茄科野生蔬菜的研究进展

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摘　要:茄科野生蔬菜为水茄、野茄、刺天茄、枸杞、少花龙葵和旋花茄,茄科野生蔬菜含有生物碱类、甾类、黄酮类、萜类等多种化学成分,本文综述近几十年来国内外对茄科野生蔬菜化学成分、生物活性及安全性的研究概况,对茄科野生蔬菜的进一步开发利用提供相关参考。

关键词:茄科野生蔬菜;化学成分;生物活性

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Research progress on Solanaceae wild vegetables

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Abstract: Solanaceae wild vegetables are *Solanum torvum* Swartz, *S. coagulans*, *S. indicum*, *Lycium chinense*, *S. nigrum* var. *photeinocarpum* and *S. spirale*, which contain a variety of chemical constituents such as alkaloids, terpenoids, flavonoids and terpene. This paper reviews the research on the chemical constituents, biological activities and safety of Solanaceae wild vegetables in recent decades, and provides reference for further development and use of Solanaceae wild vegetables.

Key words: Solanaceae wild vegetables; chemical constituent; biological activity

茄科植物是最具有经济价值的植物类群中的一种,例如土豆可以被人类作为粮食,枸杞、天仙子等可作药用,而茄子、西红柿等可以当做蔬菜食用,酸浆、人参果作为维生素含量极高的水果,像碧冬茄、夜香树等可供人们观赏使用。在中国,人们对于茄科蔬菜的需求量很大,茄子、马铃薯、番茄等都是日常餐桌上常见的蔬菜。在云南地区,由于少数民族众多,其饮食文化也各有差异,除引种的马铃薯、茄等蔬菜外,一些原生或引种的植物也被当作野菜食用,其中果实部位可食用的有水茄(*Solanum torvum* Swartz.)、野茄(*S. coagulans*)、刺天茄(*S. indicum*),茎叶部位可食用的有枸杞(*Lycium chinense*)、少花龙葵(*S. nigrum* var. *photeinocarpum*)、旋花茄(*S. spirale*)。茄科野生蔬菜按食用部位来分类,可分为果实类野菜和茎叶类野菜两种。果实作为食用部位的有水茄、野茄和刺天茄。水茄分布于我国云南、广西、台湾等地,全年可采,食用方法炒食或油炸,药用部位为根部[1]。野茄分布于云南、广东、台湾等地,7~10 月可采,食用方法烤食或炒食,可将果实蒸熟,蘸佐料食用,也可去种子后生食,全草可药用[2,3]。刺天茄主要产于我国云贵川等地,7~10 月可采,食用方法为炒食,全草可药用[4]。茎叶类作为食用部位的有枸杞、少花龙葵和旋花茄。枸杞在中国全国各地均有分布,嫩茎叶 3~10 月可采,食用方法可炒或做汤,亦可用嫩茎叶炒鸡蛋,药用部位为果实和嫩茎叶[5,6]。少花龙葵产于我国云南南部、广西、湖南等地,嫩茎叶全年可采,食用方法可炒食、单独做汤或与其他野菜混合做成杂菜汤,其药用部位为嫩茎叶[7]。旋花茄产于云南、广西、湖南,嫩茎叶全年可采,食用方法可嫩叶与鸡蛋一起拌均匀后油炸,全株皆可药用[8]。

茄科植物多含有生物碱,茄科野生蔬菜有些部位也存在有毒生物碱,作为蔬菜食用的时候需谨慎,以免中毒。茄科野生蔬菜除了实用价值外还有清热解毒、活血化瘀、利湿健胃等功效,对疔疮肿痛、感冒发烧、跌打损伤等都有一定的疗效。

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1 茄科野生蔬菜的化学成分

1.1 生物碱类化合物

生物碱(alkaloids)是存在于生物体内的由不同的氨基酸或其直接衍生物合成而来次级代谢物,是一种碱性含氮化合物,多数具有复杂的含氮杂环。生物碱的种类很多,有甾体类生物碱、吡咯类生物碱、有机胺类生物碱、托品类生物碱等。刺天茄中含有毒性极大的澳洲茄胺、澳洲茄碱、澳洲茄边碱(**1**~**3**)这些甾体生物碱,毒性大且食用有毒,所以只有在云南西双版纳和德宏地区少有食用。旋花茄的果实中也含有多种甾体生物碱(**4**~**11**),所以一般只食用旋花茄的叶子而不吃果实。枸杞中含许多吡咯类生物碱(**12**~**20**)和托品类生物碱(**29** 和 **30**),食用也应谨慎。茄科野生蔬菜中的生物碱类化合物见表 1 和图 1。

表 1 茄科野生蔬菜中的生物碱类化合物

Table 1 Alkaloids in Solanaceae wild vegetables

序号 No.	名称 Name	来源 Source
1	Solasodine	*S. indicum* L.[9-11]
2	Solamargine	*S. indicum* L.[9-11]
3	Solasonine	*S. indicum* L.[9-11]
4	(20*R*,25*S*)-23,26-Epimino-3β,16α-dihydroxycholesta-5,23(*N*)-dien-22-one	*S. spirale*[12]
5	3-*O*-(β-*D*-glucopyranosyl) etioline[(25*S*)-22,26-epimino-3β-(β-*D*-glucopyranosyloxy) cholesta-5,22(*N*)-dien-16α-ol]	*S. spirale*[12]
6	Etioline	*S. spirale*[12]
7	Spiraloside A	*S. spirale*[13]
8	Spiraloside B	*S. spirale*[13]
9	Spiraloside C	*S. spirale*[13]
10	Tomatidenol	*S. spirale*[14]
11	Droxytomatidenol	*S. spirale*[14]
12	3-[2-formyl-5-(hydroxymethyl)-1*H*-pyrrol-1-yl] Pentanedioic acid	*L. barbarum*[15]
13	(2*R*)-[2-formyl-5-(hydroxymethyl)-1*H*-pyrrol-1-yl]-1-methoxy-1-oxobutanoic acid	*L. barbarum*[15]
14	Methyl (2*R*)-[2-formyl-5-(methoxymethyl)-1*H*-pyrrol-1-yl]-4-methylpentanoate	*L. barbarum*[15]
15	Methyl (2*R*)-[2-formyl-5-(methoxymethyl)-1*H*-pyrrol-1-yl]-3-(phenyl) propanoate	*L. barbarum*[15]
16	(2*S*)-[2-formyl-5-(hydroxymethyl)-1*H*-pyrrol-1-yl]-3-Methylbutanoic acid	*L. barbarum*[15]
17	Methyl 2-[2-formyl-5-(methoxymethyl)-1*H*-pyrrol-1-yl] propanoate	*L. barbarum*[16]
18	Methyl 2-[2-formyl-5-(methoxymethyl)-1*H*-pyrrol-1-yl]-3-(4-hydroxyphenyl) propanoate	*L. barbarum*[16]
19	Dimethyl 2-[2-formyl-5-(methoxymethyl)-1*H*-pyrrol-1-yl] butanedioate	*L. barbarum*[16]
20	Dimethyl 2-[2-formyl-5-(methoxymethyl)-1*H*-pyrrol-1-yl] pentanedioate	*L. barbarum*[16]
21	Kukoamine A	*L. barbarum*[17]
22	Kukoamine B	*L. barbarum*[17]
23	Indicumine A	*S. indicum* L.[1]
24	Indicumine B	*S. indicum* L.[1]
25	*N*-(*p*-trans-coumaroyl) Tyramine	*S. indicum* L.[18]
26	*N*-Trans-feruloyltyramine	*S. indicum* L.[18]
27	*N*-*p*-Coumaroyltyramine	*S. coagulans*[2]
28	甜菜碱	*L. barbarum*[5]
29	Atropine	*L. barbarum*[5]
30	天仙子胺	*L. barbarum*[5]

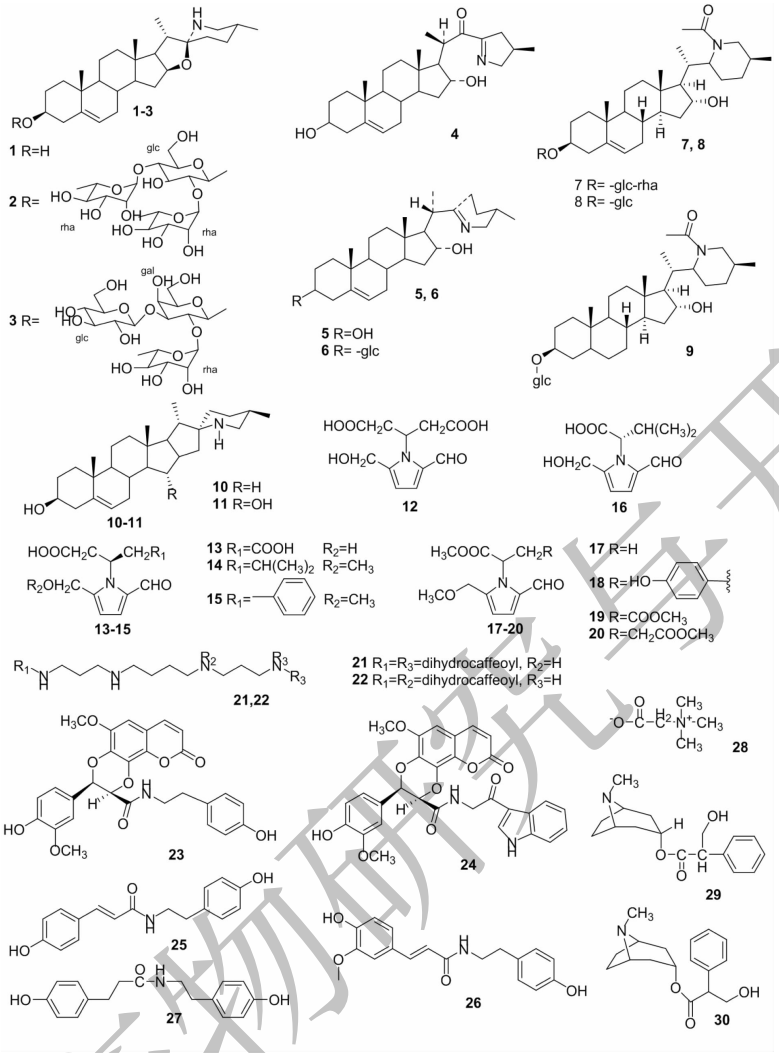

图 1 茄科野生蔬菜中的生物碱类化合物

Fig. 1 Alkaloids in Solanaceae wild vegetables

1.2 甾体类化合物

茄科野生蔬菜中有大量甾体类化合物,大多数为甾体皂苷,包括螺甾烷醇型、异螺甾烷醇型、呋甾烷醇型、变形螺甾烷醇型以及其他类型。水茄中含有大量的甾体糖苷,且与普通的甾体糖苷不同,水茄中的甾体糖苷大多在 6 位连糖而不在 3 位,这也是水茄中甾体糖苷的一个特色,6 位糖苷基主要有葡萄糖、鼠李糖、鸡纳糖和木糖。枸杞主要含 C21 甾类(**66 ~ 76**),且 3 位糖苷基中是一种稀有的去氧糖毛地黄毒糖(*β-D*-digitoxopyranos)。茄科野生蔬菜的甾类化合物见表 2、图 2 和图 3。

表 2 茄科野生蔬菜中的甾体类化合物

Table 2 Steroids in Solanaceae wild vegetables

编号 No.	名称 Name	来源 Source
31	Torvoside C	*S. torvum*[19]
32	Torvoside D	*S. torvum*[19]
33	26-Degluco-torvoside A	*S. torvum*[20]
34	(25*S*)-6α-Hydroxy-5α-spirostan-3-one 6-*O*-[α-*L*-rhamnopyranosyl-(1→3)-β-*D*-quinovopyranoside]	*S. torvum*[21]

续表 2(Continued Tab. 2)

编号 No.	名称 Name	来源 Source
35	Torvogenin	*S. torvum*[22]
36	(25*R*)-3β,6β-Dihydroxy-5α-spirostan-23-one	*S. torvum*[22]
37	Paniculogenin	*S. torvum*[22]
38	Chlorogenin	*S. torvum*[22]
39	(25*S*)-3β-Hydroxy-5α-spirostan-6α-yl-*O*-β-*D*-xylopyranoside	*S. torvum*[23]
40	(25*S*)-3-Oxo-5α-spirostan-6α-yl-*O*-β-*D*-xylopyranoside	*S. torvum*[23]
41	(25*S*)-3β-Hydroxy-5α-spirostan-6α-yl-*O*-β-*D*-glucopyranoside	*S. torvum*[23]
42	Torvoside Q	*S. torvum*[24]
43	Torvoside A	*S. torvum*[19]
44	Torvoside B	*S. torvum*[19]
45	Torvonin A	*S. torvum*[25]
46	Torvonin B	*S. torvum*[26]
47	Torvosides M	*S. torvum*[27,28]
48	Torvosides N	*S. torvum*[27,28]
49	Indioside A	*S. indicum* L.[9]
50	Indioside F	*S. indicum* L.[9]
51	Neochlorogenin-6-*O*-β-*D*-xylopyranosyl-(1→3)-β-*D*-quinovopyranoside	*S. coagulans*[2]
52	Neochlorogein-6-*O*-α-*L*-rhamnpyranosyl(1→3)-β-*D*-Quinovopyranoside	*S. coagulans*[2]
53	Torvoside E	*S. torvum*[19]
54	Torvoside F	*S. torvum*[19]
55	Torvoside H	*S. torvum*[21]
56	Torvoside A	*S. torvum*[21]
57	(25*S*)-26-(β-*D*-glucopyranosyloxy)-3-Oxo-22α-methoxy-5α-furostan-6α-yl-*O*-β-*D*-xylopyranoside	*S. torvum*[23]
58	(25*S*)-26-(β-*D*-glucopyranosyloxy)-3β-Hydroxy-22α-methoxy-5α-furostan-6α-yl-*O*-α-*L*-rhamnopyranosyl-(1→3)-β-*D*-glucopyranoside	*S. torvum*[23]
59	Torvoside O	*S. torvum*[29]
60	Indioside B	*S. indicum* L.[9]
61	Indioside C	*S. indicum* L.[9]
62	Indioside D	*S. indicum* L.[9]
63	26-*O*-β-*D*-Glucopyranosyl-(25*R*)-furost-3β,22ξ,26-triol-5-ene-3-*O*-α-*L*-rhamnopyranosyl-(1-2)-[α-*L*-Rhamnopyranosyl-(1-4)]-β-*D*-glucopyranoside	*S. spirale*[8]
64	26-*O*-β-*D*-Glucopyranosyl-(25*R*)furost-22ξ-methoxyl-3β,26-diol-5-ene-3-*O*-α-L-rhamnopyranosyl-(1-2)-β-*D*-glucopyranoside	*S. spirale*[8]
65	26-*O*-β-*D*-glucopyranosyl-(25*R*)-furost-3β,22ξ,26-triol-5-ene-3-α-*L*-rhamnopyranosyl-(1-2)-[3-*O*-(3-*O*-acetyl)-α-*L*-rhamnopyranosyl-(1-4)]-β-*D*-glucopyranoside	*S. spirale*[8]
66	Lyciumsterol A	*L. barbarum*[30]
67	Lyciumsterol B	*L. barbarum*[30]
68	Lyciumsterol C	*L. barbarum*[30]
69	Lyciumsterol D	*L. barbarum*[30]
70	Lyciumsterol E	*L. barbarum*[30]
71	Lyciumsterol F	*L. barbarum*[30]
72	Lyciumsterol G	*L. barbarum*[30]
73	Lyciumsterol H	*L. barbarum*[30]

续表 2(Continued Tab. 2)

编号 No.	名称 Name	来源 Source
74	Lyciumsterol I	*L. barbarum*[30]
75	Lyciumsterol J	*L. barbarum*[30]
76	Lyciumsterol K	*L. barbarum*[30]
77	Torvoside P	*S. torvum*[29]
78	(25*S*)-26-(*β*-*D*-glucopyranosyloxy)-3-oxo-5*α*-furost-20 (22)-en-6*α*-yl-*O*-*β*-*D*-xylopyranoside	*S. torvum*[23]
79	25(*S*)-26-*O*-*β*-D-Glucopyranosyl-5*α*-furost-22(20)-en-3*β*,6*α*,26-triol-6-*O*-[*α*-*L*-rhamnopyranosyl-(1 → 3)-*O*-*β*-*D*-quinovopyranoside]	*S. torvum*[31]
80	25(*S*)-26-*O*-*β*-*D*-glucopyranosyl-5*α*-furost-22(20)-en-3-one-6*α*,26-diol-6-*O*-[*α*-*L*-rhamnopyranosyl(1 → 3)-*O*-*β*-*D*-quinovopyranoside]	*S. torvum*[31]
81	25(*S*)-26-*O*-*β*-*D*-Glucopyranosyl-5*α*-furost-22(20)-en-3*β*,6*α*,26-triol-6-*O*-*β*-*D*-quinovopyranoside	*S. torvum*[31]
82	Solanolactoside A	*S. torvum*[27,28]
83	Solanolactoside B	*S. torvum*[27,28]
84	Solanolactoside C	*S. torvum*[32]
85	Tovoside J	*S. torvum*[33]
86	Tovoside K	*S. torvum*[33]
87	Tovoside L	*S. torvum*[33]
88	Neochlorogenin	*S. torvum*[34]
89	Neosolaspigenin	*S. torvum*[34]
90	Solaspigenin	*S. torvum*[34]
91	(22*R*,23*S*,25*R*)-3*β*,6*α*,23-Trihydroxy-5*α*-spirostane 6-*O*-*β*-*D*-xylopyranosyl (1→3)-*β*-*D*-quinovopyranoside	*S. coagulans*[2]
92	(22*R*,23*R*,25*S*)-3*β*,6*α*,23-Trihydroxy-5*α*-spirostane 6-*O*-*β*-*D*-xylopyranosyl *β*-*D*-quinovopyranoside	*S. coagulans*[2]
93	(25*S*)-3*β*,27-Dihydroxy-5*α*-spirostan-6*α*-yl-*O*-*β*-D-glucopyranoside	*S. torvum*[23]
94	Torvpregnanoside A	*S. torvum*[24]
95	Torvpregnanoside B	*S. torvum*[24]
96	5*α*-Pregn-16-en-3,20-dione-6*α*-ol-6-*O*-[*α*-*L*-rhamnopyranosyl-(1 → 3)-*β*-*D*-quinovopyranoside]	*S. torvum*[31]
97	谷甾醇	
98	3-*O*-[*β*-*D*-(6′-nonadeanoate) glucopyranosyl]-*β*-sitosterol	*S. torvum*[22]
99	Stigmast-5-en-3*β*-ol-3-*O*-*β*-D-(20-*n*-triacontanoyl) glucopyranoside	*L. barbarum*[35]
100	Torvoside G	*S. torvum*[19]
101	Torvoside B	*S. torvum*[28]
102	Smilaxchinoside A	*S. coagulans*[3,36]
103	Methylprotodioscin	*S. coagulans*[3,37]
104	Protodioscin	*S. coagulans*[3,38]
105	Anguiviosides XV	*S. coagulans*[3,39]

1.3 黄酮类化合物

黄酮类化合物广泛存在于自然界,是一类重要的天然有机化合物,茄科野生蔬菜中黄酮类成分以黄酮类的槲皮素和黄酮苷类的芦丁居多。茄科野生蔬菜的黄酮类化合物见表 3 和图 4。

1.4 其他成分

茄科野生蔬菜中除了以上三种成分外,还包含其他类型的化合物,如萜类化合物[46]、木脂素类[47]、香豆素类[1,21,42,48]、有机酸及其衍生物[49-52]等。

2 茄科野生蔬菜的生物活性

2.1 抗肿瘤活性

刺天茄(*Solanum indicum* L.)全株的 EtOH 提取物对结肠癌 Colo-205 细胞、子宫颈癌 HeLa 细胞、

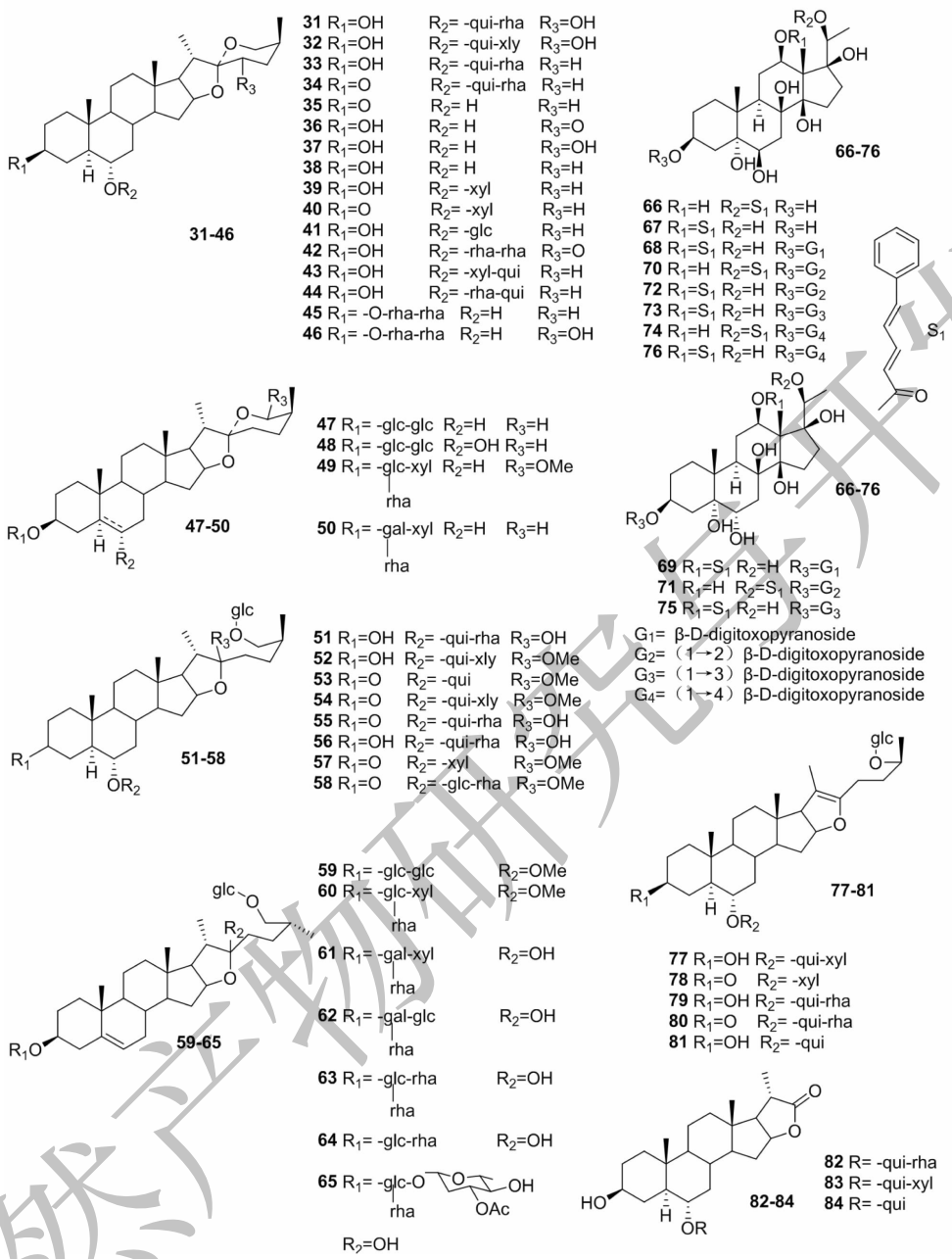

图 2 茄科野生蔬菜中的甾体类化合物

Fig. 2 Steroids in Solanaceae wild vegetables

肝细胞瘤 HA22T 细胞、神经胶质瘤等肿瘤细胞有一定的细胞毒活性。从刺天茄中分离得到的薯蓣皂苷等在 C_6 经胶质瘤细胞培养试验中也表现出细胞毒活性[10]。水茄(*Solanum torvum* Swartz)的 10% EtOH 提取部位在体外具有较强的抗肿瘤活性,10% EtOH 洗脱部位,对 Tca8113 细胞的抑制作用最强,其 IC50 值为 34.26 ± 6.84 mg/L[53]。不同浓度的枸杞叶总黄酮能诱导人肝癌细胞 HepG2 凋亡,所以枸杞叶的黄酮类成分表现出抗肿瘤活性[36]。

2.2 抗病毒活性

Arthan 等[21]对水茄(*Solanum torvum* Swartz)果实进行了研究,发现水茄中的异黄酮 torvanol A 和甾体糖苷 torvoside A 具有一定的抗病毒活性。

2.3 抗氧化活性

枸杞(*Lycium barbarum*)叶的水提物清除 DPPH 自由基效果明显,清除率为 50% 左右[54],具有良好的抗氧化活性。用枸杞叶进行了多项的动物试验,发现其增强了老年小鼠的运动耐力,提高了机体的

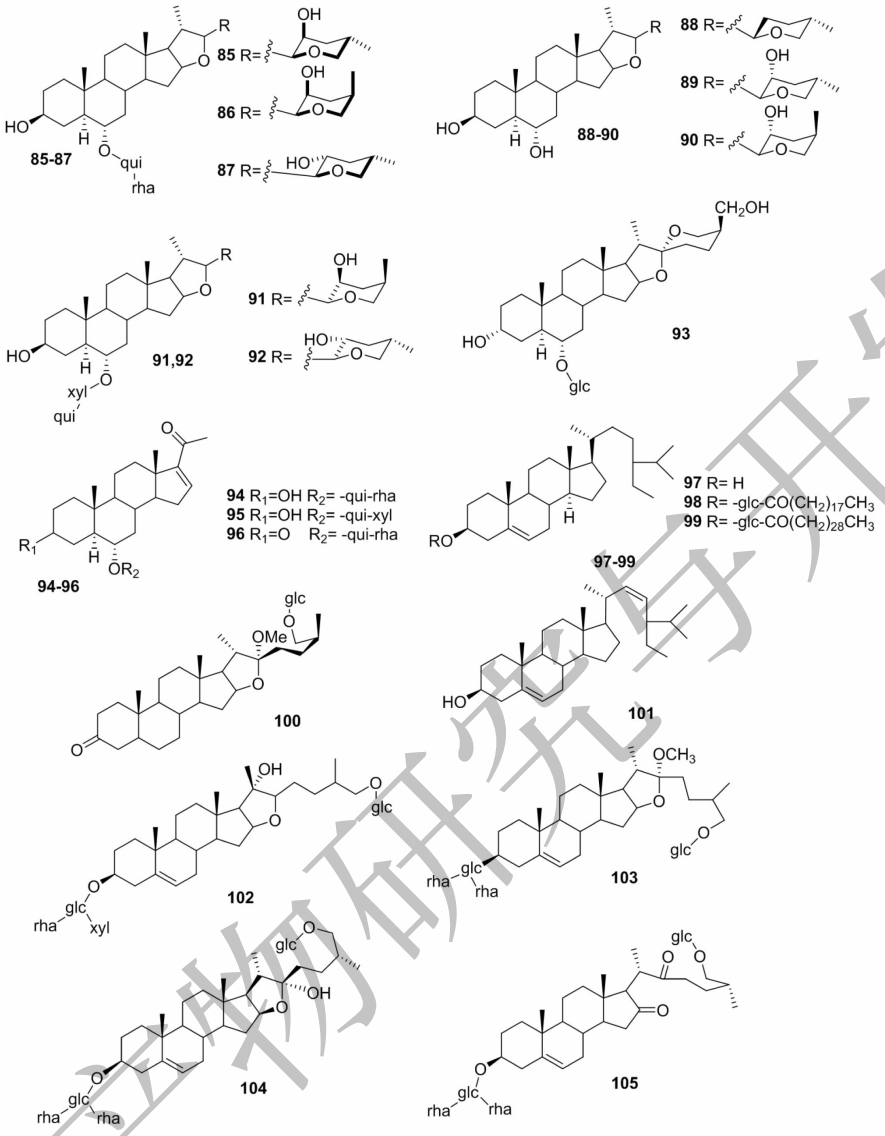

图 3 茄科野生蔬菜中的甾体类化合物

Fig. 3 Steroids in Solanaceae wild vegetables

表 3 野生蔬菜的黄酮类化合物

Table 3 Flavonoids in Solanaceae wild vegetables

编号 No.	名称 Name	来源 Source
106	Isorhamnetin 3-*O*-*β*-*D*-glucopyranoside	*S. torvum*[40]
107	槲皮素-3-*O*-*β*-*D*-吡喃葡萄糖苷	*S. torvum*[40]
108	山柰酚	*S. torvum*[41]
109	槲皮素	*S. torvum*[41] *L. barbarum*[42]
110	芦丁	*S. torvum*[43] *L. barbarum*[42] *S. nigrum* var. *photeinocarpum*[44]
111	5,7,4′-Trihydroxy-flavonol	*S. indicum* L.[45]
112	Quercetin 3-*O*-*β*-*D*-galactopyranoside	*S. coagulans*[2]

续表 3(Continued Tab. 3)

编号 No.	名称 Name	来源 Source
113	Brainoside B	*S. coagulans*[3]
114	Camsibriside A	*S. coagulans*[3]
115	3′,4′,5-三羟基-7-甲氧-6-C-*β*-*D*-葡萄糖黄酮苷	*S. coagulans*[3]
116	5,7,4′-Trihydroxyflavanone	*S. indicum* L.[45]

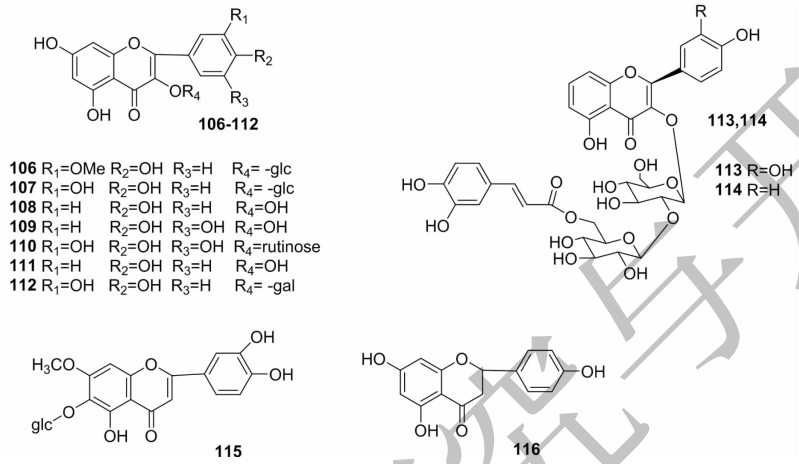

图 4 茄科野生蔬菜中的黄酮类化合物

Fig. 4 Flavonoids in Solanaceae wild vegetables

抗氧化能力[55]。

2.4 抑菌活性

Naimon 等[56]使用水茄(*Solanum torvum* Swartz)叶的 EtOH 提取物针对五种致病细菌(金黄色葡萄球菌,中间葡萄球菌,表皮葡萄球菌,蜡状芽孢杆菌和铜绿假单胞菌)测试提取物的抗菌活性,结果表明水茄叶的 EtOH 提取物对所有测试细菌表现出生长抑制,具有最小抑制浓度和最小杀菌浓度值,范围在 1.95 和 31.25 mg/mL,发现提取物对蜡状芽孢杆菌的最强抗菌活性。Kalita 等[57]使用水茄(*Solanum torvum* Swartz)果实的 EtOH 提取物,使用琼脂扩散法检测植物提取物的抗菌活性,乙醇的提取率为 20.28%,结果表明水茄的 EtOH 提取物具有抗菌活性。

2.5 抗癌活性

Keawsa 等[58]使用 KB-Oral、MCF-7 乳腺和 NCI-H187 肺癌细胞系,通过刃天青微孔板测定法(REMA)测定来自旋花茄(*Solanum spirale*)未成熟果实的精油的抗癌活性,结果显示,旋花茄的精油具有抗 MCF-7(乳腺癌)和 NCI-H187(小细胞肺癌)的抗癌活性。2015 年,Balachandran 等[50]使用水茄(*Solanum torvum* Swartz)果实中分出的咖啡酸甲酯进行抗癌活性研究,研究发现,咖啡酸甲酯通过细胞色素 C 从线粒体释放激活 Caspase 诱导 MCF-7(乳腺癌)细胞凋亡。

3 结语

茄科野生蔬菜既能作为食物供人食用,也能作为药物具有一定的药用价值,为药食同源类,在中医药学的传统之中,论药与食的关系是既有同处,亦有异处。但从发展过程来看,远古时代是同源的,后经几千年的发展,药食分化,若再往今后的前景看,也可能返璞归真,以食为药,以食代药。近年来对茄科野生蔬菜的研究发现,其具有生物碱、甾类、黄酮类、萜类等多种多样的化学成分及其生物活性,这些为今后的研究奠定了基础,茄科野生蔬菜的研究前景十分可观,所以继续深入地开展茄科野生蔬菜的食用安全性、化学成分的分离、生物活性及构效关系等的研究具有重大意义。

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