REVIEW ARTICLE

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records of natural products

Phytochemical and Biological Studies of Plants from the Genus *Oxytropis*

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Abstract: *Oxytropis* is an important genus of the family Leguminosae and subfamily Papillionoideae, also known as "Locoweed". About 350 species distribute in many zones of the world. There are about 150 species found in China, and more than 80 species mainly distributed in the northwest and northeast parts. More than 127 chemical constituents have been isolated from the genus *Oxytropis*, including flavonoids, flavonones, chalcones, isoflavones, isoflavanones, dihydroflavones, alkaloids, saponins, lignans and others compounds. Many plants have been used as folk medicine for the treatment of colds, inflammation of carbuncle swelling, pain and different types of bleeding. Meanwhile, has been proven to possess efficacy on anti-tumor, antisepticise, anti-inflammatory, hemostasis, neuroendocrine system effects, immune suppression activities, etc.

Keywords: *Oxytropis*; chemical composition; biological activities.

1. Introduction

Oxytropis is an important genus of the family *Leguminosae* and subfamily *Papillionoideae*. About 350 species distribute in many zones of the world [1,2]. According to the ecology studies, the former USSR, especially Siberia is the origin and distribution center of the global *Oxytropis*. More than 90% *Oxytropis* species could be found in this the area and about 30% are the endemic species. At

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the same time, China, especially the Qinghai-Tibet plateau and Himalaya is another distribution center of this genus [3]. There are about 150 species found in China, and more than 80 species mainly distributed in the northwest and northeast parts, such as Gansu, Qinghai, Tibet, Inner Mongolia, Ningxia and Sichuan [4,5].

Oxytropis are distributed mainly in temperate zone of continental climate, annual mean temperature under 15°C, and the annual rainfall general less than 400 mm. The plants of *Oxytropis* genus have wide distribution and good adaptability, and often grow as a roll of film in patana, swamp, grassland, under the brush and gravel. Some *Oxytropis* can be used as the animal feeds, but many of others are noxious to livestock and characterized as one of the most destructive plants, even named as "Locoweed". At the same time, many plants have been used as folk medicine for the treatment of colds, inflammation of carbuncle swelling, pain and different types of bleeding [6] (Figure 1). Pharmacological research on these plants showed anti-tumor, antisepticise, anti-inflammatory, hemostasis, neuroendocrine system effects and immune suppression activities. Phytochemical studies resulted to isolation of a lot of chemical compounds like alkaloids, flavonoids, saponins, lignans, volatile compounds and polysaccharides.

Figure 1. Photograph of *Oxytropis kansuensis*

In this review, compounds isolated from 28 species of *Oxytropis* (Table 1, Table 2, and Table 3) and the biological activities and toxicities of this genus were summarized.

Table 1. The list of the species from the genus *Oxytropis.*

Species	Designation	Species	Designation
O. bicolor	A	*O. varlakovii*	O
O. falcata	B	*O. deflexa*	P
O. jordalii	C	*O. ochrocephala*	Q
O. varians	D	*O. strobilacea*	R
O. monticola	E	*O. myriophylla*	S
O. pseudoglandulosa	F	*O. villosa*	T
O. psammocharis	G	*O. kansuensis*	U
O. microphylla	H	*O. puberula*	V
O. campestis	I	*O. muricata*	W
O. cusickii	J	*O. trichophysa*	X
O. thalassica	K	*O. muricata* (Pall.) DC. (Mongolia)	Y
O. lanata	L	*O. puberula Boriss.* (Kazakhstan)	Z
O. glabra	M	*O. glacialis* Benth ex Bge	a
O. komarovii	N	*O. chiliophylla*	b

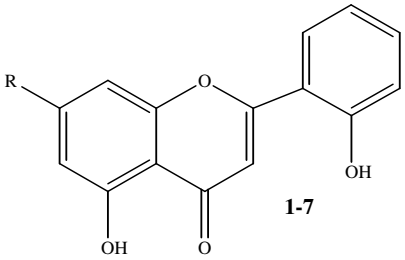
Table 2. Chemical constituents from the genus *Oxytropis.*

NO.	Name	Species	Ref.
1	Apigenin	A,B	[7-8]
2	Apigenin 7-O-glucoside	C	[1]
3	Apigenin 7-O-diglucoside	C	[1]
4	Apigenin 7-O-xylosylglucoside	C	[1]
5	Apigenin 7-O-neohesperidoside	D	[1]
6	Apigenin 7-O-rutinoside	D,E	[1]
7	Apigenin 7-O-arabinosylglucoside	E	[1]
8	Chrysin	B,F,G	[8-10]
9	Baicalein	H	[11]
10	5-Hydroxy-7-methoxyflavone	F	[12]
11	Chrysoeriol	I	[1]
12	Chrysoeriol 7-O-glucoside	C,D,E	[1]
13	Chrysoeriol 7-O-diglucoside	E	[1]
14	Chrysoeriol 7-O-rutinoside	E	[1]
15	Luteolin	B,E	[1][8]
16	Luteolin 7-O-glucoside	D,J	[1]
17	Luteolin 7-O-diglucoside	C,D,F	[1]
18	Luteolin 7-O-rutinoside	D	[1]
19	Luteolin 3′-O-glucoside	E	[1]
20	Kaempferol	H,K	[11][13]
21	Astragalin	L	[14]
22	Kaempferol 7-O-rhamnoside	M	[15]
23	Kaempferol 3-O-diglucoside	M	[15]
24	Kaempferol 3-O-xylosylglucoside	J	[1]
25	Kaempferol 3-O-rutinoside	M	[16]
26	Kaempferol 7-O-glucosylrhamnoside	N	[17]
27	Kaempferol 3-O-glucosylrhamnoside-7-O-rhamnoside	N	[17]
28	Kaempferol 3-O-glucoside-7-O-glucoside	M	[18]
29	Robinin	O	[19]
30	Kaempferol 3-O-(6″-O-malonyl)glucoside	P	[20]
31	Quercetin	B,K	[8][13]
32	Isoquercitrin	M,Q	[15][18]
33	Quercetin 3-O-diglucoside	J	[1]
34	Quercetin 3-O-rutinoside	R	[21]
35	Quercetin 3-O-xylosylglucoside	J	[1]
36	Quercetin 3,7-O-diglucoside	J	[1]
37	Oxymyrioside	S	[22]
38	Acetyloxymyrioside	S	[22]
39	Coumaroylisooxymyrioside	S	[22]
40	Rhamnetin	R	[21]
41	Isorhamnetin	T	[23]
42	Rhamnetin 3-O-glucoside	R	[21]
43	Rhamnetin 3-O-galactoside	Q	[24]
44	Isorhamnetin 3-O-glucoside	A	[7]
45	Rhamnocitrin	Q	[15]
46	Rhamnocitrin 3-O-glucoside	Q	[15]
47	Rhamnocitrin 3-O-galactoside	Q,U	[25-26]
48	Rhamnocitrin 3-O-galactoside-4′-O-glucoside	Q,U	[25-26]
49	5-Methoxy-7-hydroxy-3-O-galactoside-4′-O-glucoside	Q	[24]
50	Myricitin 3-O-glucoside	M	[18]
51	Genistin	B	[27]
52	5-Hydroxy-7,8,4′-trimethoxyflavone	H	[11]

53	5,7-Dihydroxy-4′-methoxyflavonol	B	[28]
54	7-Hydroxy-flavonone	B,F	[8] [12] [29][30]
55	(-)-7-Methoxy-dihydroflavone	B	[30]
56	7-Hydroxy-4′-methoxyflavanone	B	[28]
57	Pinocembrin	B	[8][30]
58	Pinostrobin	B,F	[8][12][30][31]
59	Liquiritigenin	B	[8]
60	2′-Methoxy-4′-hydroxychalcone	B	[28-29]
61	4′-Methoxy-2′-hydroxychalcone	B	[8][28-30]
62	2′,4′-Dihydroxychalcone	B	[8][28][30]
63	2′,4′-Dihydroxy-4-methoxychalcone	B	[28]
64	2′,4′-Dihydroxy-dihydrochalcone	B	[8][28][30]
65	3′,7-Dihydroxy-2′,4′-dimethoxyisoflavane	M	[15]
66	Formononetin	B	[29]
67	Isoliquiritigenin	F,G,V	[9-10]
68	3′,7-Dihydroxy-2′,4′-dimethoxyisoflavan	B	[28]
69	10-Methoxymedicarpin	U	[26]
70	(-)-Maackiain	B	[30]
71	Roseoside	S	[31]
72	Dalbergin	B	[30]
73	Anagyrine	B,M,Q	[32][34-40]
74	Thermopsine	B,M,Q	[32][34-37][39]
75	Sparteine	B,M,Q	[34-37][39][41]
76	Lupanine	B,M,Q	[34-37][39][42]
77	N-Formylcytisine	M,Q	[34-36]
78	13-Hydroxysparteine	M,Q	[34-36]
79	N-Methylcytisine	M,Q	[34-36]
80	Baptifoline	M,Q	[34-36]
81	Harmine	M	[43]
82	Dictamnine	M	[36]
83	N-Benzoyl-*β*-phenylethylamine	B,F,S,W,X,Y,Z	[12] [30][39][44-47]
84	N-Benzoyl-2-acetoxy-phenethylamine	W	[43]
85	Cinnamyl-*β*-hydroxyphenethylamine	F	[12] [45]
86	(-)-N-Benzoyl-2-hydroxy-2-phenylethylamine	B,S,X	[46][48-49]
87	Oxytrofalcatin A	B	[50]
88	Oxytrofalcatin B	B	[50]
89	Oxytrofalcatin C	B	[50]
90	Oxytrofalcatin D	B	[50]
91	Oxytrofalcatin E	B	[50]
92	Oxytrofalcatin F	B	[50]
93	Oxytropine A	B	[37][39]
94	Oxytropine B	B	[37][39]
95	Oxytropine C	B	[38]
96	Myriophylloside A	S	[51]
97	Swainsonine	Q	[52]
98	8-Methyl-1-dihydroxy indolizidine triol	U	[53]
99	2,2,6,6-Tetramethyl-4-piperidone	a	[54][55]
100	3-O-[*α*-L-rhamnopyranosyl-(1→3)-*β*-D-glucopyranosyl(1→6)-*β*-D-glucuronopyranosyl]-soyasapogenol B	M	[18]
101	3-O-[*α*-L-rhamnopyranosyl-(1→2)-*β*-O-glucopyranosyl(1→4)-*β*-D-glucuronopyranosyl]-soyasapogenol B	A,M,Q	[7][45][56]
102	3-O-[*α*-L-rhamnopyranosyl-(1→2)-*β*-D-arabinopyranosyl(1→4)-*β*-D-glucuronopyranosyl]-soyasapogenol B	Q	[45]
103	3-O-[*β*-D-glucopyranosyl(1→2)-*β*-D-glucuronopyranosyl]-soyasapogenol B	Q	[57]

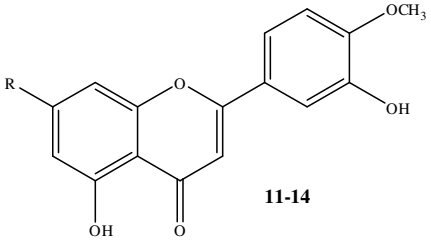
104	3-O-[*β*-D-glucopyranosyl(1→2)-*α*-L -rhamnopyanosyl(1→2)-*β*-D-glucopyranosyl (1→4)-*β*-D-glucuronopyranosyl]-soyasapogenol E	A	[55]
105	Soyasapogenol B	L	[58]
106	3-O-[*β*-D-glucopyranosyl(1→2)-*β*-D-glucuronopyranosyl]-azukisapogenol	A	[7]
107	3-O-[*β*-D-glucopyranosyl(1→2)-*β*-D-glucuronopyranosyl]-azukisapogenol methylester	A	[59]
108	3-O-[*β*-D-glucopyranosyl(1→2)-*β*-D-glucuronopyranosyl]-azukisapogenol amide	A	[59]
109	Azukisapogenol	b	[60]
110	3-O-*α*-L-rhamnopyranosyl (1→2)-*β*-D-glucopopyranosyl (1→4)-*β*-D- glucuronopyanoside-oxytrogenol	A	[56]
111	3-O-[*α*-L-rhamnopyranosyl(1→2)-*β*-D-glucopyranosyl(1→4)-*β*-D-glucuronopyranosyl]-3*β*,22*β*,-4-trihydroxyolean-12-en-oic acid	A	[56]
112	Olean-13(18)-ene-2-*α*-chloro-3*β*,24-diol	Q	[56]
113	Myrioside A	S	[61]
114	Myrioside B	S	[61]
115	Myrioside C	S	[61]
116	Myrioside D	S	[61]
117	Pericarsaponin Pk	S	[61]
118	Lupeol	B,H	[11][37][39]
119	3-O-[*β*-D-glucopyranosyl(1→2)-*β*-D-glucopyranosyl]-(20*S*, 24*S*)-9,19-cyclolanostane-3*β*,16*β*,20,24,25-pentaol	A	[7]
120	3-O-[*β*-D-glucopyranosyl(1→2)-*β*-D-glucopyranosyl]-25-O-*α*-L-rhamnopyranosyl-(20*S*,24*S*)-3*β*,16*β*,20,24,25-pentahydroxy-9,19-cyclolanostane	A	[62]
121	Stigmasterol	B,H	[11][63-64]
122	23,24-Dihydrostigmasterol	B	[64]
123	*β*-Sitosterol	B,H,b	[11][27][30][37-40] [60][63]
124	Daucosterol	B,M,b	[36-37][39-40][60]
125	*cis*-Farnesol	U	[65]
126	Schisantherin A	P	[66]
127	Ligustrin	S	[51]

Table 3. Chemical structures of compounds from the genus *Oxytropis*.



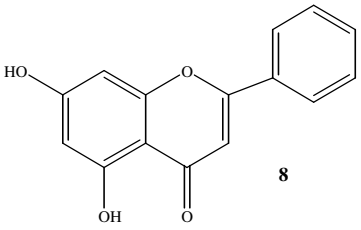
1-7

NO	R
1	OH
2	O-β-D-glc
3	O-β-D-glc(1→2)-β-D-glc
4	O-β-D-xyl(1→2)-β-D-glc
5	O-α-L-rha(1→2)-β-D-glc
6	O-α-L-rha(1→6)-β-D-glc
7	O-α-L-arb(1→6)-β-D-glc



11-14

NO	R
11	OH
12	O-β-D-glc
13	O-β-D-glc(1→2)-β-D-glc
14	O-α-L-rha(1→6)-β-D-glc



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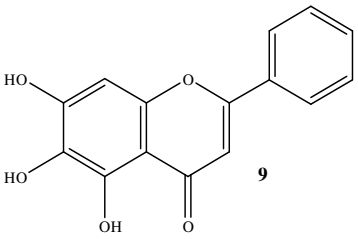

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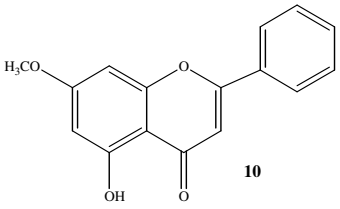

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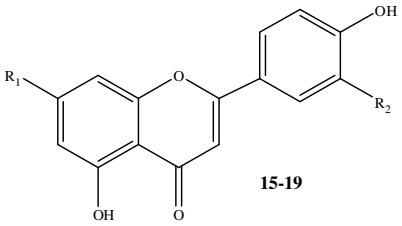
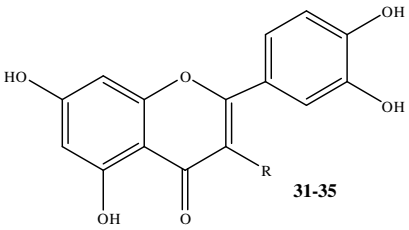


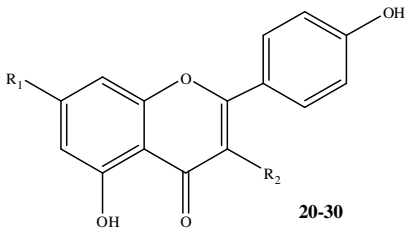
15-19

NO	R1	R2
15	OH	OH
16	O-β-D-glc	OH
17	O-β-D-glc(1→6)-β-D-glc	OH
18	O-α-L-rha(1→6)-β-D-glc	OH
19	OH	O-β-D-glc



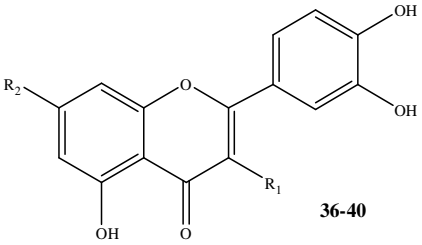
31-35

NO	R
31	OH
32	O-β-D-glc
33	O-β-D-glc (1→2)-β-D-glc
34	O-α-L-rha (1→6)-β-D-glc
35	O-β-D-xyl (1→2)-β-D-glc



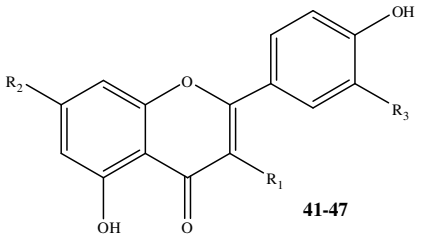
20-30

NO	R1	R2
20	OH	OH
21	OH	O-β-D-glc
22	O-α-L-rha	OH
23	OH	O-β-D-glc (1→2)-β-D-glc
24	OH	O-β-D-xyl (1→2)-β-D-glc
25	OH	O-α-L-rha (1→6)-β-D-glc
26	O-α-L-rha (1→2)-β-D-glc	OH
27	O-α-L-rha	O-α-L-rha (1→2)-β-D-glc
28	O-β-D-glc	O-β-D-glc
29	O-α-L-rha	O-α-L-rha (1→6)-β-D-gal
30	OH	O-α-L-rha (1→6)-β-D-gal



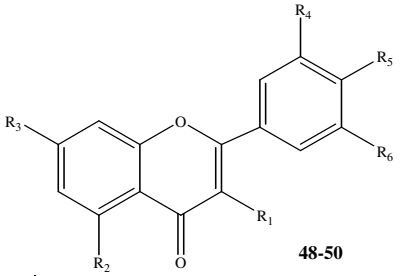
36-40

NO	R1	R2
36	O-β-D-glc	O-β-D-glc
37	O-β-D-glc (1→2)-β-D-glc	O-α-L-rha
38	O-β-D-glc(6″-O-acetyl) (1→2)-β-D-glc	O-α-L-rha
39	O-β-D-glc(6″-O-coumaroyl) (1→2)-β-D-glc	O-α-L-rha
40	OH	OMe



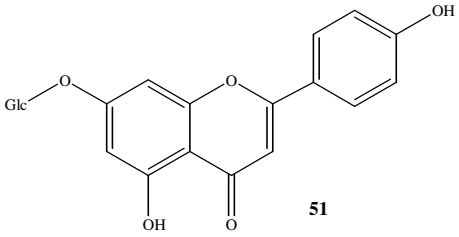
41-47

NO	R1	R2	R3
41	OH	H	OMe
42	O-β-D-glc	OMe	OH
43	O-β-D-gal	OMe	OH
44	O-β-D-glc	OH	OMe
45	OH	OMe	H
46	O-β-D-glc	OMe	H
47	O-β-D-gal	OMe	H



48-50

NO	R1	R2	R3	R4	R5	R6
48	O-β-D-gal	OH	OMe	H	O-β-D-glc	H
49	O-β-D-gal	OMe	OH	H	O-β-D-glc	H
50	O-β-D-glc	OH	OH	OH	OH	OH



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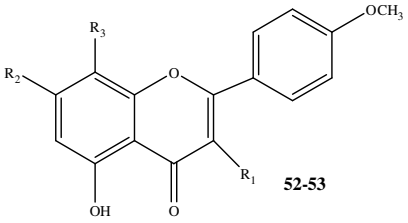
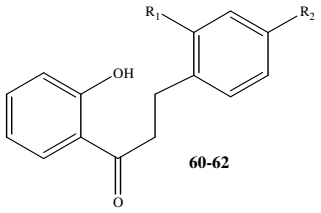


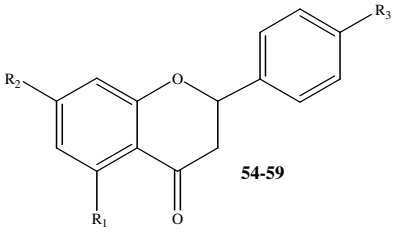
52-53

NO	R1	R2	R3
52	H	OCH_3	OCH_3
53	OH	OH	H



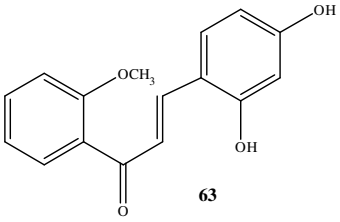
60-62

NO	R1	R2
60	OCH_3	OH
61	OH	OCH_3
62	OH	OH



54-59

NO	R1	R2	R3
54	H	OH	H
55	H	OCH_3	H
56	OH	OCH_3	H
57	H	OH	OCH_3
58	OH	OH	H
59	H	OH	OH



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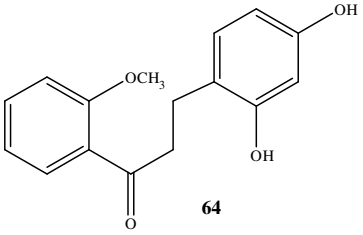

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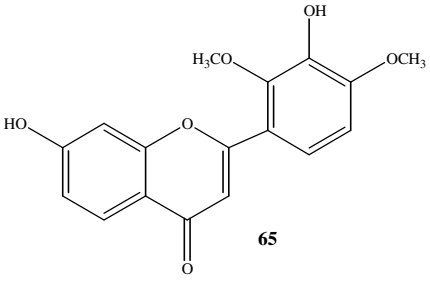

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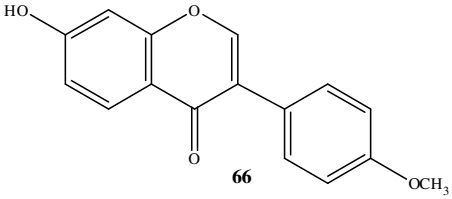

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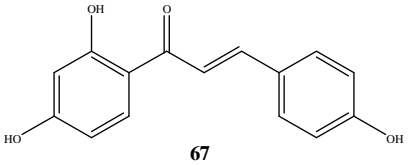

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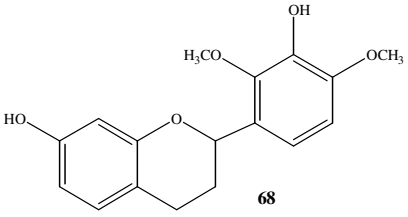

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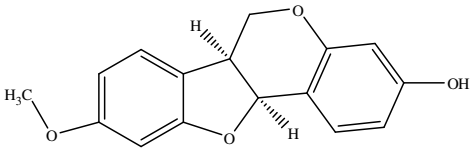

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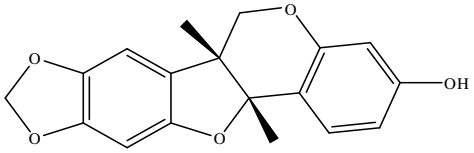

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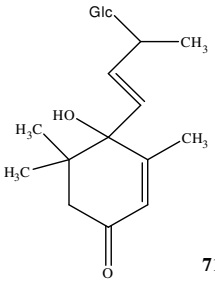

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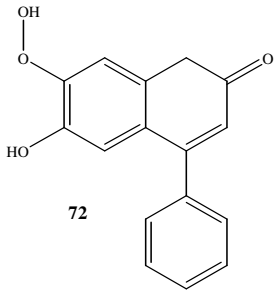

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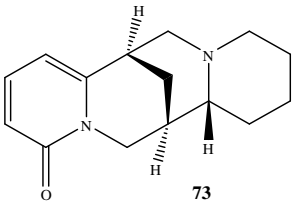

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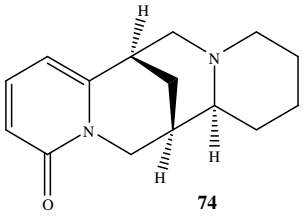

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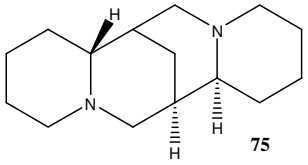

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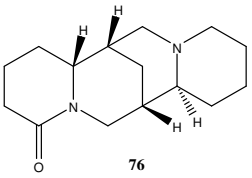

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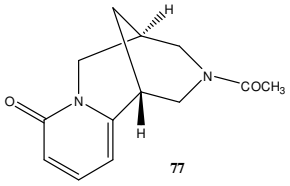

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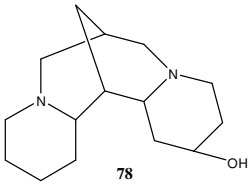

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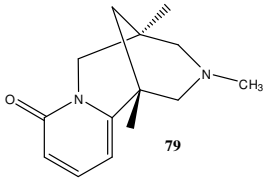

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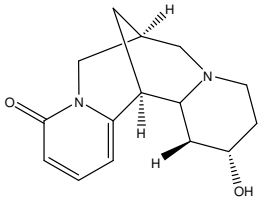

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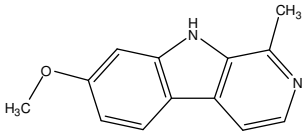

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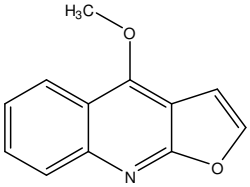

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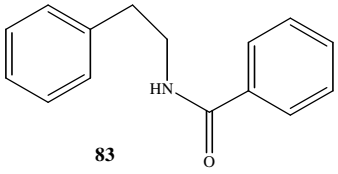

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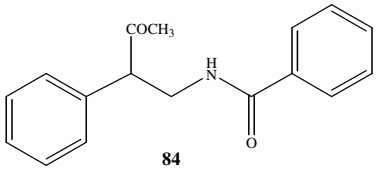

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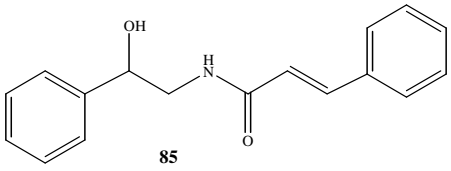

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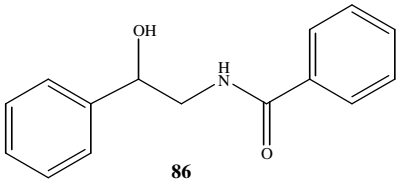

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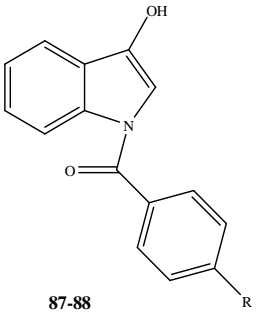
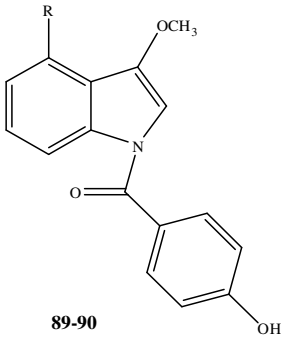


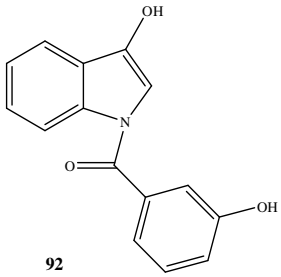
87-88

NO	R
87	H
88	OH



89-90

NO	R
89	H
90	OH



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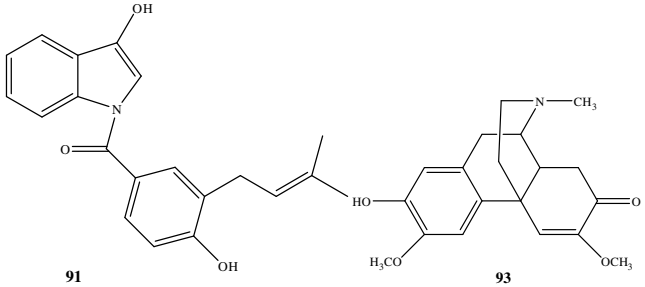
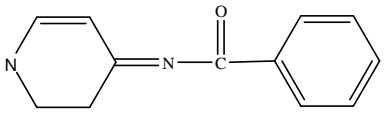


91 **93**



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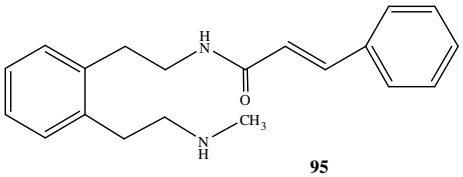

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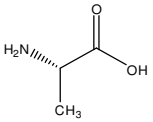

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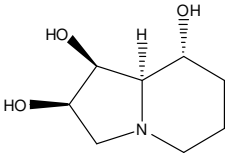

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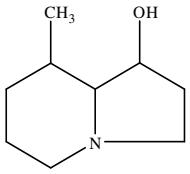

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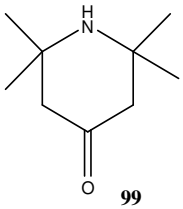

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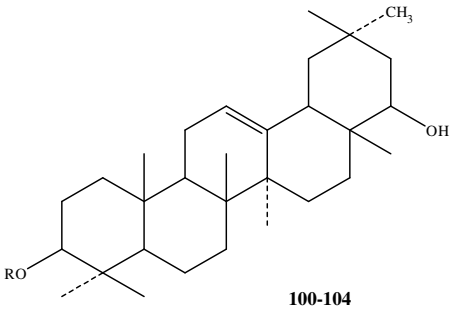
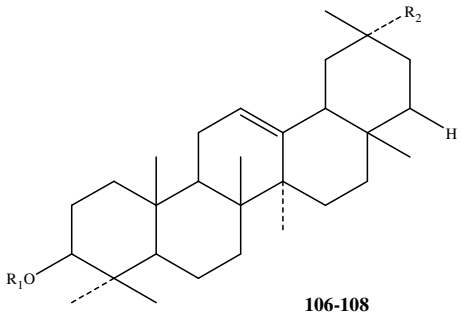


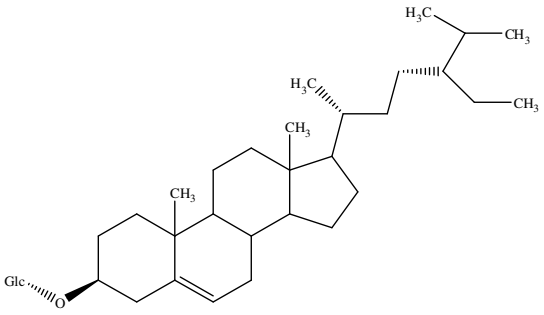
100-104

NO	R
100	α-L-rha (1→3)-β-D-glc(1→6) -β-D-gluA
101	α-L-rha (1→2)-β-D-glc(1→4) -β-D-gluA
102	α-L-rha (1→2)-β-D-arb(1→4) -β-D-gluA
103	β-D-glc(1→2)-β-D-gluA
104	[β-D-glc(1→4)][α-L-rha (1→2) -β-D-glc(1→4)]-β-D-gluA



106-108

NO	R1	R2
106	β-D-glc(1→2)-β-D-gluA	COOH
107	β-D-glc(1→2)-β-D-gluA	CO_2CH_3
108	β-D-glc(1→2)-β-D-gluA	$CONH_2$



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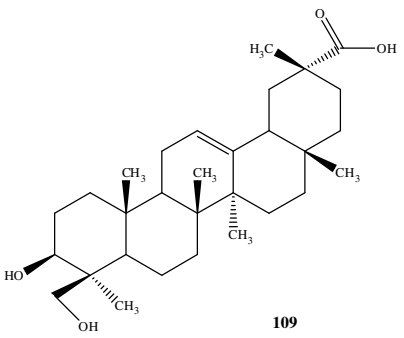

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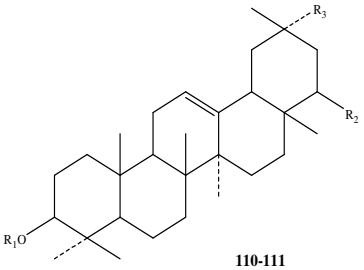
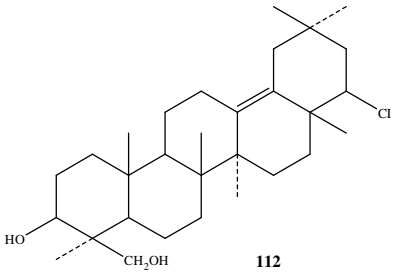
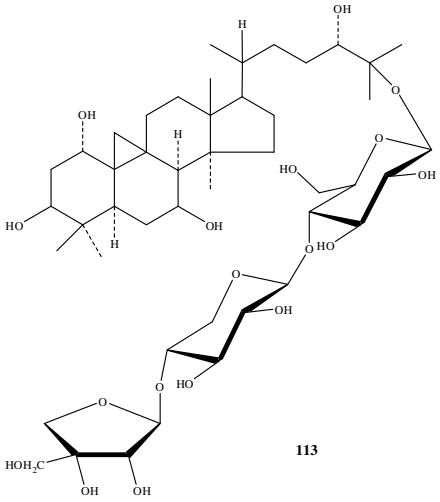


110-111



112

NO	**R1**	**R2**	**R3**
110	α-L-rha (1→2)-β-D-glc(1→4)-β-D-gluA	OH	CH_2OH
111	α-L-rha (1→2)-β-D-glc(1→4)-β-D-gluA	OH	COOH



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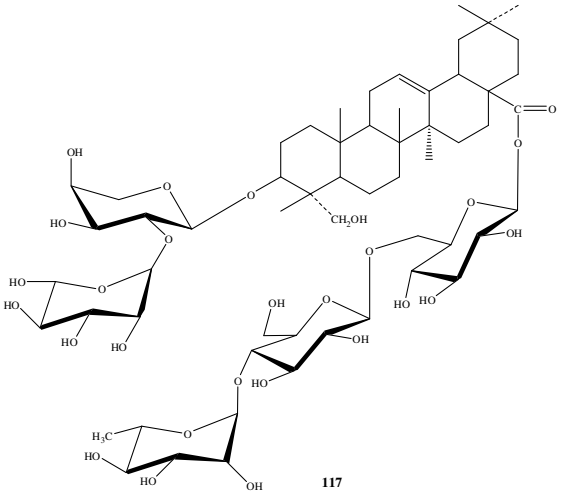
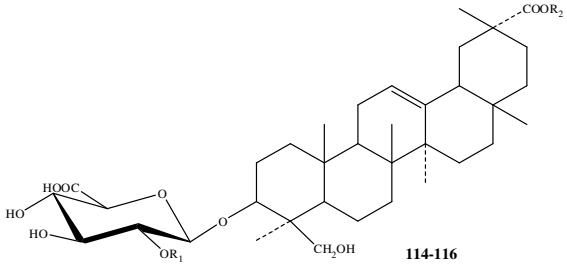


117



114-116

NO	R1	R2
114	H	H
115	H	β-D-glc pyr
116	β-D-xyl pyr	β-D-glc pyr

2. Chemical Constituents

Since the 1960's, more than 127 chemical constituents have been isolated from the genus *Oxytropis*, including flavones, alkaloids, saponins, lignanoids and others compounds.

2.1. Flavones

Flavones are the major components of this genus. The main aglycones of these compounds were apigenin, chrysin, luteolin (flavones), kaempferol, quercetin, myrecetin, rhamnetin, isorhamnetin, rhamnazin, and rhamnocitrin (flavonols). The main glycosyls were D-glucose, L-rhamnose, D-galacotose, L-arabinose, and D-xylose, and all of them are connected to the aglycones via oxygen bonds. During the last decades, 73 flavones among them many new compounds have been isolated and identified. Compounds **1-53** were isolated as flavones and flavonoid glycosides from *O. bicolor*, *O. falcata*, *O. jordalii*, *O. varians*, *O. monticola* and so on, **54-59** are flavonones mainly isolated from *O. falcata*, **60-64** are four chalcones mainly isolated from *O. falcata* also. **65-66** are two isoflavones, **67** is a isoflavanone, **68** is a dihydro-isoflavanone, they were isolated from *O. falcata*, *O. pseudoglandulosa* and *O. psammocharis*.

2.2. Alkaloids

Due to their toxicity, alkaloids of Oxytropis have been paid attention since 1929 [33]. Subsequently studied 25 alkaloids were isolated and identified, including quinolizidine akaliods **73-80**

, indolizidine alkaloids **81**, quinoline alkaloids **82**, organic amide, morphinan, and others alkaloids **(83-99)**.

2.3. Triterpenoids

In 1974, Iriste (the Soviet Union scholar) isolated triterpenoids, whose aglycones were identified as Soyasapogenol B **(105)** from *O. lanata* for the first time. There have 24 compounds been isolated from this genus, including pentacyclic triterpenoids **(100-104**, **106-112**, **114-117)** and tetracyclic triterpenoids (**105**, **113**, **118-124)**.

2.4. Other compounds

In 1990, 1,1,1,7,7,7-sexichlorine-2,6-dihydroxy-4-oenanthone, and tetratriacontane were isolated from *O. glabra* [36]. Later, cis-farnesol **(125)**, lauric acid, tetradecylic acid, 12-methyl-tetradecylic acid, 6,10,14-trimethyl-2-pentadecane and hexadecanoic acid were isolated from the essential oil part of *O. kansuensis* [65]. From *O. deflexa*, one lignanoid compound, schisantherin A **(126)** [66] was obtained. *O. myriophylla* afforded one phenolic glycoside compound, ligustrin **(127)** [52]. From the petroleum ether part of *O. falcata*, flaxseed oleinic acid ethyl ester was obtained [64]. Melissic acid and many amino acid compounds were isolated from several *Oxytropis* species [9, 67]. Meanwhile, microelement Se and the compounds, whose structures contain Se, were also reported [68].

3. Biological activities

3.1. Anti-tumor activity

In recent decades, more and more alkaloids from the genus *Oxytropis* have been the targets of anti-cancer drug study in the world.

In 1991, Zhang et al had evaluated the anti-tumor activity of the alcohol extract of *O. ochrocephala* on mice sarcoma S180 by intragastric administration and intraperitoneal injection. The results displayed the extract could obviously inhibit S180, and the inhibition ratio were 55.89% and 64.93% [69]. At the same time they studied the anti-tumor activity of an alcohol extract of *O. kansuensis* on hypodermic inoculation tumor S37 and liver cancer ascites H22. The results showed that the inhibition ratio were 39.88% and 51.02% [70]. Then in 1997 and 2003, the anti-tumor activity on mice sarcoma S180 of the alkaloids of *O. kansuensis* and *O. glabra* had been proved respectively, they could significantly inhibit the development of sarcoma S180 and improve the pathological section. Furthermore, the results also showed that the alkaloids of *O. kansuensis* could reduce the express of PCNA and the mutant of p53 [71,72].

Swainsonine **(97)** isolated from *O. ochrocephala* has been thought as the most potential anti-tumor alkaloid [73]. It could inhibit tumor metastasis, the growth of solid tumors in mice and cancer patients, stimulate the immune system and strengthen the immune cells activity [2]. Meanwhile, it also could suppress the growth of lung tumor [74], human colorectal carcinoma, melanoma and breast carcinoma xenografts, and prolong survival of tumor bearing mice [75-76]. Many studies have shown that it has been good for solid tumors, but limited effect to metastatic renal cell carcinoma (RCC). Meanwhile there was no evidence of anti-tumor activity has been observed [77-83].

3.2. Clearing and inducing free radicals activities

The chemical constituents of *O. myriophylla* could clear and inhibit O^{2-}•OH and lipid peroxidation (LPO), and showed the detumescence, stop bleeding, wound healing effects [84]. Li et al

discovered the total of alkaloids from *O. glabra* could significantly degrade the activity of antioxidase and raise the content of malondialdehyde (MDA), which induces the body to produce the oxygen free radicals [85].

In 2008, the chloroform, ethylacetate extracts, and essential oil of *O. falcate* were investigated by 1, 1-diphenyl-2-picryldydrazyl (DPPH) radical- scavenging assay. The results showed the ethylacetate extract has the highest antioxidant activity (IC_{50}=2.05 mg/mL). And some flavonids, purified from chloroform and ethyl acetate extracts, such as rhamnocitrin **(45)**, kaempferol **(20)**, rhamnetin **(40)**, and 2′, 4′-dihydroxychalcone **(62)**, also exhibited considerable antioxidant activities, but the two dihydrochalcones were very weak [86]. At the same time the essential oil from *O. falcate* had good antioxidant activity too. The GC and GC/MS analysis revealed 89.0% compositions of the total oil, including viridiflorol (11.5%), (E)-nerolidol (8.2%), ethyl hexadecanoate (6.5%), trieosane (5.6%) and spathulenol (5.4%) [87].

Geng [88] et al had evaluated the effect of thermopsine **(74)** on the impact of free radicals *in vivo*. The results showed that thermopsine could significantly induce the emergence of oxygen free radicals, reduce some antioxidant enzyme activity and increase malondialdehyde (MDA) in the major organs and tissues of the body.

3.3. Bacteriostatic activity

The ether, chloroform and 95% alcohol extracts of *O. glacialis* showed the bacteriostatic activities on *staphylococcus aureus* and *bacillus thuringiensis*, but no inhibitory effect on *Bacillus coli* [89].

Some extracts of *O. glacialis* have significant inhibition on *staphylococcus aureus*, *pasteurella multocida* and *streptococcus agalactiae*. But no inhibition on *Bacillus coli*, *Salmonella* and *yeast fungus* was observed in the distilled water extract [90].

Chen et al used ethyl acetate as solvent to receive active components from *O. bicolor* by supersonic method, and the bacteriostatic activity of this extract was tested by inhibition zone of eight pathogenic bacteria such as *wheat root rot fungus, Alternaria solani, Colletotrichum apple, watermelon Fusarium oxysporum, Valsa mali, grape white rot, tobacco brown spot* and *black spot disease of sweet potato*. The results showed significant inhibition on five of these eight pathogenic bacteria, and relative inhibition rate of 90% at the 0.01 g/mL concentration of crude extracts [91].

Jiang et al reported that the flavonoids of *O. falcate* i.e. rhamnocitrin **(45)**, kaempferol **(20)**, rhamnetin **(40)**, 2′,4′-dihydroxychalcone **(62)** showed obvious antibacterial activities against nine tested Gram-positive and Gram-negative bacteria. The minimal inhibitory concentrations (MICs) and minimal bactericidal concentrations (MBCs) of the four compounds ranged 125 to 515 μg/mL, and *staphylococcus aureus* was the most susceptible to these flavonoids [92].

At the same time, the crude extract of *O. latibracteata* was proved with lower antibacterial activity on the *wheat scab, botrytis cinerea, alternaria solani, alternaria alternata, colletotrichum apple*, but no significant killing and stomach toxicity activity to 3rd instar larvae of armyworm [93].

3.4. Eliminating phlegm and anti-inflammatory effect

The total flavonoid glycoside was isolated from *O. falcate*, could enhance the secretion of adrenal cortex hormones, and induce a large number of these hormones being released into the peripheral blood stream. At the same time, this effect was activated in the hypothalamus median eminence area, and was adjusted by neuroendocrine. In a word, the total flavonoid glycoside of *O. falcate* could activate the hypothalamus-pituitary-adrenal axis; improve the body stress to achieve expectorant, anti-inflammatory effect [37]. Further studies proved rhamnocitrin **(45)**, isolated from the total flavonoid aglycones of *Oxytropis*, was the active ingredient for the treatment of the chronic bronchitis in clinical [10].

3.5. Hemostasis

The hemostatic effects of the total extracts, petroleum ether parts, dichloromethane parts, ethyl acetate parts, butanol and aqueous parts of *O. falcate* were evaluated by measuring the clotting time, prothrombin time and plasma recalcification time of mice. The results showed *O. falcate* could stop bleeding, promote blood clotting function, and the parts of the n-butanol and water extract were the active ones [94].

3.6. Other activities

The total alkaloids isolated from the root of *O. glabra* showed strong analgesic and sedative effect. It could descend the blood pressure effect to anesthetized dogs, and this effect could be antagonized by the part of the Propranolol. At the other aspect, the total alkaloids could shrink blood vessels on isolated rabbit ears, it shows short and slight inhibition in isolated rabbit heart, but this effect could not to be antagonized by Phentolamine. Meanwhile, it has excitatory effect on isolated intestinal smooth muscle [95].

4. Toxicity

4.1. Enzyme inhibition

Some plants from *Oxytropis* and *Astragalus* are known as locoweed [96]. Li et al reported that the total alkaloids in *O. glabra* could significantly decrease the activity of glutathione reductase and superoxide dismutase in the liver and brain, and increase the content of malondialdehyde ($P<0.01$) in the brain tissue and plasma [85].

Cao et al isolated swainsonine **(97)** from *O. ochrocephala*, and confirmed its inhibitory activity on the α-mannosidase. But when intoxicated goats stopped to eat the *O. ochrocephala*, content of α-mannosidase would quickly return to the normal level [97-98]. At the same time, Zhao et al isolated 8-methyl-1-dihydroxy indolizidine triol from *O. kansuensis*, and proved its inhibitory activity on α-mannosidase in the goat serum [53].

In 2002, Tan et al reported that the isolated 2,2,6,6-tetramethyl-4-piperidone (TMPD) **(99)** from *O. glacialis* Benth ex Bge has a significant inhibitory effect on α-mannosidase in mouse serum, at a maximal concentration 200, 300, 400 mg/kg of TMPD, the α-mannosidase activity in mouse serum could be inhibited completely [54].

4.2. Effect on embryonic development

Toxicology studies showed some alkaloids have a direct developmental toxicity on rat embryos. In the early organogenesis stage, Yolk Sac (YS) is the main place for material exchange between rodent embryos and mother nuclide. When the structure and function of YS are damaged, the embryo's growth and development will be inevitably affected.

Whole Embryo Culture method, as one of YS functions models were adopted to study the development toxicity of the total alkaloids, which were isolated from *O. ochrocephala* [99]. The total alkaloids with the concentration over 50 μg/mL could reduce the level of differentiation of vascular YS significantly in a dose dependent-manner. And electron microscopy showed that the microvillus on pithelial cell of YS became sparsate and short, the number of pusule became less in cytoplasm, and the endomembrane system took place kinds of pathological changes such as mitochondria, endocytoplasmic reticulum, and cell junctional complex damage. At the 200 μg/mL concentration, the diameter of YS and the number of abnormity were significantly different to the control group.

This phenomenon showed that the blood vessels differentiation of YS and its ultramicrostructure were susceptible to the alkaloids, and the effects were coincident with the degree of the embryonic development and the differentiation of blood vessels. In a word, the damage of the structure and function of YS would be caused by the alkaloids of *O. ochrocephala* [100].

4.3. Immune suppression activity

The decoction extract of *O. falcate* showed a stimulating effect on the phagocytosis of macrophages [101]. *O. kansuensis* was reported with the inhibitory activities on the cellular immune function in goats, and could significantly reduce the formation rate of the poisoning goat E-rosette in a dose dependent-manner [102]. *O. ochrocephala* could inhibit the immune function too, and mainly decrease the value of T lymphocytes, phagocytic percentage in mouse blood [103].

4.4. Effect on tissue and cell

In 2005, Ma et al suggested that the indolizidine alkaloids isolated from *Oxytropis* could induce the vacuolar degeneration of mammalian tissue cells [103]. Then the noxious properties of *O. ochrantha* and *O. kansuensis* have been investigated. The results showed that *O. ochrantha* and *O. kansuensis* could induce the cells granular degeneration in the heart, liver, kidney, lung, pancreatic acinar cells and other organs in rabbits, sheep, horse, mice and goats [104-108].

5. Conclusion

Plants of the genus *Oxytropis* afford complex constituents, and many of them have been used in traditional folk medicine throughout the world. Phytochemical investigations led to the 127 components including flavonoids, alkaloids and saponins, *etc*. Some crude extracts and chemical constituents of the genus *Oxytropis* were found with significant biological and pharmacological activities. But how to deal with the activities and the toxicities of *Oxytropis* is a challenging study.

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