绞股蓝皂苷成分的研究进展

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摘 要：绞股蓝是五加科外含有人参皂苷的植物之一，具有滋补保健、抗癌防衰、增强体质和改善脂质代谢等多种功能，近年来一直是国内外学者研究的热点。综述绞股蓝皂苷成分的研究近况，为绞股蓝的进一步研究和开发提供参考，也为临床用药及相关活性成分的确定提供科学依据。

关键词：绞股蓝；皂苷；达玛烷型

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Research advances on the saponins of *Gynostemma pentaphyllum*

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Abstract: *Gynostemma pentaphyllum* is the example containing ginsenosides ever found from a plant not belonging to *Araliaceae*. Pharmacological investigations demonstrated that extracts of this plant exhibited a variety of biological effects, such as nourishment, anticancer, anti-inflammatory, and cadiovascular effects. To provide references and clinical applications for the further research and development of *G. pentaphyllum* provides, and to provide relevant biological active ingredients for the scientific approaches, this review covers the progress about the saponins of *G. pentaphyllum* in recent years.

Key words: *Gynostemma pentaphyllum* (Thunb.) Makino; saponin; dammarane-type

绞股蓝 *Gynostemma pentaphyllum* (Thunb.) Makino 为我国常用的药食同源品，又名七胆草、小苦药、遍地生根等。具有清热解毒，止咳化痰，补气生津，健脾安神之功效。它作为一种与人参相似的免疫增强剂，有着“南方人参”的美誉。其保护心脑血管、调血脂、降血糖、抗肿瘤、增强免疫力等作用显著[1]。现代药学研究表明，主要活性成分是绞股蓝皂苷[2]。

1 绞股蓝皂苷成分

1976 年，Nagai 等[3]报告了从绞股蓝总皂苷的水解产物中得到人参二醇和 2α-羟基人参二醇，首次揭示了绞股蓝含有达玛烷型皂苷类成分。此后，Takemoto 等[4-12]、Yoshikawa 等[13-16]对绞股蓝皂苷进行了大量研究。至 1990 年分离出绞股蓝皂苷 84 个，吴基良等[17]、覃章铮等[18]对它们进行了较系统的归纳和总结。沈宏伟等[17]在 2007 年对之后得到的 52 个绞股蓝皂苷进行了综述性报道。结合前人工作，本文将现已明确的 165 个绞股蓝皂苷按苷元结构相似的程度划分为 12 类。

第一类：主要特点是侧链 24、25 位有双键，见图 1-A、表 1。第二类：主要特点是侧链 23、24 位有双键，见图 1-B、表 2。第三类：主要特点是侧链 25、26 位有双键，见图 1-C、表 3。第四类：主要特点是侧链具有 21-羧酸 21，23-内酯结构，24、25 位有双键，见图 1-D、表 4。第五类：主要特点是 12 位具有-OH 基，侧链 20、24 位具有环氧结构，

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见图 1-E、表 5。第六类：主要特点是 12 位具有-OH 基，侧链 20、25 位具有环氧结构，见图 1-F、表 6。第七类：主要特点是侧链 21 与 24 位环合，见图 1-G、表 7。第八类：主要特点是侧链 21、23 位具有环氧结构，24、25 位有双键，见图 1-H、表 8。第九类：主要特点是侧链 21、24 位环合，25、26 位有双键，见图 1-I、表 9。第十类：主要特点是 12 位与 24 位连氧环合，同时 24 位与 20 位连氧环合，见图 1-J。第十一类：主要特点是侧链 23 与 24 位，25 与 26 位有共轭双键，见图 1-K。第十二类：主要特点是 3 位成五糖苷，侧链 21 位成二糖苷或三糖苷，见图 1-L、表 10。

所有绞股蓝皂苷的苷元部分都为达玛烷型四环三萜类，其中最主要的是 20(*S*)-原人参二醇和 2α-羟基-20(*S*)-原人参二醇。绝大多数绞股蓝皂苷的达玛烯双键在 24、25 位，糖基大多连在 C-3 和 C-20 位，由葡萄糖、阿拉伯糖、鼠李糖和木糖构成单糖、双糖和三糖等。

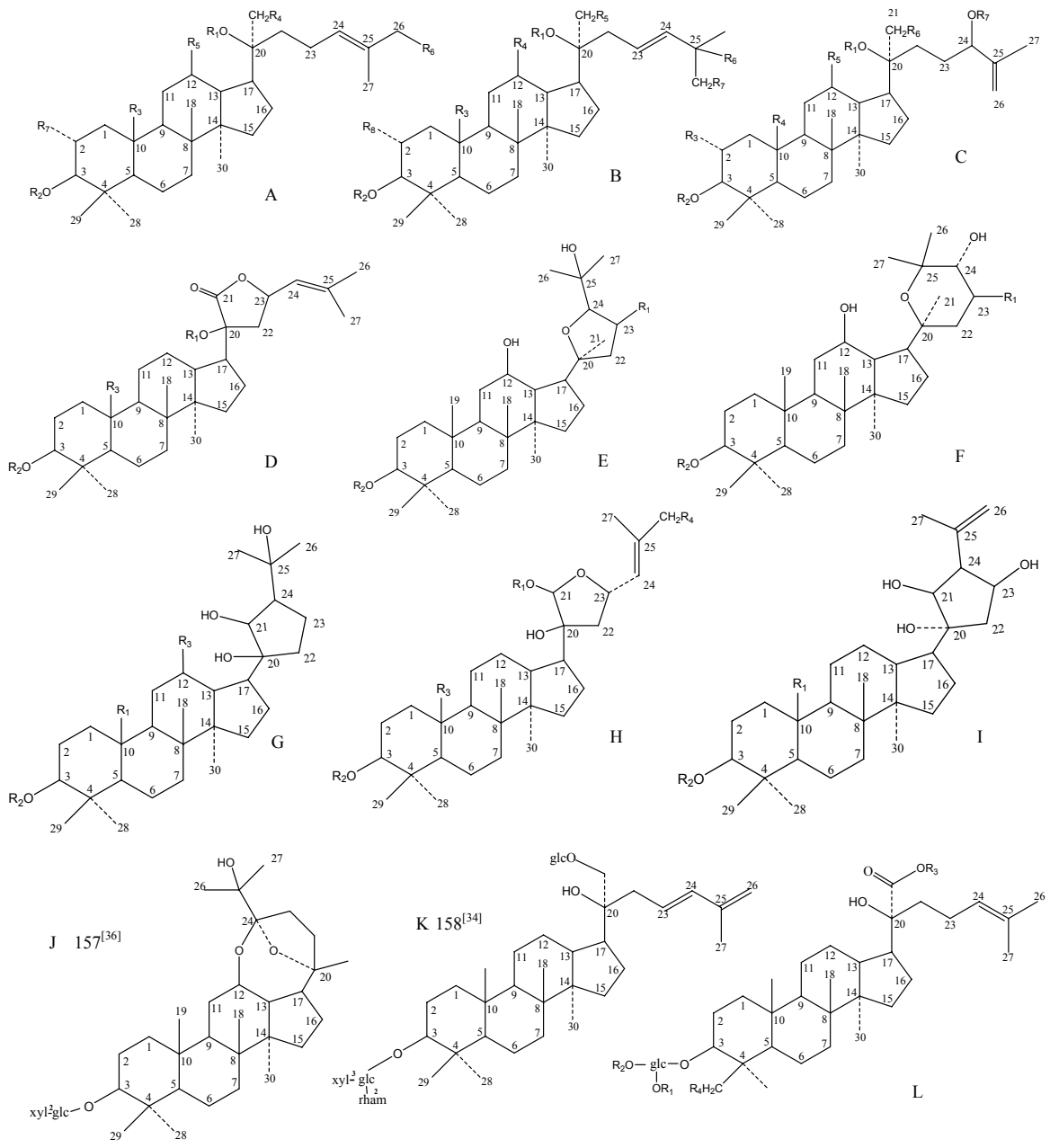

图 1 绞股蓝皂苷基本母核结构

Fig. 1 Structure of saponins from *G. pentaphyllum*

表 1 第一类绞股蓝皂苷

Table 1 First category of saponins from *G. pentaphyllum*

序号	R_1	R_2	R_3	R_4	R_5	R_6	R_7	文献
1	-glc^6-glc	-glc^6-rham |^2 glc	-CH_3	-H	-OH	-H	-H	[4]
2	-glc^6-rham	-glc^6-rham |^2 glc	-CH_3	-H	-OH	-H	-H	[4]
3	-glc^6-glc	-glc^2-glc	-CH_3	-H	-OH	-H	-H	[4]
4	-glc^6-xyl	-glc^2-glc	-CH_3	-H	-OH	-H	-H	[4]
5	-glc^6-rham	-glc^2-glc	-CH_3	-H	-OH	-H	-H	[4]
6	-glc	-glc^6-rham |^2 glc	-CH_3	-H	-OH	-H	-H	[4]
7	-glc^6-rham	-glc^6-rham	-CH_3	-H	-OH	-H	-H	[4]
8	-glc	-glc^2-glc	-CH_3	-H	-OH	-H	-H	[4]
9	-glc^6-xyl	-glc	-CH_3	-H	-OH	-H	-H	[4]
10	-glc^6-rham	-glc	-CH_3	-H	-OH	-H	-H	[4]
11	-glc	-glc^6-rham	-CH_3	-H	-OH	-H	-H	[4]
12	-glc	-glc	-CH_3	-H	-OH	-H	-H	[4]
13	-glc^6-xyl	-H	-CH_3	-H	-OH	-H	-H	[4]
14	-glc^6-rham	-H	-CH_3	-H	-OH	-H	-H	[4]
15	-glc^6-xyl	-glc^2-xyl	-CH_3	-H	-OH	-H	-H	[5]
16	-glc^6-rham	-glc^2-xyl	-CH_3	-H	-OH	-H	-H	[5]
17	-glc^6-glc	-glc	-CH_3	-H	-OH	-H	-H	[5]
18	-glc^6-xyl	-ara^2-glc	-CH_3	-H	-OH	-H	-H	[12]
19	-glc^6-glc	-H	-CH_3	-H	-OH	-H	-H	[16]
20	-glc^6-rham	-glc^6-rham |^2 glc	-CH_3	-H	-OH	-OH	-H	[5]
21	-glc^6-rham	-glc^2-glc	-CH_3	-H	-OH	-OH	-H	[5]
22	-glc^2-glc	-glc^6-rham |^2 glc	-CH_3	-H	-OH	-OH	-H	[5]
23	-glc^6-xyl	-H	-CH_3	-H	-OH	-OH	-H	[5]
24	-glc^6-xyl	-glc^2-glc	-CH_3	-H	-OH	-OH	-H	[14]
25	-glc^2-glc	-glc^{2}glc |$^{6''}$ $COCH_2COOH$	-CH_3	-H	-OH	-H	-H	[20]
26	-glc	-glc^{2}glc |$^{6''}$ $COCH_2COOH$	-CH_3	-H	-OH	-H	-H	[20]
27	-glc^6-rham	-glc^{2}glc |$^{6''}$ $COCH_2COOH$	-CH_3	-H	-OH	-H	-H	[20]
28	-H	-glc^2-glc	-CH_2OH	-H	-OH	-H	-H	[6]
29	-H (*R*)	-glc^2-glc	-CH_2OH	-H	-OH	-H	-H	[6]
30	-H (*R*)	-glc^2-glc	-CHO	-H	-OH	-H	-H	[6]
31	-H (*R*)	-ara^2-glc	-CHO	-H	-OH	-H	-H	[9]
32	-H	-ara^2-glc	-CH_2OH	-H	-OH	-H	-H	[9]
33	-glc^6-xyl	-glc^2-glc	-CH_2OH	-H	-OH	-H	-H	[13]

（续表 1）

序号	R_1	R_2	R_3	R_4	R_5	R_6	R_7	文献
34	-glc^6-xyl	-glc	-CH_2OH	-H	-OH	-H	-H	[13]
35	-glc^6-xyl	-H	-CH_2OH	-H	-OH	-H	-H	[15]
36	-glc^6-rham	-H	-CH_2OH	-H	-OH	-H	-H	[15]
37	-glc	-glc^6-rham	-CH_2OH	-H	-OH	-H	-H	[15]
38	-glc	-H	-CH_2OH	-H	-OH	-H	-H	[16]
39	-glc^6-xyl	-glc^2-glc	-CH_2OH	-OH	-H	-H	-H	[7]
40	-H	-glc^2-glc	-CH_2OH	-Oglc	-H	-H	-H	[7]
41	-H	-glc^2-glc	-CHO	-Oglc	-H	-H	-H	[7]
42	-H	-ara^2-glc	-CHO	-Oglc	-H	-H	-H	[8]
43	-glc	-ara^2-glc	-CHO	-OH	-H	-H	-H	[8]
44	-H	-glc^2-glc	-CH_2OH	-H	-H	-H	-H	[6]
45	-H	-glc^2-glc	-CHO	-H	-H	-H	-H	[6]
46	-H	-ara^2-glc	-CHO	-H	-H	-H	-H	[8]
47	-glc	-glc	-CH_2OH	-OH	-H	-H	-H	[7]
48	-H	-glc^2-glc	-CH_2OH	-OH	-H	-H	-H	[7]
49	-H	-glc	-CH_2OH	-Oglc	-H	-H	-H	[7]
50	-H	-glc^2-glc	-CHO	-OH	-H	-H	-H	[7]
51	-glc^6-rham	-glc^2-glc	-CHO	-OH	-H	-H	-H	[8]
52	-glc^6-xyl	-glc^2-glc	-CHO	-OH	-H	-H	-H	[8]
53	-glc^6-rham	-ara^2-glc	-CHO	-H	-H	-H	-H	[9]
54	-glc^6-xyl	-ara^2-glc	-CHO	-H	-H	-H	-H	[9]
55	-H(20*R*)	-glc^2-glc	-CH_2OH	-H	-H	-H	-H	[6]
56	-H	-ara^2-rham ^{3}glc	-CHO	-Oglc	-H	-H	-H	[11]
57	-H	-ara^2-rham ^{3}xyl	-CHO	-Oglc	-H	-H	-H	[11]
58	-H	-ara^2-rham	-CHO	-Oglc	-H	-H	-H	[11]
59	-glc^6-xyl	-glc	-CH_2OH	-H	-H	-H	-H	[6]
60	-glc^6-xyl	-glc^2-glc	-CH_2OH	-H	-H	-H	-H	[13]
61	-glc	-glc	-CH_2OH	-H	-H	-H	-H	[15]
62	-H	-ara^2-rham ^{3}xyl	-CHO	-OH	-H	-H	-H	[21]
63	-glc	-glc^2-glc	-CH_2OH	-H	-H	-H	-H	[22]
64	-glc	-glc^2-glc	-CHO	-H	-H	-H	-H	[22]
65	-H	^{6}($COCH_3$) -glc^2-rham ^{3}xyl	-CH_3	-Oglc	-H	-H	-H	[23]
66	-H	-glc^2-rham ^{3}xyl	-CH_3	-Oglc	-H	-H	-H	[23]
67	-H	-glc^2-rham ^{3}xyl	-CH_3	-Oglc	-H	-H	-H	[23]
68	-H	-ara^2-rham ^{3}xyl	-CH_2OH	-Oglc	-H	-H	-H	[23]

（续表 1）

序号	R_1	R_2	R_3	R_4	R_5	R_6	R_7	文献
69	-H	-glc^2-rham ^{3} xyl	$-CH_2OH$	-Oglc	-H	-H	-H	[23]
70	-glc^6-rham	-glc^2-glc	$-CH_2OH$	-H	-H	-H	-H	[24]
71	-glc^6-rham	-glc^2-glc	-CHO	-H	-H	-H	-H	[24]
72	-glc	-ara^2-glc	-CHO	-H	-H	-H	-H	[24]
73	-H	-glc^2-rham ^{3} xyl	$-CH_3$	-OH	-H	-H	-H	[25]
74	-H	-ara^2-rham ^{3} glc	$-CH_3$	O-glc^6-glc	-H	-H	-H	[26]
75	-H	rham ^{6} -glc^2-rham ^{3} rham	$-CH_3$	-H	=O	-H	-H	[35]
76	-H	-ara^2-rham ^{3} glc	$-CH_3$	-Oglc	=O	-H	-H	[26]
77	-H	-xyl^2-rham ^{3} glc	$-CH_3$	-Oglc	=O	-H	-H	[26]
78	-glc	-H	$-CH_3$	-H	-OH	-H	-OH	[27]
79	-glc^6-rham	-H	$-CH_3$	-H	-OH	-H	-OH	[27]
80	-glc^6-glc	-glc^2-glc	$-CH_3$	-H	-OH	-H	-OH	[10]
81	-glc^6-rham	-glc^2-glc	$-CH_3$	-H	-OH	-H	-OH	[10]
82	-glc^6-glc	-glc	$-CH_3$	-H	-OH	-H	-OH	[10]
83	-glc^6-rham	-glc	$-CH_3$	-H	-OH	-H	-OH	[10]
84	-glc	-glc^2-glc	$-CH_3$	-H	-OH	-H	-OH	[10]
85	-glc^6-rham	-glc^2-glc	$-CH_3$	-H	-OH	-OH	-OH	[11]
86	-H	-glc^2-glc	$-CH_3$	-H	-OH	-H	-OH	[11]
87	-H (*R*)	-glc^2-glc	$-CH_3$	-H	-OH	-H	-OH	[11]
88	-glc^6-xyl	-glc^2-glc	$-CH_3$	-H	-OH	-H	-OH	[12]
89	-glc^6-xyl	-glc	$-CH_3$	-H	-OH	-H	-OH	[12]
90	-glc^6-xyl	-H	$-CH_3$	-H	-OH	-H	-OH	[12]
91	-glc^6-xyl	-glc^2-glc	$-CH_3$	-H	-OH	-OH	-OH	[13]
92	-glc^6-xyl	-glc^2-glc	$-CH_2OH$	-H	-H	-H	-OH	[13]
93	-glc^6-rham	-glc	$-CH_3$	-H	-H	-H	-OH	[15]
94	-glc^6-glc	-H	$-CH_3$	-H	-OH	-H	-OH	[16]
95	-glc^6-xyl	-H	$-CH_3$	-H	-OH	-H	-OH	[16]
96	-glc^6-xyl	-H	$-CH_3$	-H	-H	-H	-OH	[16]
97	-glc^6-xyl	-glc	$-CH_3$	-H	-H	-H	-OH	[28]
98	-glc	-glc	$-CH_3$	-H	-OH	-H	-OH	[29]
99	-glc^6-xyl	-glc^4-glc	$-CH_3$	-H	-OH	-H	-OH	[30]
100	$COCH_3$ ^{6} -glc^2-glc	-glc	$-CH_3$	-H	-OH	-H	-OH	[30]
101	-glc^6-rham	-glc^2-glc	$-CH_3$	-H	=O	-H	-OH	[22]
102	-glc^6-xyl	-glc^2-glc	$-CH_3$	-H	=O	-H	-OH	[22]

表 2 第二类绞股蓝皂苷

Table 2 Second category of saponins from *G. pentaphyllum*

序号	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	文献
103	-H	-glc^{2}-glc	-CH_3	-H	-H	-H	-H	-CH_2OH	[6]
104	-H (*R*)	-glc^{2}-glc	-CH_3	-H	-H	-H	-H	-CH_2OH	[6]
105	-H (*R*)	-ara^{2}-glc	-CH_3	-H	-H	-H	-H	-CHO	[9]
106	-rham	-ara^{2}-glc	-CH_3	-H	-H	-OH	-Oglc	-H	[31]
107	-H	-ara^{2}rham ^{1}|$_{3}$ xyl	-CHO	-H	-Oglc	-OOH	-H	-H	[32]
108	-glc^{6}-xyl	-glc^{2}-glc	-CH_3	-OH	-H	-OOH	-H	-H	[23]
109	-H	-ara^{2}-rham ^{1}|$_{3}$ xyl	-CHO	-H	-OH	-OOH	-H	-H	[21]
110	-H	-glc^{2}-rham ^{1}|$_{3}$ xyl	-CH_3	-H	-Oxyl	-OCH_3	-H	-H	[21]
111	-H	-ara^{2}-rham ^{1}|$_{3}$ glc	-CH_3	=O	-Oglc	-OH	-H	-H	[26]

表 3 第三类绞股蓝皂苷

Table 3 Third category of saponins from *G. pentaphyllum*

序号	R_1	R_2	R_3	R_4	R_5	R_6	R_7	文献
112	-glc^{6}-xyl	-glc^{2}-glc	-H	-CH_3	-OH	-H	-H	[14]
113	-H	-ara^{2}-glc	-H	-CH_3	-H	-Oglc	-rham	[31]
114	-H	-ara^{2}rham ^{1}|$_{3}$ xyl	-H	-CHO	-H	-Oglc	-H	[23]
115	-glc	-H	-OH	-CH_3	-OH	-H	-H	[32]
116	-glc^{6}-xyl	-glc^{2}-xyl	-OH	-CH_3	-OH	-H	-OH	[28]

表 4 第四类绞股蓝皂苷

Table 4 Forth category of saponins from *G. pentaphyllum*

序号	R_1	R_2	R_3	文献
117	-rham (*S*)	-ara^{2}-glc	-CH_3	[31]
118	-rham (*R*)	-ara^{2}-glc	-CH_3	[31]
119	-H (*S*)	^{COCH_3} ^{6}| -glc^{2}rham ^{1}|$_{3}$ xyl	-CH_3	[33]
120	-H (*R*)	^{COCH_3} ^{6}| -glc^{2}rham ^{1}|$_{3}$ xyl	-CH_3	[33]
121	-H (*S*)	-glc^{2}rham ^{1}|$_{3}$ xyl	-CH_3	[33]
122	-H (*R*)	-glc^{2}rham ^{1}|$_{3}$ xyl	-CH_3	[33]
123	-H (*S*)	-glc^{2}rham ^{1}|$_{3}$ glc	-CH_3	[33]
124	-H (*R*)	^{COCH_3} ^{3}| -glc^{2}rham ^{6}|^{1} |^{4} xyl $COCH_3$	-CH_3	[33]
125	-H (*R*)	-ara^{2}-rham ^{1}|$_{3}$ xyl	-CHO	[34]

表 5 第五类绞股蓝皂苷

Table 5 Fifth category of saponins from *G. pentaphyllum*

序号	R_1	R_2	24 位	文献
126	-OH (S)	-glc^{2}-xyl	(*S*)	[21]
127	-H (S)	-glc^{6}-xyl		[36]
128	-H	-glc^{6}-glc	(*S*)	[36-37]
129	-H (R)	-glc^{2}-xyl		[36-37]
130	-OH (R)	-glc^{2}-xyl	(*S*)	[36-37]

表 6 第六类绞股蓝皂苷

Table 6 Sixth category of saponins from *G. pentaphyllum*

序号	R_1	R_2	文献
131	-OH	-glc^{2}xyl ^{6}|^{1} xyl	[23]
132	-OH	-glc^{2}glc ^{6}|^{1} xyl	[23]
133	-OH	-xyl^{2}-glc	[23]
134	-OH	-glc^{2}-xyl	[23]
135	-OAc	-xyl^{2}-xyl	[23]
136	-OAc	-glc^{2}-xyl	[23]
137	-OAc	-glc^{2}xyl ^{6}|^{1} xyl	[23]

表 7 第七类绞股蓝皂苷

Table 7 Seventh category of saponins from *G. pentaphyllum*

序号	R_1	R_2	R_3	文献
138	$-CH_3$	$COCH_3$ (6) -glc^{2}rham (3) xyl	-H	[38]
139	-CHO	-ara^{2}rham (3) xyl	-H	[38]
140	$-CH_3$	-ara^{2}rham (3) glc	-OH	[26]
141	$-CH_3$	-ara^{2}rham (3) glc	=O	[26]

表 8 第八类绞股蓝皂苷

Table 8 Eighth category of saponins from *G. pentaphyllum*

序号	R_1	R_2	R_3	R_4	21 位	文献
142	-H	-ara^{2}rham (3) xyl	-CHO	-H		[38]
143	-H	-glc^{2}rham (3) xyl	$-CH_3$	-H		[38]
144	-H	OAc (6) -glc^{2}rham (3) xyl	$-CH_3$	-H		[38]
145	-Et	-ara^{2}rham (3) xyl	-CHO	-H		[38]
146	-Et	-glc^{2}rham (3) xyl	$-CH_3$	-H		[38]
147	-H	-lyx^{2}glc (3) rham	$-CH_3$	-H		[39]
148	-H	-ara^{2}rham (3) xyl	-CHO	-OH	(*S*)	[34]
149	-*n*-Bu	-ara^{2}rham (3) xyl	$-CH_3$	-H	(*R*)	[40]
150	-*n*-Bu	-glc^{2}rham (3) xyl	$-CH_3$	-H	(*R*)	[41]
151	-*n*-Bu	-glc^{2}rham (3) xyl	$-CH_3$	-H	(*S*)	[41]
152	-*n*-Bu	-ara^{2}rham (3) xyl	-CHO	-H	(*R*)	[41]
153	-*n*-Bu	-ara^{2}rham (3) xyl	-CHO	-H	(*S*)	[41]
154	-H	-ara^{2}rham (3) xyl	$-CH_3$	-OH		[26]

表 9 第九类绞股蓝皂苷

Table 9 Ninth category of saponins from *G. pentaphyllum*

序号	R_1	R_2	文献
155	$-CH_3$	OAc (6) -glc^{2}rham (3) xyl	[38]
156	-CHO	-ara^{2}rham (3) xyl	[38]

表 10 第十二类绞股蓝皂苷

Table 10 Twelfth category of saponins from *G. pentaphyllum*

序号	R_1	R_2	R_3	R_4	文献
159	-rham	-rham	-glc^{6}rham (2) glc	-OH	[42]
160	-rham	-rham	-glc^{2}glc	-OH	[42]
161	-rham	-xyl	-glc^{6}rham (2) glc	-OH	[42]
162	-rham	-rham	-glc^{6}rham (2) glc	-H	[42]
163	-rham	-glc	-glc^{6}rham (2) glc	-H	[42]
164	-rham	-glc	-glc^{2}glc	-H	[42]
165	-rham	-xyl	-glc^{6}rham (2) glc	-H	[42]

2 展望

皂苷类成分在绞股蓝植物中大量存在，苷元主要是达玛烷型四环三萜类。目前，国内外学者对绞股蓝皂苷的研究取得了一定进展，并且不断有新化合物被报道。我国绞股蓝植物资源丰富，如能进一步调查研究，大力发掘新的结构类型及新的绞股蓝皂苷，深入展开生物活性的研究，必将使绞股蓝的深度开发与利用迈上新的台阶，对于提高人民群众健康和促进国民经济发展都具有重要意义。

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