D	*P. intermedia*	[21]
35	Patrinoside D_1	*P. intermedia*	[21]
36	Scabioside B	*P. scabiosaefaolia*	[22]
37	Scabioside D	*P. scabiosaefaolia*	[22]
38	Scabioside E	*P. scabiosaefaolia*	[22]
39	Scabioside G	*P. scabiosaefaolia*	[22]
40	Scabioside F	*P. scabiosaefaolia*	[23]
41	Giganteaside D	*P. scabiosaefaolia*	[24]
42	3-*O*-*β*-*D*-Glc-(1 → 3)-*α*-L- rha-(1 → 2)-*β*-*D*-xyl oleanolic acid	*P. scabiosaefaolia*	[25]
43	2α-Hydroxy oleanolic acid	*P. scabiosaefaolia*	[26]
44	3-*O*-*β*-*D*-xyl Oleanolic acid	*P. scabiosaefaolia*	[26]
45	Sulfapatrinoside II	*P. scabiosaefaolia*	[27]
46	11*α*,12*α*-Epoxy-3-*O*-*β*-*D*-xyl-olean-28,13*β*-olide	*P. scabiosaefaolia*	[28]
47	11α,12α-Epoxy-3-O-β-D-xyl-(1 → 3)-α-L-rha-(1 → 2)-β-D- xyl-olean-28,13β-olide	*P. scabiosaefaolia*	[28]
48	3-*O*-*β*-*D*-Xyl-(1 → 3)-*α*-L-rha-(1 → 2)-*β*-*D*-xyl-oleanolic acid-28-*O*-*β*-*D*-glucopyranoside	*P. scabiosaefaolia*	[28]
49	3-*O*-*β*-*D*-Xyl-(1 → 3)-*α*-L- rha-(1 → 2)-*β*-*D*-xyl-oleanolic acid 28-*O*-*β*-*D*-glc-(1 → 6)-*β*-*D*-glucopyranoside	*P. scabiosaefaolia*	[28]
50	3-*O*-*β*-*D*-Xyl-(1 → 3)-*α*-L- rha-(1 → 2)-*β*-*D*-xyl-12*β*,30-dihydroxy-olean-28,13*β*-olide	*P. scabiosaefaolia*	[28]
51	3-*O*-*α*-L-Rha-(1 → 2)-*β*-*D*-xyl-12*β*,30-dihydroxy-olean-28,13*β*-olide	*P. scabiosaefaolia*	[28]
52	3-*O*-*β*-*D*-Xyl-(1 → 2)-*β*-*D*-glc-12*β*,30-dihydroxy-olean-28,13*β*-olide	*P. scabiosaefaolia*	[28]
53	3-*O*-*β*-*D*-Glc-(1 → 4)-*β*-*D*-xyl (1 → 3)-*α*-L-rha-(1 → 2)-*β*-*D*-xyl -oleanolic acid 28-*O*-*β*-*D*- glicopyranoside	*P. scabiosaefaolia*	[28]
54	3-*O*-*β*-*D*-Glc-(1 → 4)-*β*-*D*- xyl-(1 → 3)-*α*-L-rha-(1 → 2)-*β*-*D*-xyl-oleanolic acid-28-*O*-*β*-*D*- glc-(1 → 6)-*β*-*D*-glucopyranoside	*P. scabiosaefaolia*	[28]
55	3-*O*-*β*-*D*-Glc-(1 → 4)-*β*-*D*-xyl-(1 → 3)-*α*-L-rha-(1 → 2)-*α*-L-ara-oleanolic acid-28-*O*-*β*-*D*-glc-(1 → 6)-*β*-*D*-glucopyranosyl ester	*P. scabiosaefaolia*	[28]
56	Oleanonic acid	*P. scabiosaefaolia*	[29]
57	Patrinolide A	*P. scabiosaefaolia*	[30]
58	3-*O*-*α*-L-Glc-(1 → 3)-*β*-*D*-xyl oleanolic acid	*P. scabiosaefaolia*	[31]
59	3,11-Dioxo-olean-12-en-28-oic acid	*P. scabiosaefaolia*	[32]
60	29-Hydroxy-3-oxo-olean-12-en-28-oic acid	*P. scabiosaefaolia*	[32]
61	3*β*, 12*α*-Dihydroxy-oleanane-28, 13*β*-lactone	*P. scabiosaefaolia*	[32]
62	Oleanolic acid 28-*O*-*β*-*D*-glc-(1 → 6)-*β*-*D*-glucopyranosyl ester	*P. scabiosaefaolia*	[32]
63	3-*O*-*β*-*D*-Xyl oleanolic acid 28-*O*-*β*-*D*-glucopyranosyl ester	*P. scabiosaefaolia*	[32]
64	3-*O*-*α*-L-Rha-(1 → 2)-*β*-*D*-xyl oleanolic acid 28-*O*-*β*-*D*-glucopyranosyl ester	*P. scabiosaefaolia*	[32]
65	3-Hydroxyolean-11-oxo-12-en-28-oic acid	*P. scabiosaefaolia*	[32]

Table 1 (continued)

Number	Compounds	Source	Ref.
66	3β-Hydroxyolean-12-en-28-oic acid	*P. villosa*	[33]
67	3-*O*-α-L-Ara-(1 → 4)-β-*D*-glc oleanolic acid 28-*O*-β-*D*-Glc-(1 → 6)-β-*D*-glucopyranoside	*P. heterophylla*	[34•]
68	3-*O*-α-L-Ara-(1 → 4)-β-*D*-glc oleanolic acid 28-*O*-β-*D*-glucopyranose	*P. heterophylla*	[34•]
69	β-Amyrin	*P. heterophylla*	[35]
70	Friedelin	*P. heterophylla*	[35]
71	Canophyllol	*P. heterophylla*	[35]
Ursane-type triterpenoid saponins 72–82			
72	Patrinia-glycoside A-I	*P. scabiosaefaolia*	[5]
73	Patrinia-glycoside B-I	*P. scabiosaefaolia*	[5]
74	3-*O*-β-*D*-Glc-(1 → 3)-α-L-ara ursolic acid	*P. scabiosaefaolia*	[5]
75	23-Hydroxy ursolic acid	*P. scabiosaefaolia*	[14]
76	2α-Hydroxy ursolic acid	*P. scabiosaefaolia*	[26]
77	Sulfapatrinoside I	*P. scabiosaefaolia*	[27]
78	3α-Ursoloic acid	*P. scabiosaefaolia*	[28]
79	23-Sulfates (as sodium salts) of 3β-hydroxyurs-12-en-28-oic acid	*P. scabiosaefaolia*	[33]
80	α-Amyrin	*P. scabiosaefaolia*	[35]
81	Ursolic acid	*P. scabiosaefaolia/scabra*	[36, 37]
82	3β-Acetyloxy-12-en-28-ursolic acid	*P. scabiosaefaolia*	[36••]
Iridoids and iridoid glycosides 83–153			
83	Patrirupin B	*P. rupestris*	[4]
84	Homobaldrinal	*P. rupestris*	[4]
85	11-Ethoxyviburtinal	*P. rupestris*	[4]
86	Patriscabrol	*P. rupestris*	[4]
87	7-Ketologanin	*P. rupestris*	[4]
88	Narcotic alcohol A	*P. heterophylla*	[34•]
89	1′,3′-Dioxane[6,7]cyclopenta[c]pyran-3(1H)-one,hexahydro-2′,2′,4-trimethyl-(4*R*,4a*S*,6*R*,7*R*,7a*S*)	*P. heterophylla*	[34•]
90	(4*S*,4a*S*,6*S*,7*S*,7a*S*)-6-Hydroxy-7-(hydroxymethyl)-4-methylhexahydrocyclopenta[c]pyran-3(1H)-one	*P. heterophylla*	[34•]
91	Villoside	*P. villosa*	[37]
92	Loganin	*P. villosa/scabiosaefaolia*	[37, 38]
93	Villosol	*P. villosa*	[39]
94	Villosolside	*P. villosa*	[39]
95	IsopatriscabrosideI	*P. scabra/scabiosaefaolia*	[38, 40]
96	Patriscabroside II	*P. scabra*	[40]
97	Isopatriscabroside II	*P. scabra*	[40]

Table 1 (continued)

Number	Compounds	Source	Ref.
98	Patriscabroside III	*P. scabra*	[40]
99	Isopatriscabrol	*P. scabra/scabiosaefaolia*	[38, 40]
100	Patriscabroside I	*P. scabra/scabiosaefaolia*	[38, 40]
101	Patrinoside	*P. scabiosaefaolia*	[41]
102	Scabroside A	*P. scabra*	[42]
103	Scabroside B	*P. scabra*	[42]
104	Scabroside C	*P. scabra*	[42]
105	Scabroside D	*P. scabra*	[43]
106	Scabroside E	*P. scabra*	[43]
107	Scabroside F	*P. scabra*	[43]
108	Scabroside G	*P. scabra*	[43]
109	Scabroside H	*P. scabra*	[43]
110	Scabroside I	*P. scabra*	[43]
111	Scabrol A	*P. scabra*	[43]
112	Jatamanin A	*P. scabra/scabiosaefaolia*	[38, 43]
113	(3*S*,4*S*,5*S*,7*S*,8*S*,9*S*)-3,8-Epoxy-7-hydroxy-4,8-dimethyl-perhydrocyclopenta-[c]pyran	*P. scabra*	[43]
114	(3*S*,4*R*,5*S*,7*S*,8*S*,9*S*)-3,8-Epoxy-7-hydroxy-4,8-dimethyl-perhydrocyclopenta-[c]pyran	*P. scabra*	[43]
115	Patriscadoid I	*P. scabiosaefaolia*	[44]
116	Patriscadoid II	*P. scabiosaefaolia*	[44]
117	Patriridosides D	*P. scabra*	[45]
118	Patriridosides E	*P. scabra*	[45]
119	Patriridosides F	*P. scabra*	[45]
120	Patriridosides G	*P. scabra*	[45]
121	Patriridosides H	*P. scabra*	[45]
122	Patriridosides I	*P. scabra*	[45]
123	1,3-Dimethoxy-4,7-dimethyl-octahyhro-cyclopenta[c]pyran-6,7-diol	*P. scabra*	[46]
124	Isovillosol	*P. scabra*	[46]
125	Scabroside J	*P. scabiosaefolia*	[38]
126	Scabroside K	*P. scabiosaefolia*	[38]
127	Scabroside L	*P. scabiosaefolia*	[38]
128	Vibutinal	*P. scabra*	[47]
129	6-Hydroxy-7-methyl-hexahydro-cyclopenta[c]pyran-3-one	*P. scabra.*	[48]
130	[1*R*,3*S*-(1α,3α)]-1,3,6,7-Tetrahydro-1,3-dimethoxy-4-(meyhoxymethyl)cyclopenta[c]pyran	*P. scabra*	[49]
131	[1*S*,3*R*-(1α,3α)]-1,3,6,7-Tetrahydro −1,3- dimethoxy-4-(methoxymethyl)cyclopenta [c]pyran	*P. scabra*	[49]

Table 1 (continued)

Number	Compounds	Source	Ref.
132	9α-1,7-Dihydro-1-β-*O*-(3-methylbutanoyl)-4-[(3-methylbutanoyl)-*O*-]methyl-6-one-8-α-hydroxymethyl-8-β-hydroxycyclopenta[c]pyran	*P. scabra*	[49]
133	[1*S*,3*R*-(1α,3α)]-1,3,6,7-Tetrahydro-1,3-dimethyl-4-[(3-methylbutanoyl)-*O*-]methyl-7-one-8-hydroxymethylcyclopenta [c]pyran	*P. scabra*	[49]
134	1,3,4,5,6,7-Hexhydro-3,4,7-trihydroxy-4-methyl-8-methenecyclopenta[c]pyran	*P. scabra*	[49]
135	3-Patriscabrol	*P. scabra*	[49]
136	1,3,4,5,6,7-Hexhydro-3,4,7- trihydroxy-4,8- dimethylcyclopenta[c]pyran	*P. scabra*	[49]
137	Rupesin A	*P. rupestris*	[50]
138	Rupesin B	*P. rupestris*	[50]
139	Rupesin C	*P. rupestris*	[50]
140	Rupesin D	*P. rupestris*	[50]
141	Rupesin E	*P. rupestris*	[50]
142	Isovaltratum	*P. rupestris*	[51]
143	1β,3α-Diethyloxy-7-hydromethyl-4-(3-methyl-butyryloxymethyl)-cyclopenta-4(4a),7(7a)-diene[c]pyran-6-one	*P. rupestris*	[52]
144	(1α,4aα,6α,7β,7aα)-[4a,5,6,7,7a-Hexahydro-6,7-dihydroxy-1-(3-methyl-1-oxobutoxy) cyclopenta[c]pyran-4,7-diyl]bis(methylene)3-methyl-butanoic acid ester	*P. rupestris*	[52]
145	Sarracenin	*P. rupestris*	[4]
146	Morroniside	*P. villosa*	[37]
147	7α-Methoxy-morroniside	*P. scabra*	[43]
148	7β-Methoxy-morroniside	*P. scabra*	[43]
149	7α-Morroniside	*P. scabra*	[43]
150	7β-Morroniside	*P. scabra*	[43]
151	Sweroside	*P. scabra*	[43]
152	Jatamanin J	*P. scabiosaefaolia*	[38]
153	Patrinioside	*P. scabra*	[53]
Flavonoids and flavonoid glycosides 154–186			
154	Quercetin	*P. rupestris*	[4]
155	Quercetin-3-*O*-β-*D*-glucopyranoside	*P. rupestris*	[4]
156	Flavovilloside	*P. villosa*	[33]
157	Kaempferol-3-*O*-β-rhamninoside	*P. villosa*	[33]
158	Rhamnocitrin-3-*O*-[α-L-rha(1 → 4)-*O*-α-L-rha(1 → 6)]-β-*D*-galactopyranoside	*P. heterophylla*	[34•]
159	Kaempferol-7-*O*-α-L-rhamninoside	*P. scabra*	[47]
160	Isorhamnetin	*P. scabiosaefaolia*	[54]
161	Rutin	*P. scabiosaefaolia*	[55•]
161	Hyperin	*P. heterophylla*	[56]
162	Isoquercitrin	*P. heterophylla*	[56]

Table 1 (continued)

Number	Compounds	Source	Ref.
163	Kaemperol	*P. scabra*	[57]
164	5,7-Dihydroxyflavone	*P. scabra*	[57]
165	5-Hydroxy-7,3′,4′-trimethoxyflavone	*P. villosa*	[58]
166	5-Hydroxy-7,4′-dimethoxyflavone	*P. villosa.*	[58]
167	Luteolin	*P. villosa*	[58]
168	8-*C*-glc-7-Methoxy-4′5-dihydroxyflavone	*P. villosa.*	[58]
169	Isoorientin	*P. villosa.*	[59]
170	Isovitexin	*P. villosa.*	[59]
172	Kaempferol-3-*O*-*β*-*D*-galactopyranoside	*P. villosa*	[60]
173	Kaempferol-3-*O*-*β*-*D*-galactopyranoside(6 → 1)-*α*-L-rhamninoside	*P. villosa*	[60]
174	3′-Isovaleroyl-apigenin	*P. villosa*	[61]
175	Apigenin	*P. villosa*	[61]
176	(2*S*)-5,7,2′,6′-Tetrahydroxy-6-lavandulylated flavanone	*P. villosa.*	[61]
177	Orotinin	*P. villosa.*	[61]
178	Patriniaflavanone A	*P. villosa*	[62••]
179	Orotinin-5-methyl ether	*P. villosa.*	[63]
180	Bolusanthol B	*P. villosa.*	[64]
181	(2*S*)-5,7,2′,6′-Tetrahydroxy-6,8-di(γ,γ-dimethylallyl) flavanone	*P. villosa*	[64]
182	Tetrapterol I	*P. villosa*	[64]
183	(2*S*)-5,2′,6′-Trihydroxy-2″,2″-dimethylpyrano[5″,6″:6,7]flavanone	*P. villosa*	[65]
184	(2*S*)-5,7,2′,6′-Tetrahydroxy-4′-lavandulylated flavanone	*P. villosa*	[65]
185	(2*S*,3″*S*)-5,2′,6′-Trihydroxy-3″-γ,γ-dimethylallyl-2″,2″-dimethyl-3″,4″-dihydropyrano[5″,6″:6,7] flavanone	*P. villosa*	[65]
186	Licoagrochalcone B	*P. villosa*	[65]
Anthraquinones and anthraquinones glycosides 187–192			
187	1,3,6,8-Tetrahydroxyanthraquinone	*P. scabra*	[47]
188	Lunatin	*P. scabra*	[47]
189	1,3,6-Trihydroxy-2-methylanthraquinone	*P. scabra*	[47]
190	Xanthopurpurin	*P. scabra*	[47]
191	1,3,6-Trihydroxy-2-methylanthraquinone-3-*O*-(6′-*O*-acetyl)-neohesperidin	*P. scabra*	[47]
192	1,3,6-trihydroxy-2-methylanthraquinone-3-*O*-neohesperidin	*P. scabra*	[47]
Phenylpropanoids			
Coumarins 193–197			
193	Esculetin	*P. scabiosaefaolia*	[11]
194	Scopoletin	*P. scabiosaefaolia*	[11]

Table 1 (continued)

Number	Compounds	Source	Ref.
195	Scabiosaclactone[6-methoxy-7(1′-henicosacyloxy-3′-hydroxy-2′-propoxy)coumarin]	*P. scabiosaefaolia*	[36••]
196	7-Hydroxy-3-methyl-3,4-dihydrocoumarin	*P. intermedia*	[66]
197	7-Hydroxy-3-methyl-3,4-dihydrocoumarin	*P. intermedia*	[66]
Lignans 198–219			
198	Styraxlignolide D	*P. scabra*	[43]
199	Styraxlignolide E	*P. scabra*	[43]
200	Matairesinol	*P. scabra*	[43]
201	(−)Pinoresinol	*P. scabra*	[43]
202	(−)-Pinnoresinol-4-*O*-*β*-*D*- glucopuranoside	*P. scabra*	[43]
203	(+)-Nortrachelogenin	*P. scabra*	[47]
204	(7*S*,8*R*)-3′4,9′-trihydroxy-4-methoxy-9-*O*-shikkyl-acyl-7,8-dihydrobenzofuran-1′-propyl lignan	*P. scabiosaefaolia*	[55•]
205	Lariciresinol	*P. scabiosaefaolia*	[55•]
206	4-[1-Ethoxyl-1-(4-hydroxy-3-methoxy)benzyl]methyl-2-(4- hydroxy-3- methoxy) benzyl-3-hydroxymethyl-tetrahydro-furan	*P. scabra*	[67]
207	Nortracheloside	*P. scabra*	[67]
208	Lariciresinol-4′-*O*-*β*-*D*-glucopyranoside	*P. scabra*	[68]
209	Lariciresinol-4-*O*-*β*-*D*- glucopyranoside	*P. scabra*	[68]
210	Matairesinol-4,4′-di-*O*-*β*-*D*-glucopyranoside	*P. scabra*	[68]
211	Pinoresinol-4,4′-di-*O*-*β*-*D*-glucopyranoside	*P. scabra*	[68]
212	Syringaresinol	*P. scabra*	[69]
213	Syringaresinol mono-*β*-*D*-glc	*P. villosa*	[70•]
214	Isolariciresinol 4-*O*-*β*-*D*-glc	*P. villosa*	[70•]
215	(7′*S*,8*R*,8′*R*)-isolariciresinol	*P. villosa*	[70•]
216	(7′*S*,8*R*,8′*S*)-isolariciresinol	*P. villosa*	[70•]
217	(7′*R*,8*S*,8′*S*)-isolariciresinol	*P. villosa*	[70•]
218	5-Methoxyisolariciresinol	*P. villosa*	[70•]
219	Lyoniresinol	*P. villosa*	[70•]
Phenylpropionic acid 220–224			
220	Ethyl caffeate	*P. rupestris*	[4]
221	Hexacosanyl caffeate	*P. rupestris*	[4]
222	Caffeic acid	*P. scabiosaefaolia*	[5]
223	5-*O*-Feruloylquinic acid	*P. scabra*	[46]
224	Ferulic acid	*P. scabiosaefaolia*	[55•]
Sterols 225–232			
225	Ergost-6,22-diene-3*β*,5*α*,8*α*-triol	*P. scabiosaefaolia*	[4]

Table 1 (continued)

Number	Compounds	Source	Ref.
226	Daucosterol	*P. scabiosaefaolia*	[6]
227	Campesterol-*D*-glucoside	*P. scabiosaefaolia*	[7]
228	*β*-sitosterol	*P. scabiosaefaolia*	[26]
229	Stigmasterol	*P. scabiosaefaolia*	[28]
230	*β*-Ergosterol	*P. rupestris*	[51]
231	6*β*-Hydroxenone	*P. rupestris*	[51]
232	7*β*-Hydroxy-*β*-sitosterol	*P. villosa*	[71]

identified 9 compounds [74]. He et al. studied the essential oils from the roots and rhizomes of *P. scabra* by capillary GC and GC-MS-computer system and identified 26 compounds, of which the main compounds are *β*-caryophyllene and *α*-humulene [75].

Other Compounds

Li et al. [26] isolated protocatechuic acid and Di [43] isolated 2,3-dihydroxypropyl-9*Z*,12*Z*-octadecadienote from *P. scabra.*

PHB-P_1 and PHB-P_2 are two different polysaccharide compounds in *P. heterophylla*, and these species also contained ketose, uronic acids and others. The content of uronic acids is in the range of 18–21% [76].

Biological Activities

Sedative and Analgesic Activities

Studies have shown that the essential oils distilled from *P. scabra* have sedative effect and suggested that patrinene and isopatrinene might be the representative active sedative and hypnotic components in *Patrinia* species, which can directly act on the central nervous system to perform an analgesic effect. However, the effects vary in different species.

The ethanol extracts of *P. scabiosaefaolia* have effective sedative effect on mice, with longer sedative time, but no hypnotic effect. The essential oils of *P. scabiosaefaolia* also have sedative effect, but duration is shorter [56]. All 20% tincture, tablets of 60% ethanol extract and essential oil sealed capsules of *P. scabiosaefaolia* have a certain therapeutic effect on the treatment of neurasthenia and neurasthenia syndrome with insomnia as the main symptom, and the latter has a significant improvement over the former two. In addition, pharmacological studies also showed that the essential oil sealed capsule had little or no toxicity [77]. Xiao et al. observed the extracts of *P. scabiosaefaolia* by *n*-butanol, ethyl acetate, and petroleum ether had a synergistic central nervous inhibitory effect with pentobarbital sodium, and the sedative effect of the *n*-butanol extract was the strongest [78].

The essential oils distilled from *P. scabra* can significantly prolong the sleeping time of mice caused by intraperitoneal injection of pentobarbital sodium, with no detectable cytotoxicity, which is similar to the essential oils from *P. heterophylla*, but the intensity of action is weaker than that of *P. scabiosaefaolia* [79]. In addition, the essential oil distilled from *P. scabra* has the activities of inhibiting the spontaneous activity of mice

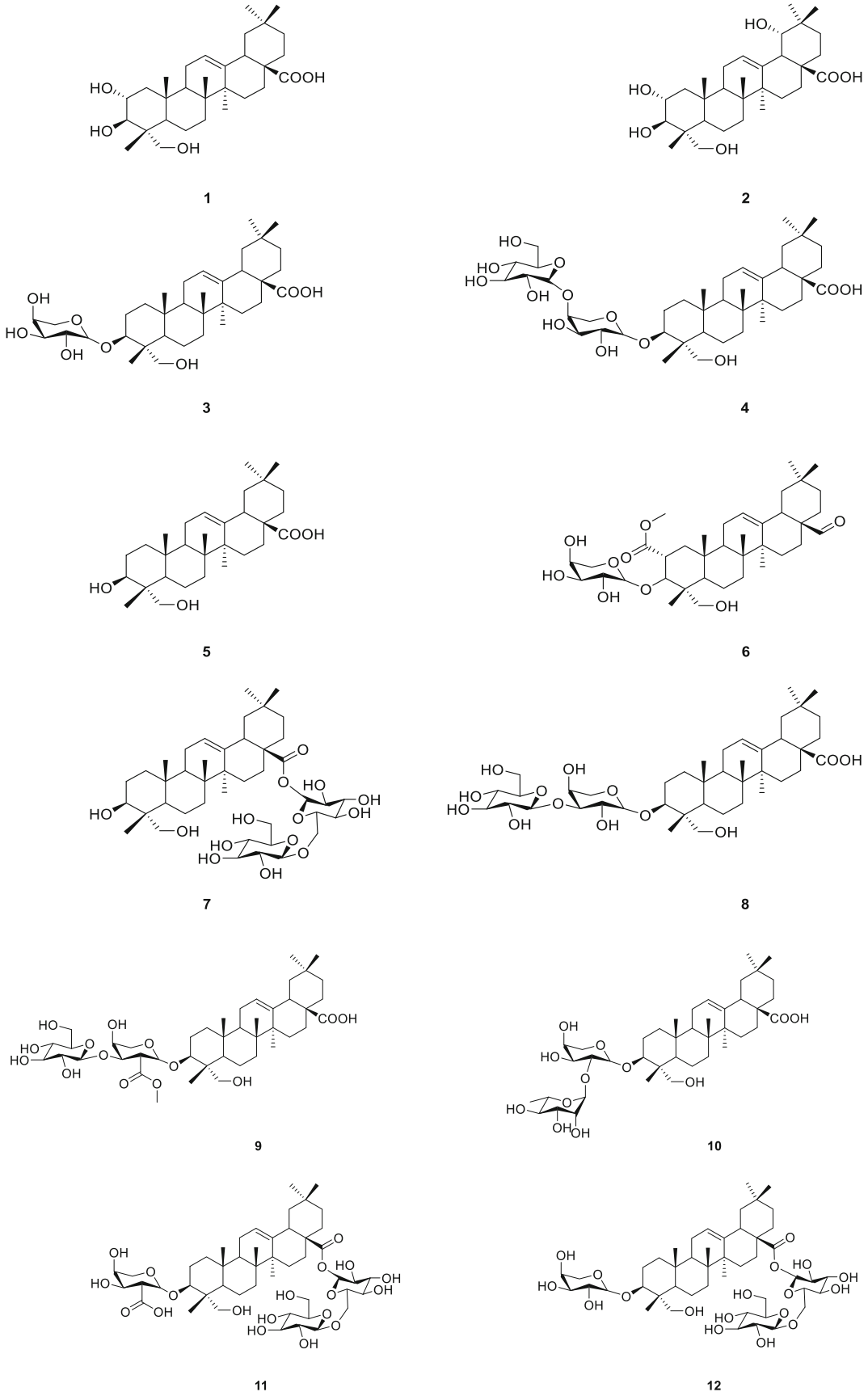
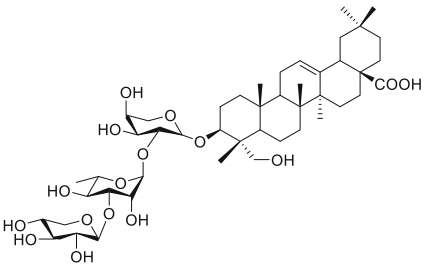


Fig. 1 Hederagenin-type triterpenoids isolated from genus *Patrinia*



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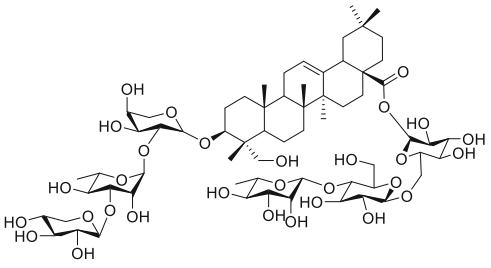

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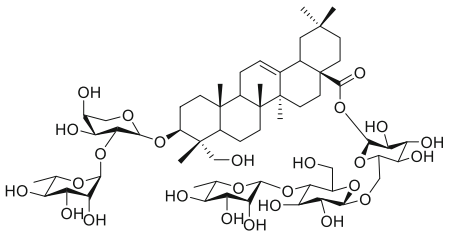

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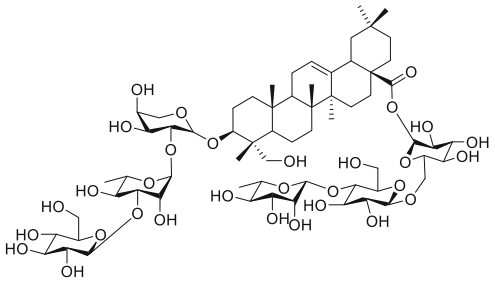

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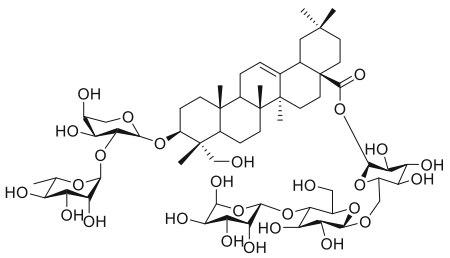

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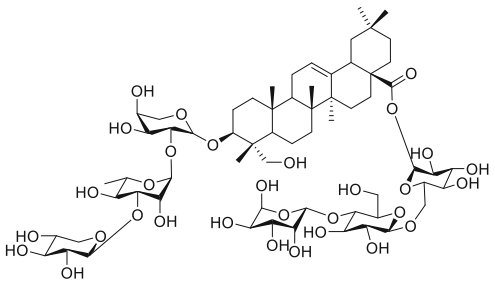

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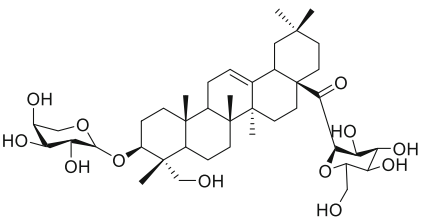

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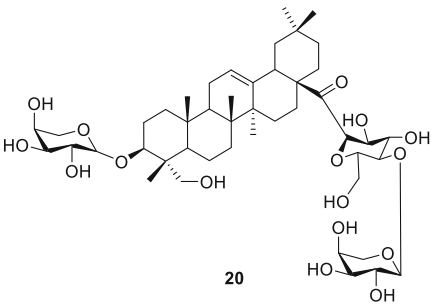

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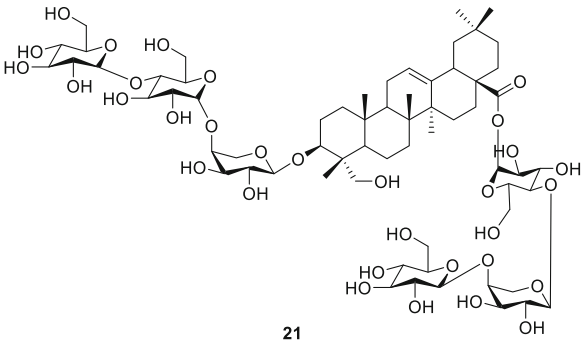

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Fig. 1 (continued)

induced by pentobarbital sodium and activating the P-450 [80].

The water extract of *P. villosa* also has obvious central nervous inhibitory effect and the essential oils had a synergistic central nervous inhibitory effect with pentobarbital sodium [81].

Antibacterial and Antiviral Activities

Cai et al. reported that the extracts of *P. scabiosaefolia* oral liquid, granules and *P. villosa* granules had significant antibacterial properties against *Staphylococcus aureus*, while they had different degrees of inhibitory effects on *Staphylococcus albus*, *typhoid bacillus*, *Streptococcus B*, *pneumococcus*, *Escherichia coli*, *dysentery bacillus*, and *Pseudomonas aeruginosa* [82]. The essential oils distilled from *P. scabiosaefolia* have a strong inhibitory effect on *Staphylococcus aureus* and *Streptococcus*, but they have weak bacteriostatic effect against *Pasteurella* and *Salmonella*, while the ethanol extract has weak bacteriostatic effect on all the above bacteria [83].

By improving microcirculation and cellular immune function, some species like *P. villosa* can promote the absorption of local blood stasis, treat chronic pelvic inflammation, and achieve the functions of antibacterial and anti-inflammatory [84]. The aqueous extract of *P. scabiosaefolia* was effective for the acute pancreatitis induced by cholecystokinin octa peptide in rats [85]. The total saponins from *P. villosa* could inhibit the swelling ears of mouse induced by xylene and the increase of peritoneal capillary permeability induced by acetic acid in mice to varying degrees, which indicated that saponins were the effective anti-inflammatory components of *P. villosa* [86].

The compound derived from *Patrinia* herbs has obvious therapeutic effect on chronic pelvic inflammatory disease in rats caused by mixed bacterial solution, and its mechanism may be to restore immune function to the normal range [87].

There are two polysaccharides, AP_3 and AP_4 isolated from *Patrinia* herbs, which was proved to possess significant antivirus activity. AP_3 showed significant dose-dependent antiviral effects against respiratory syncytial virus (RSV) in Hela cell culture, and its median cytotoxic concentration (TC_{50}), median effective dose (EC_{50}), and therapeutic index (T_I) were 11.45 mg/mL, 0.0986 mg/mL, and 116.12, respectively [88]. AP_4 could significantly inhibit the proliferation of RSV in vitro and TC_{50}, EC_{50}, and T_I were 10.89 mg/mL, 0.0801 mg/mL, and 135.95, respectively. It also has a significant inhibitory effect on influenza virus in chicken embryos [89]. Triterpenoid compound (Sulfa patrinosides) isolated from the seeds of *P. villosa*has demonstrated the effect of inhibiting HIV [90]. In addition, the methanol extracts of *P. villosa* showed marked antiviral activity against influenza virus A/Puerto Rico/8/34 (H1N1) by a viral replication inhibition test [91].

Antitumor Activity

The ethanol extract of *P. heterophylla* could inhibit the proliferation of PC-3 cells in a concentration- and time-dependent manner. Moreover, further study also demonstrated that i.p. administration of 20, 40, and 60 mg/kg ethanol extracts exhibited a significant inhibitory effect on the growth of transplantation tumor, with inhibition rate of 23.9%, 48.4%, and 53.6% on S_{180} cells and 21.0%, 46.3%, and 57.2% on H_{22} cells, respectively [92]. Xu et al. screened the antitumor parts of *P. heterophylla* and found that the chloroform extract had the strongest antitumor activity [93], and *P. heterophylla* glucosides tablets had a strong inhibitory effect on Ehrlich Ascites carcinoma and S_{180} sarcoma. Later, he further found that the tablets also had a good inhibitory effect on human colorectal cancer cells [94]. In vitro, PHB-P_1 can inhibit the proliferation of HeLa cells and reduce the activity of gelatinase and telomerase, thereby inducing apoptosis of HeLa cells. In addition, PHB-P_1 can also induce the apoptosis of tumor cells in U14 tumor-bearing mice and block tumor cells in G0/G1 phase [76]. The iridoid aglycones PS-1 and villosol of *P. scabra* can significantly inhibit the growth of C_{26} cell line in a dose-dependent manner, and PS-1 can also inhibit the growth of DU-145 and PC-3 cells [95, 96]. By comparing the difference among *P. scabra* extracts on growth-inhibiting effects of tumor cell in vitro, Chen et al. found that the total lignans and total saponins of *P. scabra* inhibited the tumor cells SPCA-1, HepG2 and K562 in vitro, among which the *P. scabra* lignanoid inhibited the growth of K562 cells most significantly through promoting the apoptosis of K562 cells. The *P. scabra* lignanoid has obvious inhibitory effect on the growth of human chronic myeloid leukemia cells [97, 98]. Some other studies found that the iridoid aglycones of *P. scabra* can significantly improve the thymus index and spleen index of mice, promote the proliferation of spleen lymphocytes induced by Con-A, improve the level of serum hemolysin in mice, increase the activity of NK cells, and enhance the phagocytic activity of peritoneal macrophages. It was

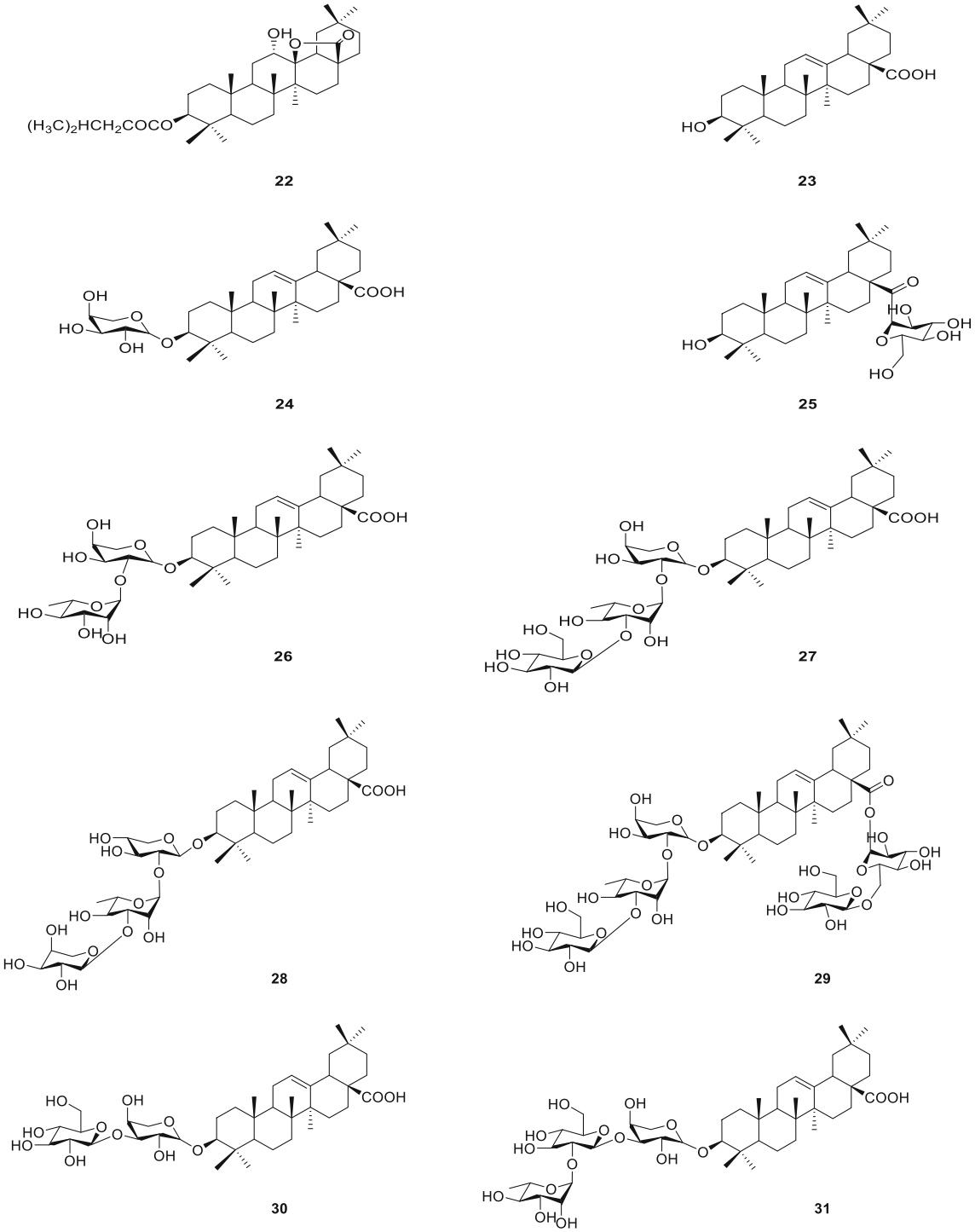
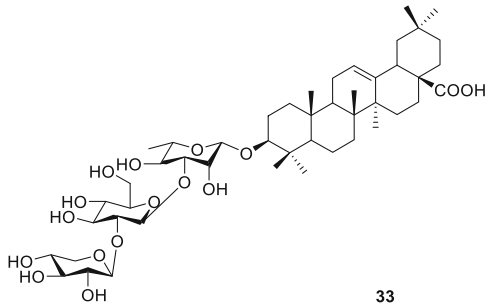


Fig. 2 Oleanane-type triterpenoids isolated from genus *Patrinia*

found that iridoid aglycones could significantly improve the immune function of mice, which might be the potential mechanisms of *P. scabra* in inhibiting tumor growth [99].

The water extract of *P. villosa* inhibited the growth and proliferation of U14 cervical cancer cells, reduced the serum MDA level of U14 tumor-bearing mice, and increased the activity of T-AOC and SOD [100]. The saponin extracted from *P. villosa* (SPVJ) (50 mg/kg and 100 mg/kg) effectively reduced the weight of U14 cervical tumor (35.1% and 57.1%, respectively). Compared with the control group, SPVJ (100 mg/kg) significantly



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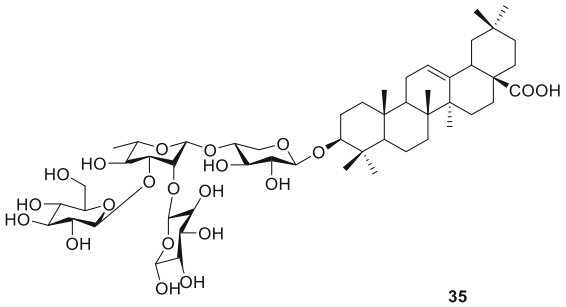

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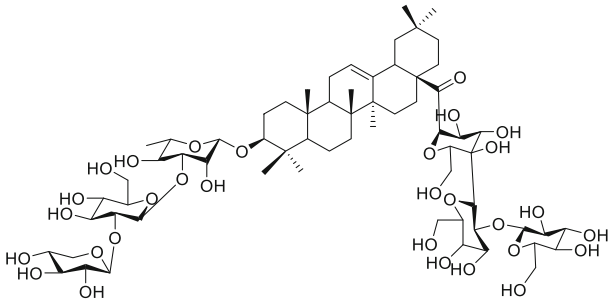

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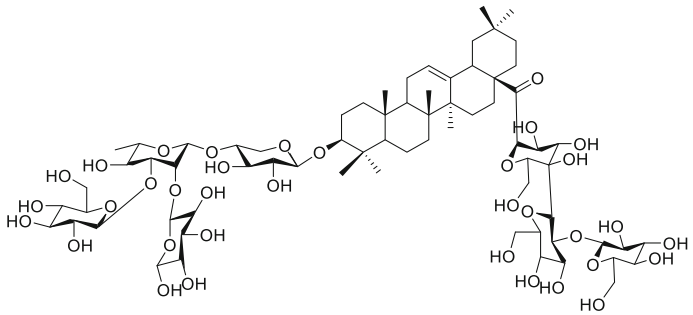

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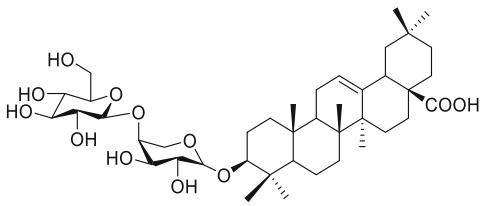

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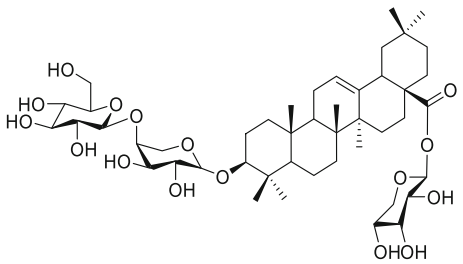

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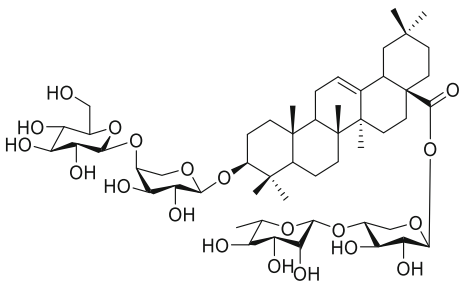

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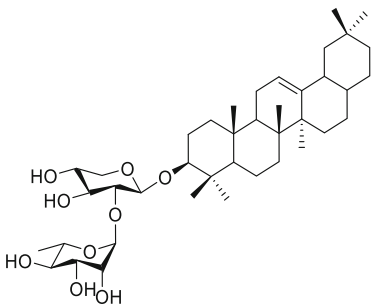

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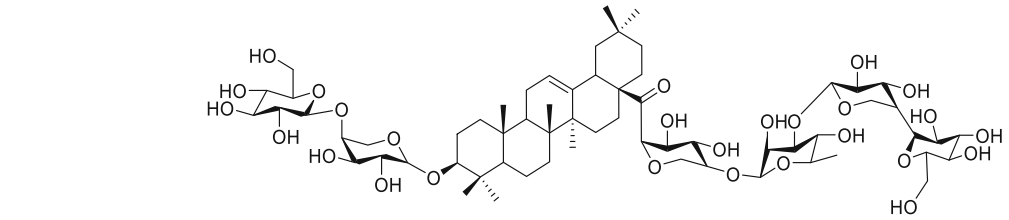

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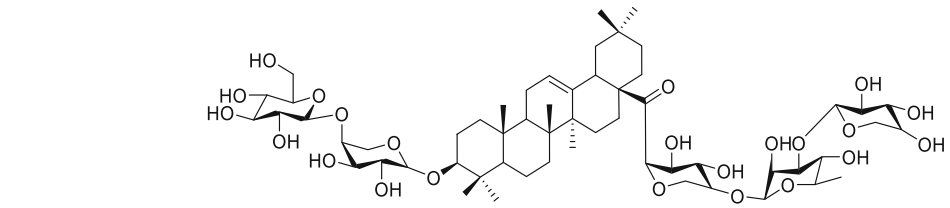

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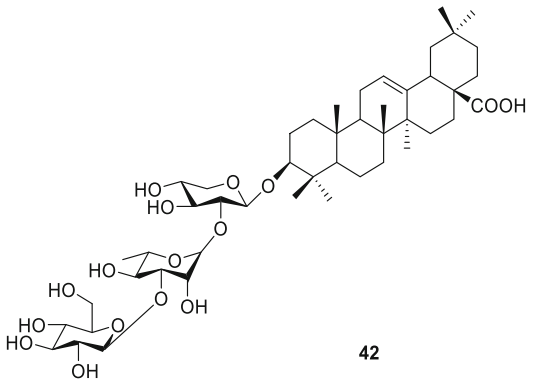

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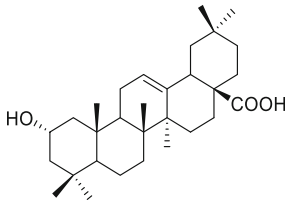

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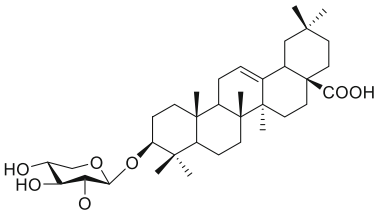

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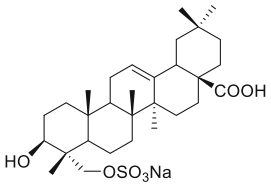

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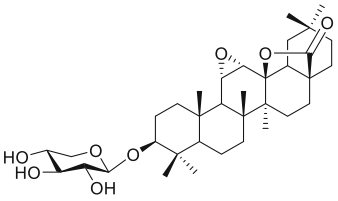

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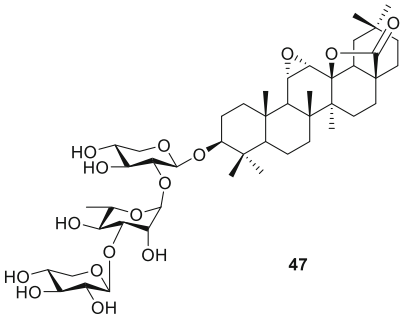

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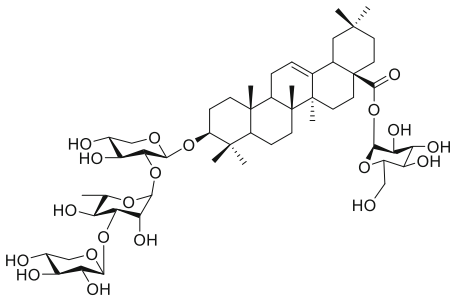
Fig. 2 (continued)



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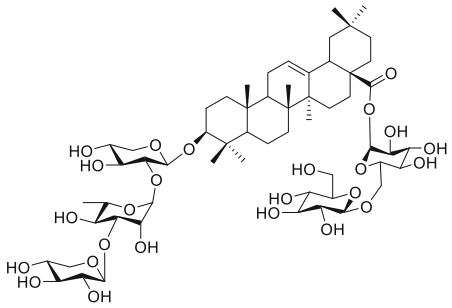

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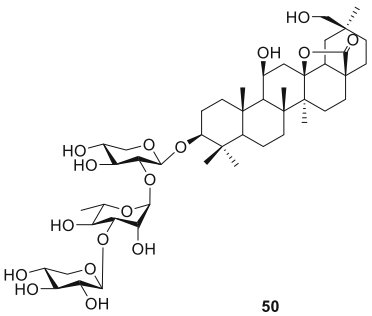

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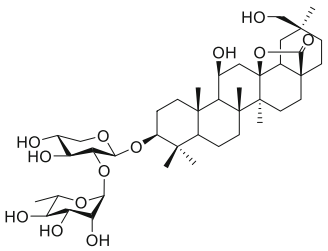

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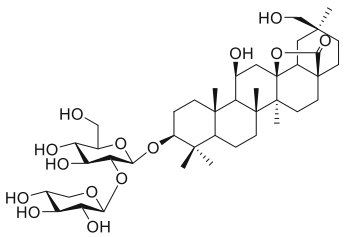

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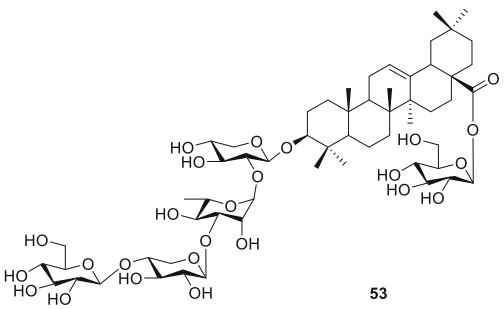

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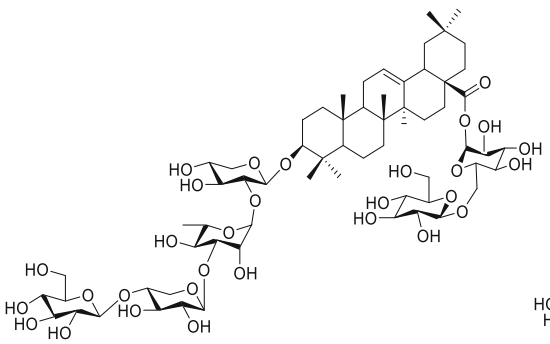

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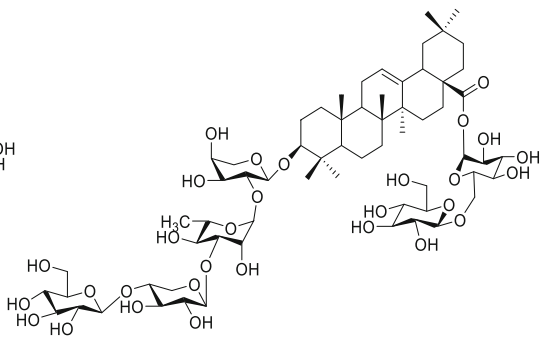

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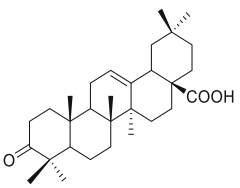

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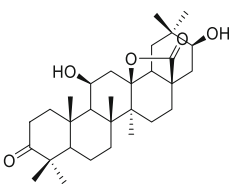

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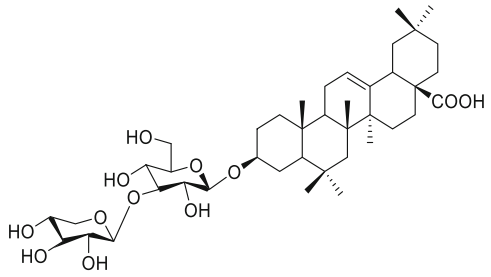
Fig. 2 (continued)



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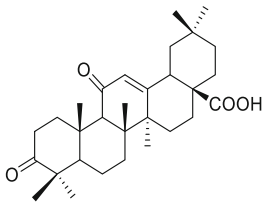

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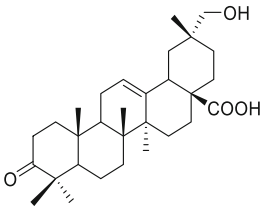

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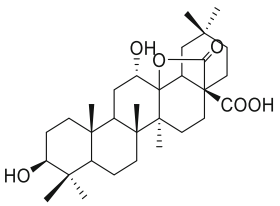

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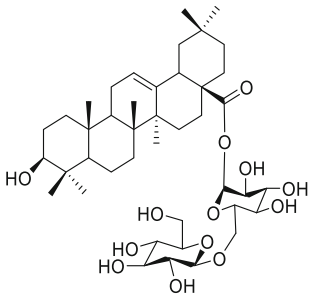

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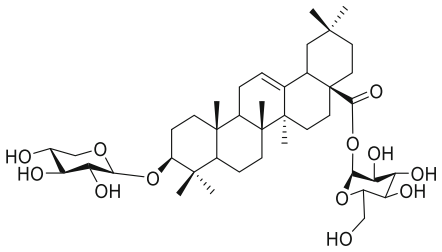

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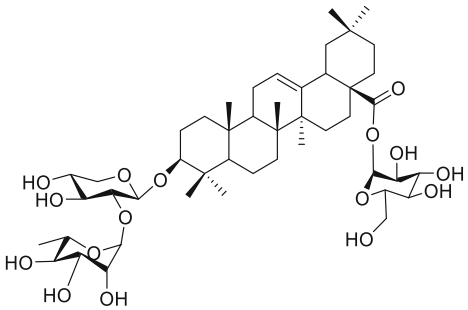

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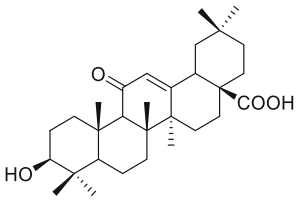

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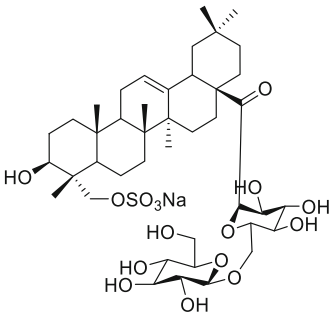

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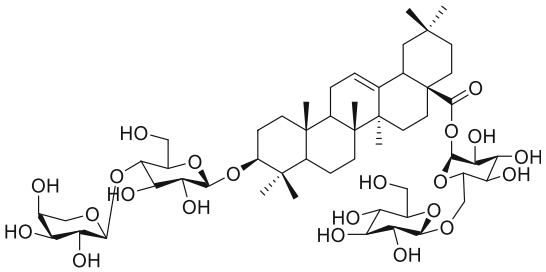

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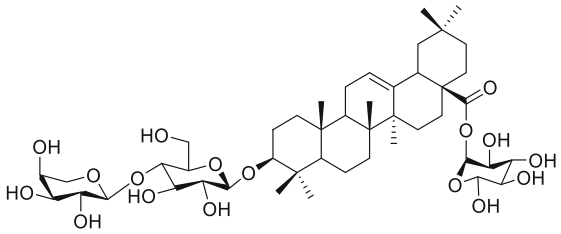
Fig. 2 continued.



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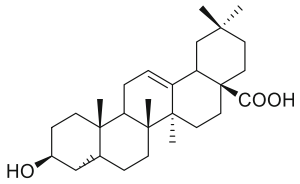

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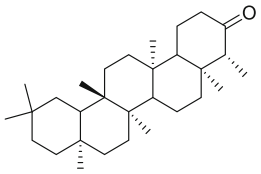

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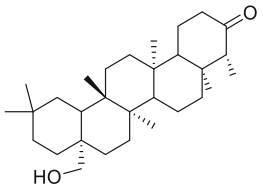


71

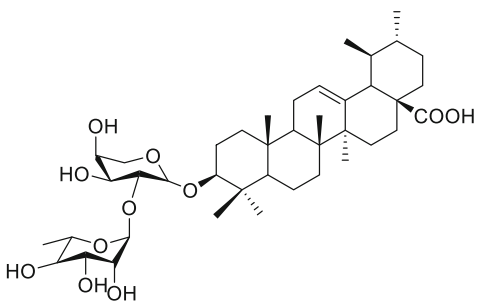
Fig. 2 continued.

increased the number of tumor cells and cells in apoptosis in the G0/G1 phase, decreased the number of cells in S phase and G2/M, inhibited the proliferating cell nuclear antigen (PCNA) of the tumor cell and downregulated the expression of mutant p53 and Bcl-2 protein [89].

The extracts from the roots of *P. scabiosaefolia* had an inhibitory effect on S_{180} [101]. It was observed by MTT assay that the saponins from *P. scabiosaefolia* could prolong the survival of mice with Ehrlich ascites carcinoma, which showed the antitumor effect in vivo of the saponins from *P. scabiosaefolia*. But the effect intensity is relatively weak [102]. The ethanol extract of *P. scabiosaefolia* (EEPS) could inhibit colorectal cancer (CRC) growth both in vivo and in vitro, without apparent adverse side effects. Besides, EEPS could inhibit the expression of anti-apoptotic Bcl-2, enhance pro-apoptotic Bax expression and induce the loss of mitochondrial membrane potential and activation of caspases-9 and -3 in HT-29 cells [103]. Liu et al. also found EEPS could inhibit the phosphorylation of STAT3 in U266 cells and the expression of cyclin D1 and Bcl-2 [104]. In addition, EEPS treatment not only significantly blocked G1 to S phase cell cycle progression, but also decreased the expression of pro-proliferative CyclinD1 and CDK4, at both the mRNA and protein levels [105•].

Hepatoprotective Activity

Patrinia herbs promoted the regeneration of liver cells and inhibits cell degeneration [106]. For example, the extract from



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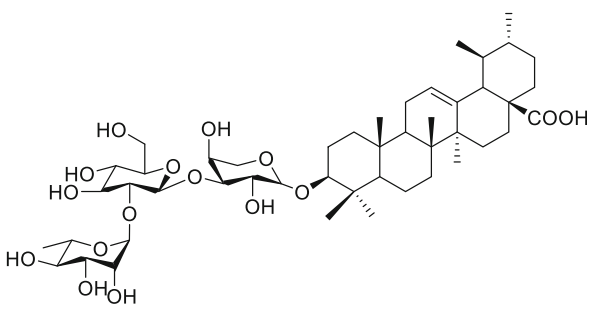

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Fig. 3 Ursane-type triterpenoids isolated from genus *Patrinia*

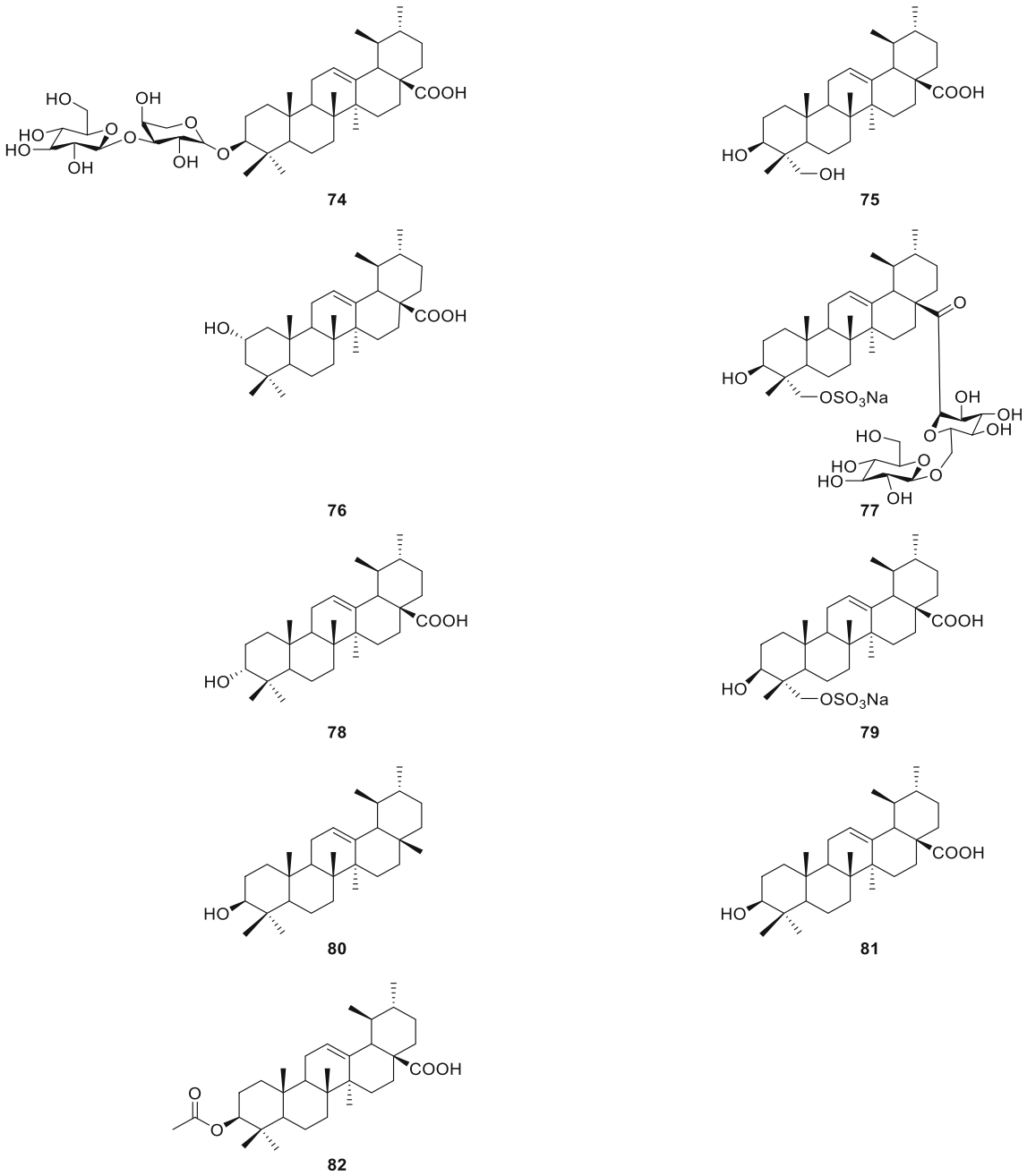
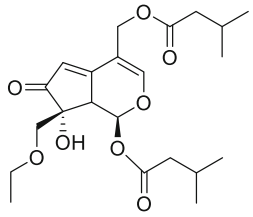


Fig. 3 continued.

P. villosa inhibited liver lipid peroxidation in rats in vitro with a dose–effect relationship [107], and the fruit branch extract of *P. villosa* possessed marked hepatoprotective activity [106]. The oleanolic acid from *Patrinia* plants is a common component of anti-hepatitis activity, which has a significant protective effect on liver injury and reduction of serum alanine amino transferase and triglyceride accumulation in the liver [108].

Effect on the Immune System

The anti-tumor mechanism of the genus *Patrinia* is not only related to the direct cytotoxic effect, but also to the regulation of the immune system. *Bai Jiang Cao* has an anti-endotoxin effect, through a direct destruction of endotoxin, rather than a temporary inhibition of endotoxin activity. Many evidence



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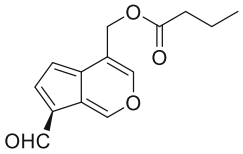

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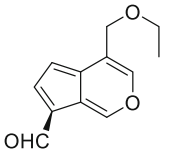

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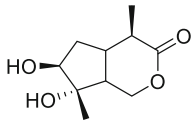

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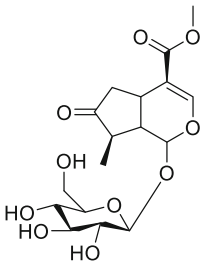

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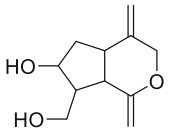

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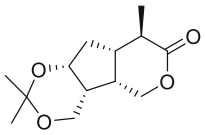

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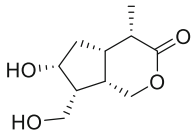

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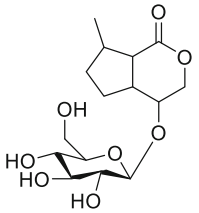

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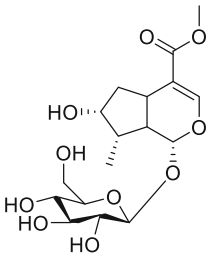

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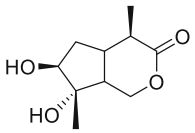

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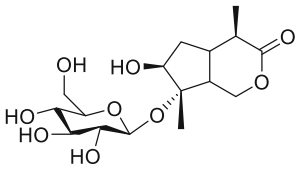

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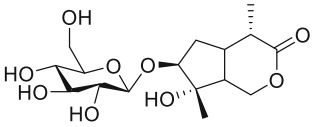

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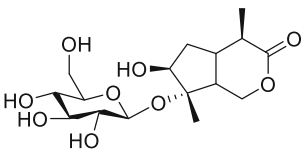

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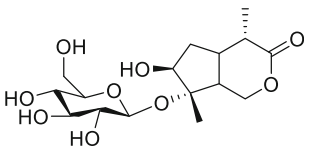

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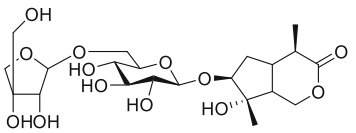
Fig. 4 Iridoids isolated from genus *Patrinia*



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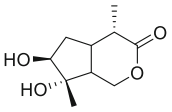

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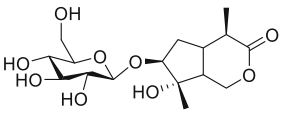

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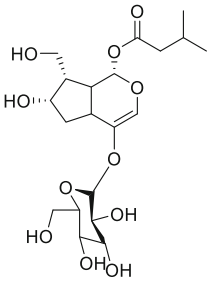

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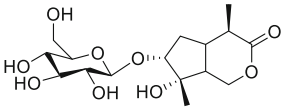

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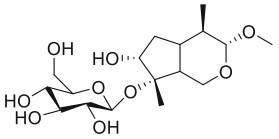

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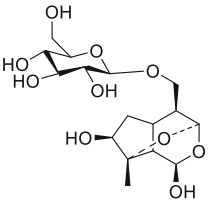

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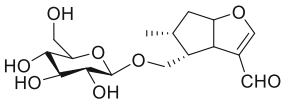

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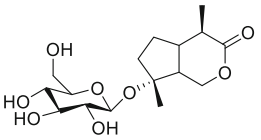

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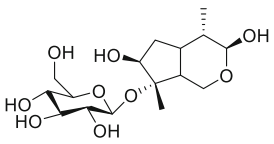

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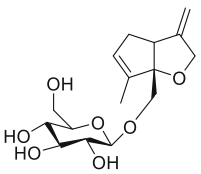

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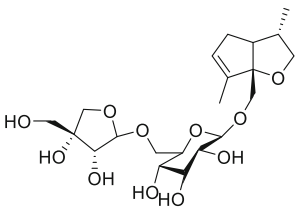

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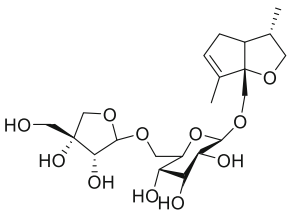

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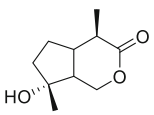

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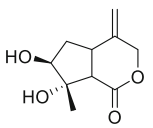

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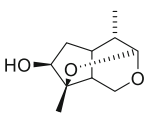

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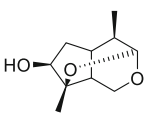

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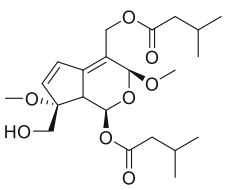

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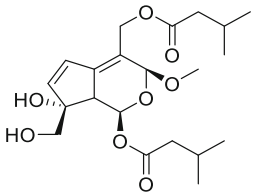

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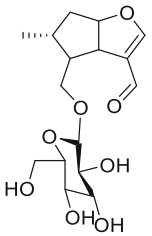

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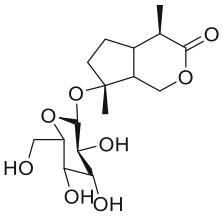

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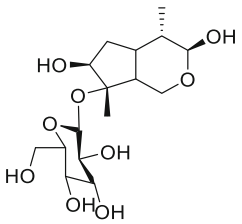

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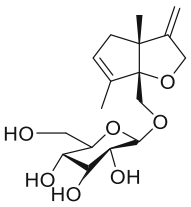

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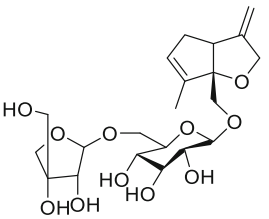

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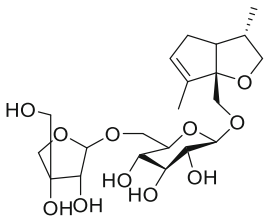

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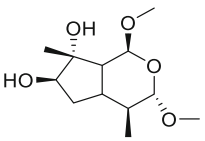

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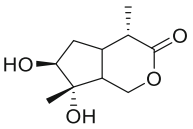

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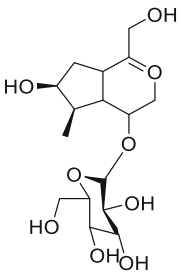

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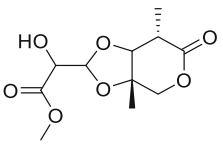

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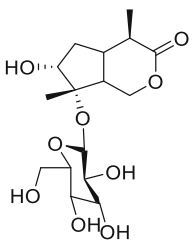

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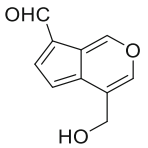

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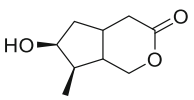

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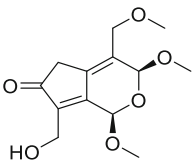

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Fig. 4 continued.

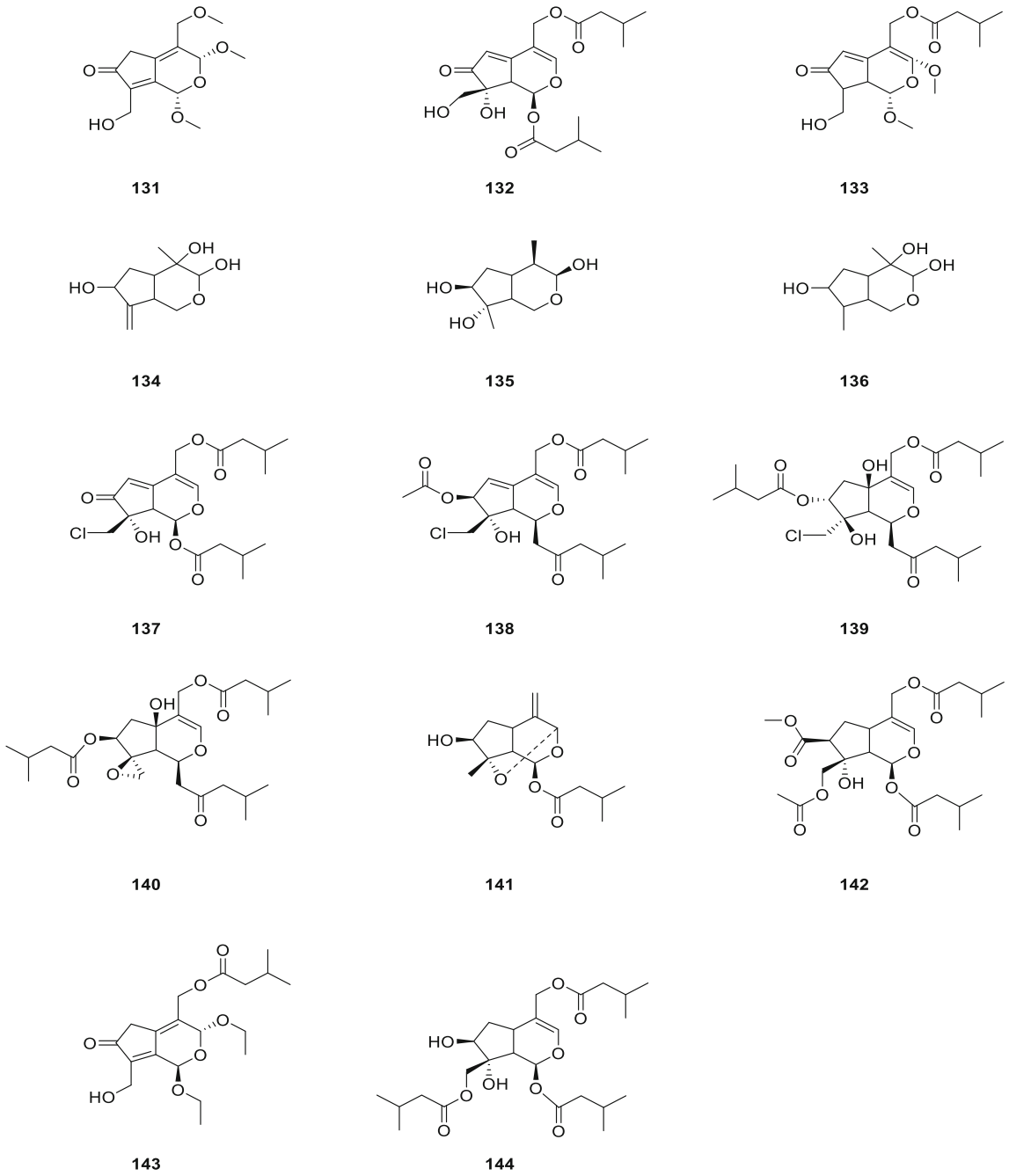


Fig. 4 continued.

showed that *Bai Jiang Cao* could markedly inhibit the secretory granulocyte of Kupffer's cells induced by lipopolysaccharide (LPS), i.e., the colony-stimulating factor of the macrophage (CM-CSF) increased the content of prostaglandin E_2 secreted by Kupffer's cells [109, 110]. The ethanol extract of *P. scabra* could increase the phagocytosis activity and cytotoxic effect of macrophages as well as the percentage of lymphocyte ANAE positive lymphocytes and EA rosette formation in mice, and inhibit the growth of S_{180} in mice, which might be related to the enhancement of nonspecific immune function [111]. Wang et al. demonstrated that the water extracts from *P. scabra* could prolong the life expectancy of

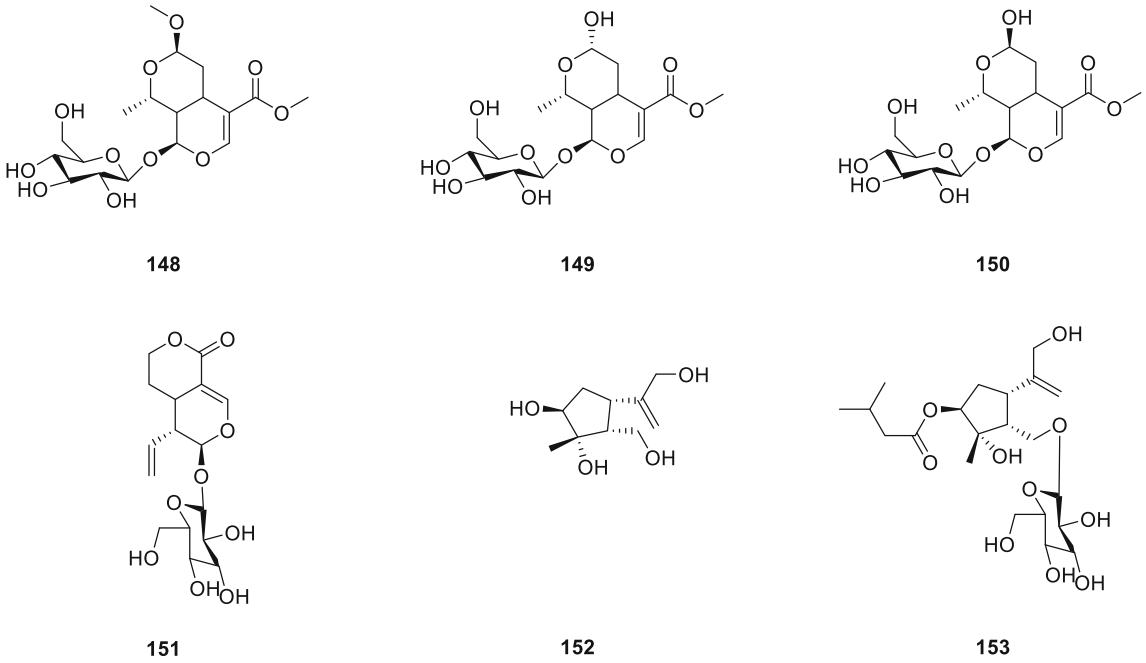


Fig. 4 continued.

mice, improve erythrocyte immunologic function and increase the CD35 and CD44s contents of the red blood cell [112]. Wang et al. reported that the *P. scabra* extracts separated by macroporous adsorptive resins at dosages ranging from 0.5 to 2.0 g/kg improved the spleen and thymus indexes of S_{180} tumor-bearing mice, strengthened the transformation functions of spleen T and B lymphocytes and prompted the killing abilities of NK and LAK cells. Moreover, the antibodies producing ability of the B cells in vivo were strengthened, and the amount ratio of $CD4^+$ cells to $CD8^+$ cells was increased [113].

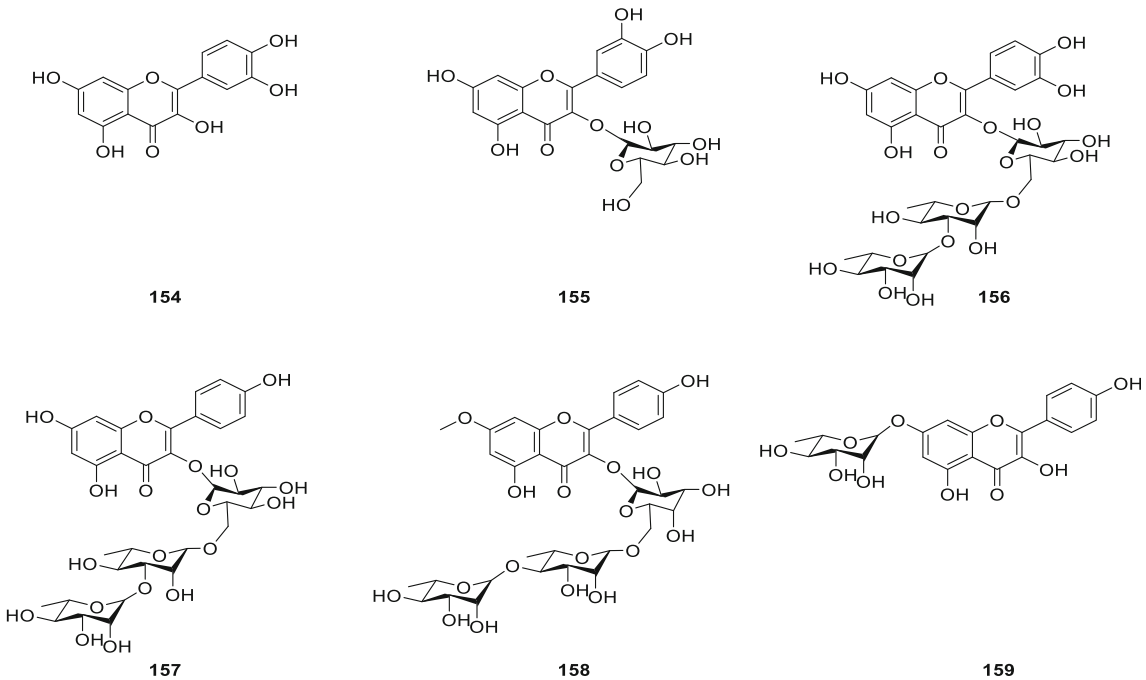
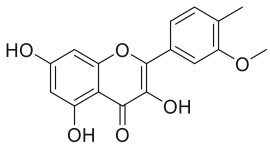


Fig. 5 Flavonoids isolated from genus *Patrinia*



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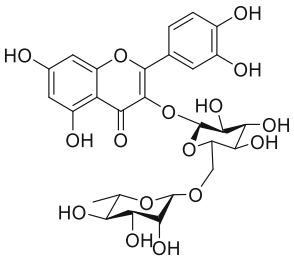

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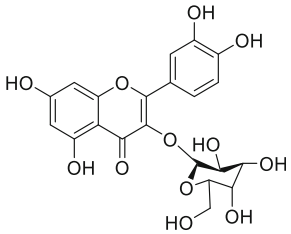

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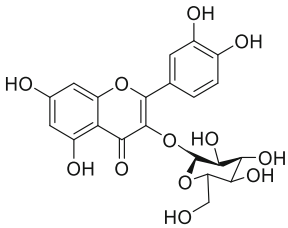

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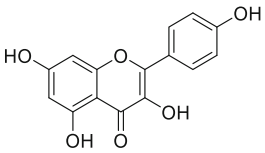

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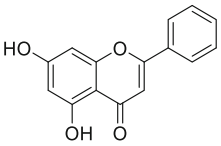

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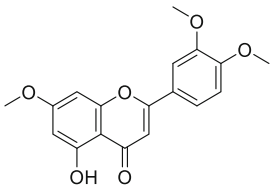

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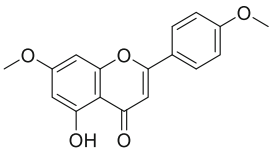

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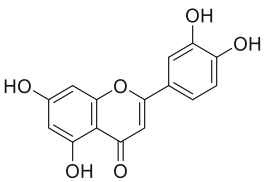

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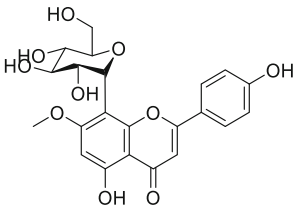

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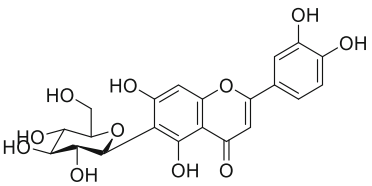

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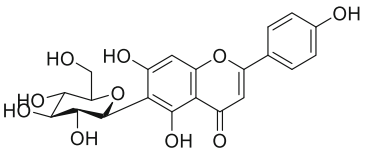

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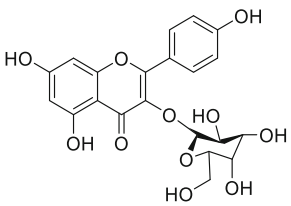

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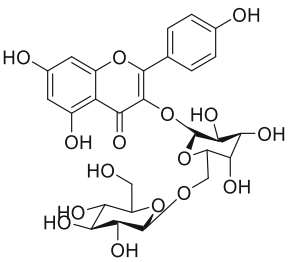

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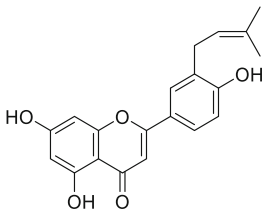

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Fig. 5 continued.

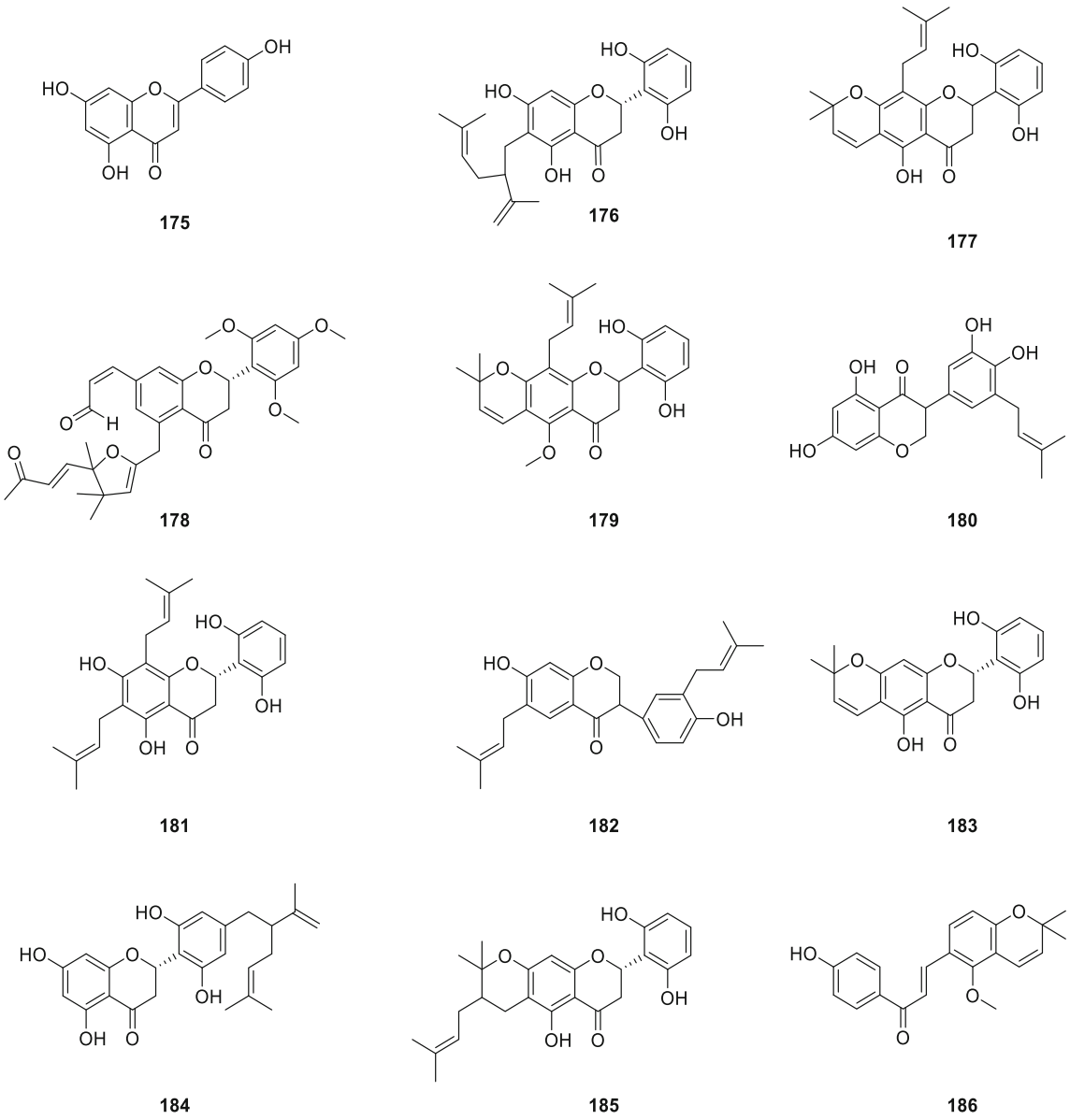

Fig. 5 continued.

Effect on the Blood System

Sun et al. reported that *P. heterophylla* demonstrated a significant inhibitory effect on acute leukemia cells [114]. The reason might be related to the hederagenin from *P. heterophylla*, which could inhibit the proliferation of HL-60 cells at low concentrations (10 ~ 40 μmol/L) and cause cell death at high concentrations (40 ~ 50 μmol/L). The main mechanism to achieve the above effects was the G_1 phase inhibition and apoptosis induction of HL-60 cells caused by hederagenin [115].

Zhang et al. conducted subacute experiments in dogs with *P. scabra*. Results showed that *P. scabra* could increase the number of white blood cells, temporarily decrease the number of platelets, and produce granular lesions in liver cells [116]. Another research found that the ethanol extract of *P. scabra* (i.p.) showed the hemostasis effect in blood vessels of rabbits, which might be related to the significant promotion on the aggregation of circulating platelets [117].

The extracts of *P. heterophylla* at the doses of 750 mg/kg and 375 mg/kg could reduce the blood viscosity of U14

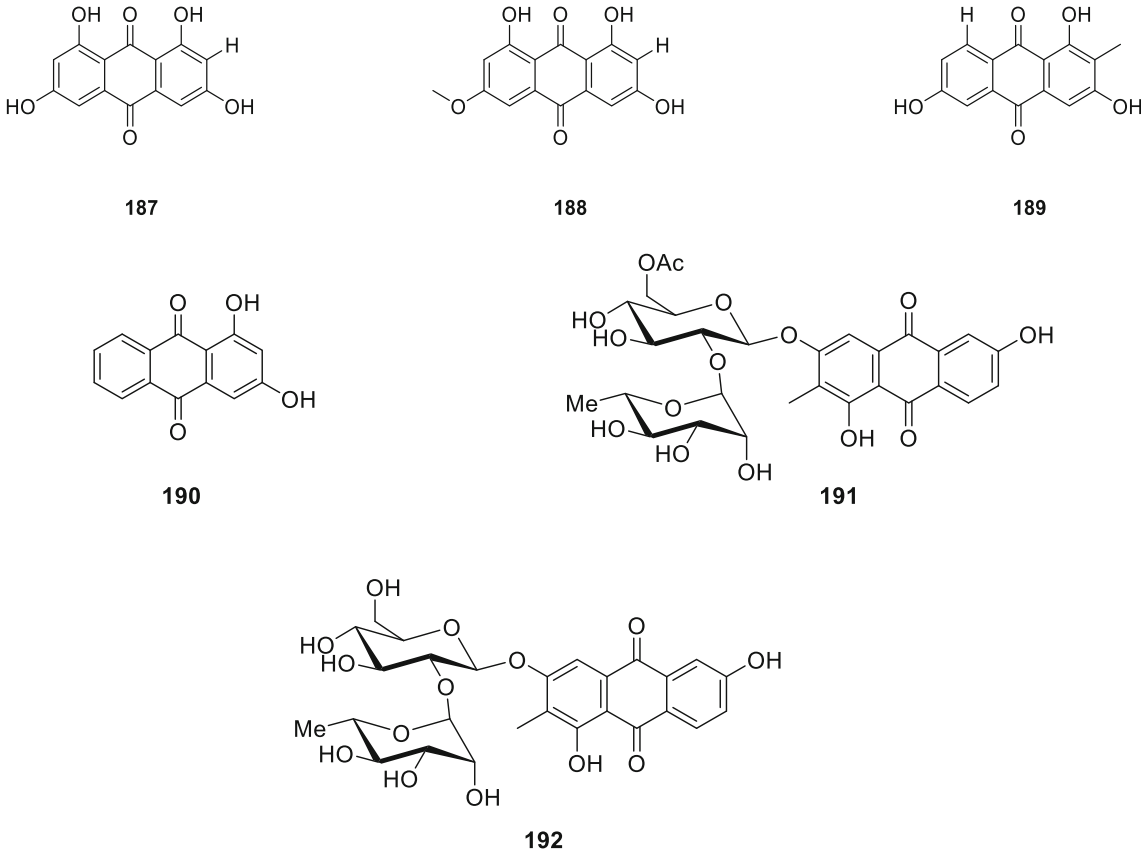

Fig. 6 Anthraquinones isolated from genus *Patrinia*

cervical cancer mouse in different shear rates and improve the indexes of hemorheology [118]. Using cell culture technology, it was found that the water extract of *P. heterophylla* has a "two-way" regulatory effect, which means it was not only a strong anticancer drug, but also an accelerator of hematopoietic progenitor cells. When the dose is high, it will demonstrate the effect of killing tumor cells, whereas it will induce the formation of stromal cells and promote hematopoiesis by secreting the hematopoietic-stimulating factor at a low dose [119].

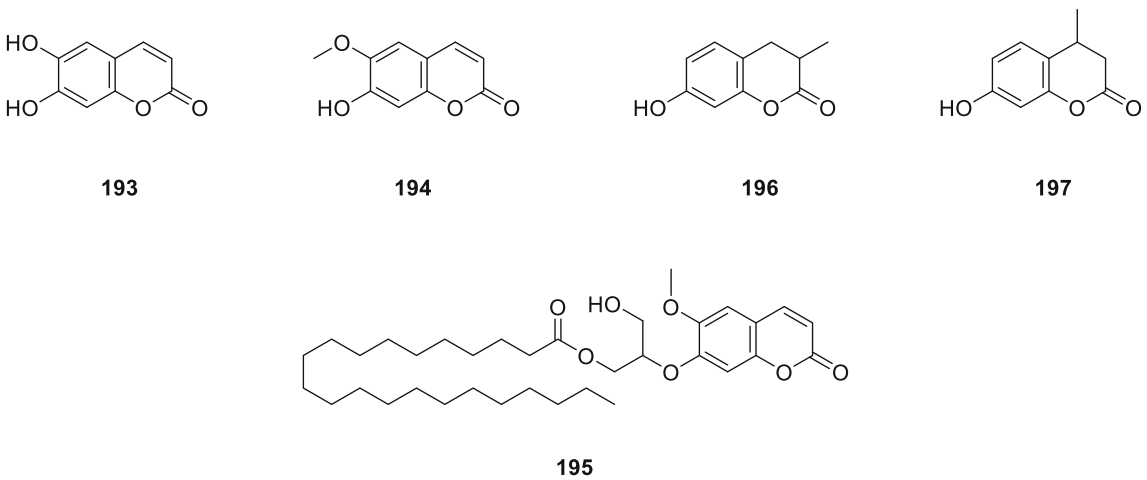

Fig. 7 Coumarins isolated from genus *Patrinia*

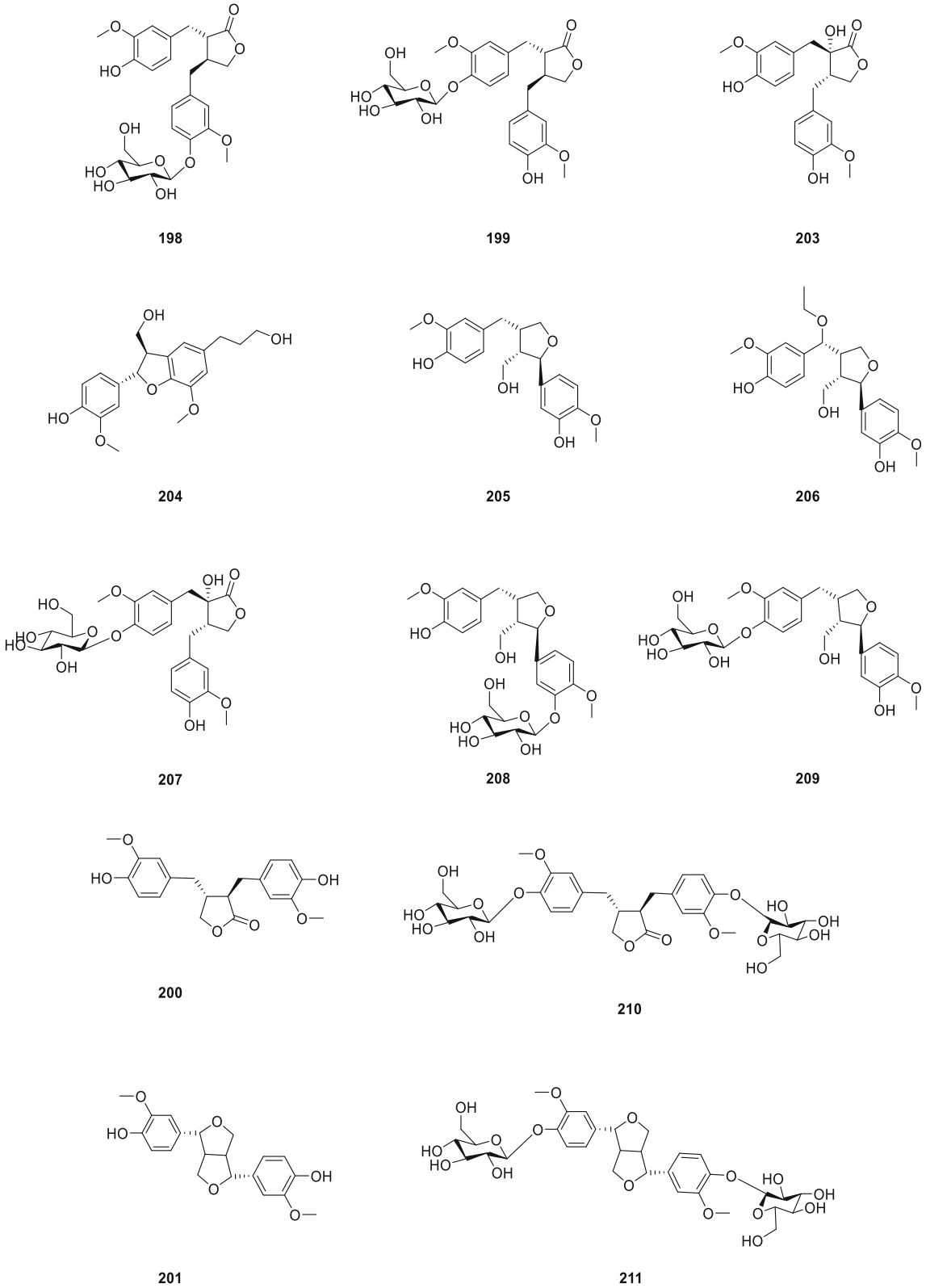

Fig. 8 Lignans isolated from genus *Patrinia*

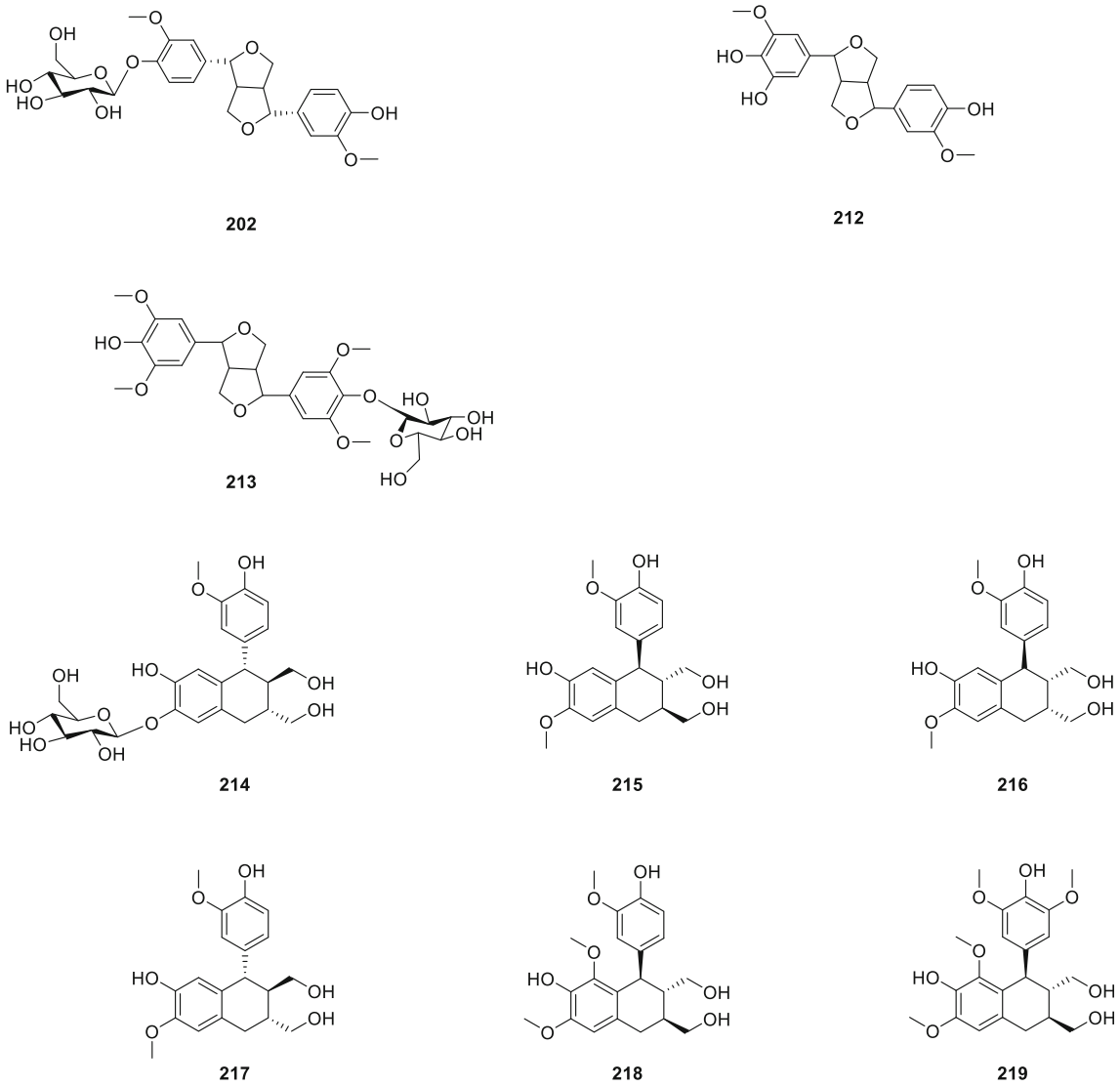

Fig. 8 continued.

Effect on Gastrointestinal Tract Function

It was proved that *Bai Jiang Cao* could eliminate local inflammation, improve microcirculation of lesions, and effectively treat chronic ulcerative colitis [120]. Besides, the animal test about the tannin extract of *P. villosain vitro* showed strong effect ($P < 0.05$) on small intestinal peristalsis of mice and significantly reduced the times of defecation, indicating that

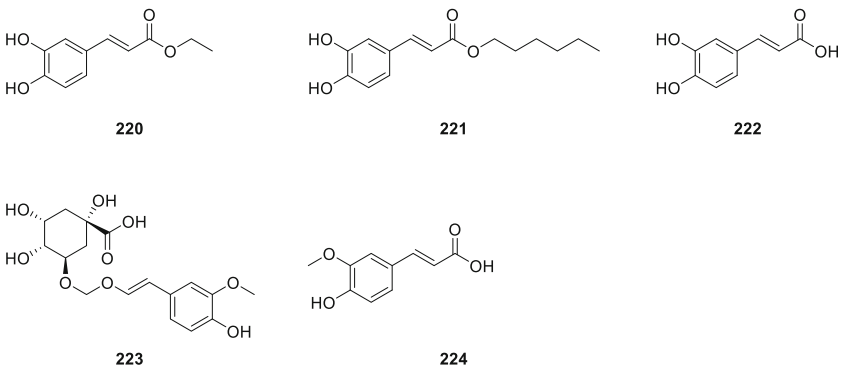

Fig. 9 Phenylpropionic acids isolated from genus *Patrinia*

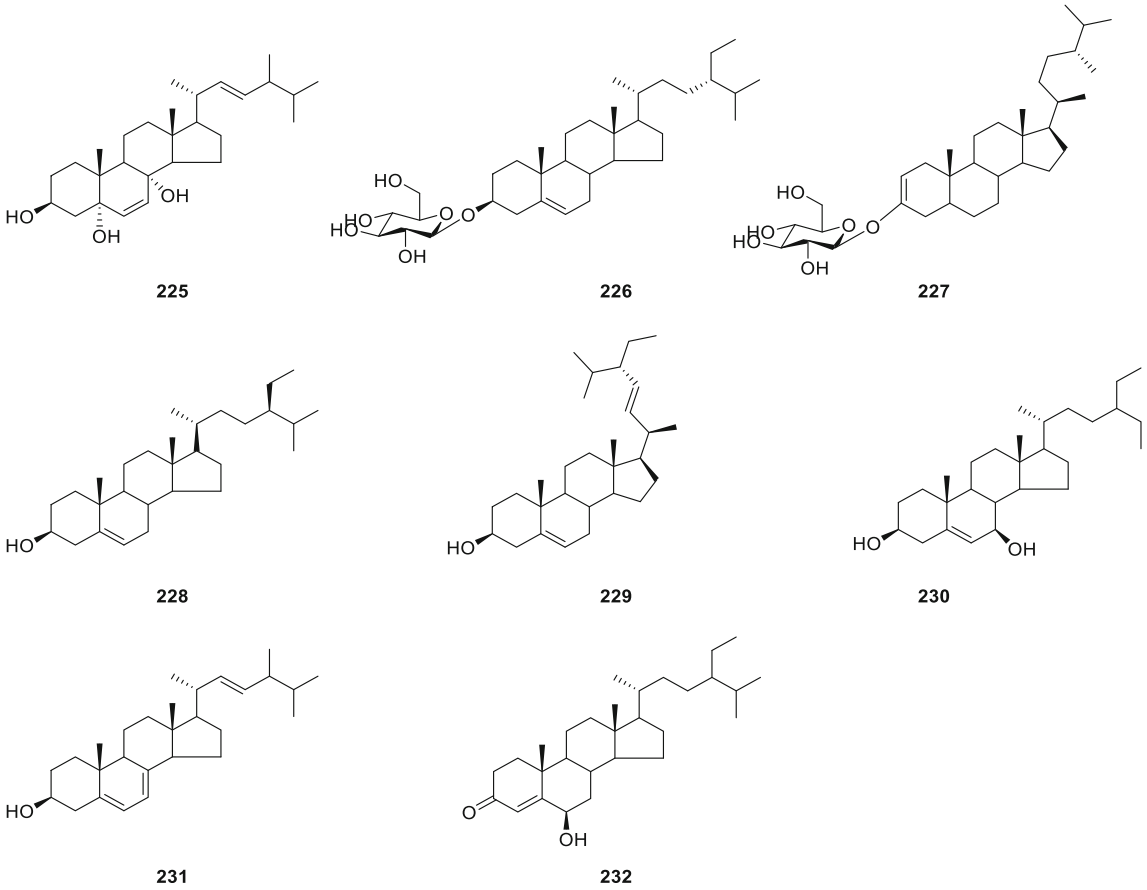

Fig. 10 Sterols isolated from genus *Patrinia*

the tannin extract would have a two-way therapeutic effect on constipation and diarrhea [121].

Other Activities

Bai Jiang Cao also can be used to treat gonorrhea and infantile diarrhea [2], while its extracts have significant antioxidant activity in vivo, and decrease malondialdehyde (MDA) content in serum and tissues [122]. *P. scabiosaefolia* possesses the effect of inhibiting the DNA polymerase of hepatitis B virus. *P. villosa* has a significant anti-hypoxia effect [123]. It is also used to treat fallopian tube obstruction and semen in liquefaction as well as poisonous snakebite [124, 125]. In addition, its methanol extracts have inhibitory activity against substance P (SP)-induced itching [126].

Future Perspectives and Conclusion

Patrinia plants have a long history of medicinal application in China. According to the Chinese Pharmacopeia of 1977, the whole herb including the roots of *P. scabiosaefolia* and *P. villosa* were authentic *Bai Jiang Cao* with high development and utilization value. As a traditional Chinese medicine, this genus has the advantages of abundant bioactive ingredients, wide application, rich resources, and others. It has long been used in China for the treatment of neurasthenia, postpartum disease, lung carbuncle, dysentery, and leucorrhea. Based on the studies both in vitro and in vivo, the genus *Patrinia* demonstrated wide pharmacological activities, including sedative, antibacterial, antivirus, and antitumor activities and protection efficacies of the liver and gallbladder, among others.

The plant resources of genus *Patrinia* in China are very rich, and there are a large number of prescriptions in traditional Chinese medicine practice, mainly depending on *Patrinia* plants, such as *Baijiang San, Hongteng Baijiang Zaoci Tang*, etc. However, the pharmacological effects of the compounds isolated from *Patrinia* are less studied, and the mechanisms are also not clearly elucidated. In addition, the phytochemical and pharmacological research have not been coherently combined together and comprehensively analyzed. Therefore, in the future research of *Patrinia*, we should further systematically explore the mechanisms and bioactive ingredient basis of *Patrinia*, which is of great significance for its in-depth research and rational development of *Patrinia*.

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Compliance with Ethical Standards

Conflict of Interest All the authors declare that there are no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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•• Of major importance

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