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Review

Systematic Review of Chemical Constituents in the Genus *Lycium* (Solanaceae)

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Abstract: The *Lycium* genus is widely used as a traditional Chinese medicine and functional food. Many of the chemical constituents of the genus *Lycium* were reported previously. In this review, in addition to the polysaccharides, we have enumerated 355 chemical constituents and nutrients, including 22 glycerogalactolipids, 29 phenylpropanoids, 10 coumarins, 13 lignans, 32 flavonoids, 37 amides, 72 alkaloids, four anthraquinones, 32 organic acids, 39 terpenoids, 57 sterols, steroids, and their derivatives, five peptides and three other constituents. This comprehensive study could lay the foundation for further research on the *Lycium* genus.

Keywords: *Lycium* genus; chemical constituents; goji berry; Lycii cortex

1. Introduction

Lycium is one of the genera in the Solanaceae family, comprising 80 species, seven of which are found in China [1]. These species are all deciduous shrubbery, possessing a highly similar morphology and structure. The *Lycium* genus has been an important source of medicines and nutrient supplements for thousands of years in Southeast Asia, especially in China. Two species in particular, *Lycium barbarum* and *Lycium chinense*, have been widely used as traditional Chinese medicinal herbs for centuries and *L. barbarum* is currently widely cultivated in China.

Goji berries (Chinese name Gouqizi), which are derived from the fruits of *Lycium* Linn, have been used as traditional herbs for a long time in China for their benefits of replenishing vital essence to improve eyesight, nourish the liver and kidneys. Lycii cortex is a "heat cleansing" drug that is derived from the root bark of *L. chinense* and *L. barbarum* [2]. Goji berries and Cortex Lycii have demonstrated good therapeutic effects in some chronic diseases such as hectic fever, night sweats, cough, hemoptysis, and diabetes. Recently, medical research has indicated that these fruits and root bark have many pharmacological functions, such as antiglaucoma, immunoregulatory, antitumor, antioxidant, antiaging, neuroprotective, and blood sugar level reducing activities [3–10].

Traditionally, the berry and root bark available have been used as medicinal sources, as well as important components in some traditional Chinese patent medicines. They are not only famous medical herbs, but are also functional foods widely consumed in health-preserving cuisines, i.e., soups, congee, herbal tea, etc. People also eat the fresh leaves as vegetables. In particular, goji berries have become increasingly popular for improving overall well-being and as an anti-aging remedy. There are many goji derived-products on health food market, such as dried fruits, juice, goji wine and goji yoghurt. Many research papers were published focused on the phytochemical fingerprinting and antioxidant activity of these products [11–14].

Two valuable medicinal herbs, namely *L. barbarum* and *L. chinense*, have received remarkable attention due to their effective clinical therapy, especially in the anti-aging category. In addition, there are increasing numbers of publications about several other *Lycium* plants, i.e., *Lycium ruthenicum* [15,16]. Many researchers have focused great attention on the *Lycium* genus in recent years, and many chemical components from this genus have been isolated. Therefore, a comprehensive and systematic review on the chemical constituents of the *Lycium* genus is much needed.

Most of the published reviews not only covered chemical composition, but also summarized the pharmacology, clinical studies, safety, toxicology and adverse actions of *L. barbarum* or *L. chinense* [17–19]. The aim of this review was to focus on chemical constituents in different parts of plants from different species in *Lycium* genus, especially small molecular compounds with updated research reports. This paper comprehensively summarizes the reports of constituents from the genus *Lycium*. Up to 2016, at least 355 constituents were reported from different species in the *Lycium* genus and different parts (fruits, root bark, leaves, seeds, and flowers) of the plant. This review describes the advances in the phytochemistry of the genus *Lycium* from 1975 to 2016, based on the 142 cited references. The reported constituents can be classified as glycerogalactolipids, phenylpropanoids, coumarins, lignans, flavonoids, amides, alkaloids, anthraquinones, organic acids, terpenoids, sterols, steroids, peptides, and other constituents. The aim of this review is to illustrate the recent advances in the characterization of the *Lycium* genus. The results, based on these phytochemical studies, could lay a solid foundation for better understanding of pharmacological activities of *Lycium* and quality assessment.

2. Constituents

Until now, other than polysaccharides, more than 355 compounds have been isolated and identified from the *Lycium* genus. The small molecules can be assigned to various classes of glycerogalactolipids, phenylpropanoids, coumarins, lignans, flavonoids, amides, alkaloids, anthraquinones, organic acids, terpenoids, sterols, steroids and their derivatives, and peptides. Beyond that, other groups of compounds have also been reported. The proportion of different compounds of the *Lycium* genus is show in Figure 1. Their structures are shown below, and their names and corresponding plant sources are included in this paper.

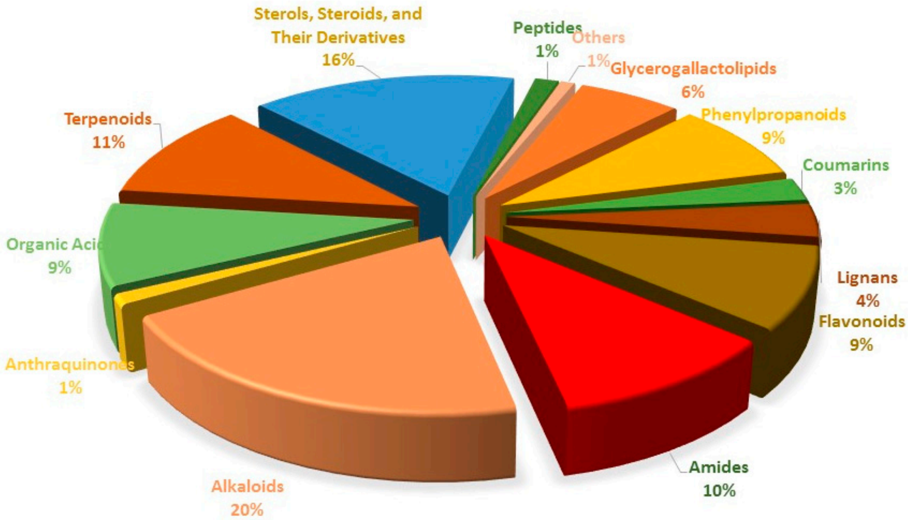


Figure 1. Different subtype comparison of the 355 constituents reported from *Lycium* genus.

2.1. Macromolecules in the Lycium Genus

Polysaccharides

Polysaccharides are the most important group of substances in the goji berry, which are estimated to comprise 5–8% of the dried fruits [20], 1.02–2.48% of the raw material [21–23]. More than 40 polysaccharides, with a molecular weight range of 8–241 kDa, were isolated from the fruit of *L. barbarum*, *L. chinense* and *L. ruthenicum*. Two, LRLP4-A and LBLP5-A, were isolated from the leaves of *L. ruthenicum*. The polysaccharides share a glycan-O-Ser glycopeptide structure and contain galacturonic acid, 18 amino acids, and nine monosaccharides, namely, xylose (Xyl), glucose (Glc), arabinose (Ara), rhamnose (Rha), mannose (Man), galactose (Gal), fucose (Fuc), galacturonic acid (GalA), glucuronic acid (GlcA) [24]. The molar ratios of the polysaccharides are shown in Table 1. The polysaccharides can be isolated and purified by water extract alcohol precipitation, DEAE ion-exchange cellulose, gel-permeation chromatography, high performance liquid chromatography (HPLC). Sevage method and organic reagents were used to remove proteins, pigments and other impurities. The structural composition of a LBP can be studied by SDS-PAGE gel electrophoresis, high perfomance size exclusion chromatography (HPSEC), gas-chromatographic–mass-spectrometry (GC-MS), nucleic magnetic resonance (NMR), and matrix-assisted laser desorption ionization-time of flight-mass spectrometry (MALDI-Tof-MS) [18,21,25].

Table 1. The molar ratios and source of LBPs.

LBPs	Molar Ratio	Source	Reference
LbGp1	Ara:Gal:Glc = 2.5:1.0:1.0	*L. barbarum*	[26]
LbGp2	Ara:Gal = 4:5	*L. barbarum*	[27]
LbGp3	Ara:Gal = 1:1	*L. barbarum*	[28,29]
LbGp4	Ara:Gal:Rha:Glc = 1.5:2.5:0.43:0.23	*L. barbarum*	[28,30]
LbGp5	Rha:Ara:Xyl:Gal:Man:Glc = 0.33:0.52:0.42:0.94:0.85:1	*L. barbarum*	[28]
LbGp5B	Rha:Ara:Glc:Gal = 0.1:1:1.2:0.3	*L. barbarum*	[31]
LBP3p	Rha:Ara:Xyl:Gal:Man:Glc = 1.25:1.10:1.76:1:1.95:2.12	*L. barbarum*	[32]
$LBPC_2$	Xyl:Rha:Man = 8.8:2.3:1	*L. barbarum*	[33]
$LBPC_4$	Glc	*L. barbarum*	[33]
LBPA1	heteroglycan	*L. barbarum*	[33]
LBPA3	heteroglycan	*L. barbarum*	[33]
LBP1a-1	Glc	*L. barbarum*	[34]
LBP1a-2	Glc	*L. barbarum*	[34]
LBP3a-1	GalA	*L. barbarum*	[34]
LBP3a-2	GalA	*L. barbarum*	[34]
LBPF1	-	*L. barbarum*	[35]
LBPF2	-	*L. barbarum*	[35]
LBPF3	-	*L. barbarum*	[35]
LBPF4	-	*L. barbarum*	[35]
LBPF5	Ara, Man, Xyl, Glu, Rha	*L. barbarum*	[35,36]
LBPF6	-	*L. barbarum*	[36]
LPBC4	Glc	*L. barbarum*	[37]
LBP-1	Rha:Ara:Xyl:Gal:Man:GalA = 1:7.85:0.37:0.65:3.01:8.16	*L. barbarum*	[22]
WSP1	Rha:Fuc:Ara:Xyl:Man:Gal:Glc = 1.6:0.2:51.4:4.8:1.2:25.9:7.3	*L. barbarum*	[23]
AGP	Rha:Ara:Xyl:Gal:Glc:GalA:GlcA = 3.3:42.9:0.3:44.3:2.4:7.0	*L. barbarum*	[38]
LBP-IV	Rha:Ara:Xyl:Glc:Gal = 1.61:3.82:3.44:7.54:1.00	*L. barbarum*	[39]
LbGp1	Ara:Gal = 5.6:1	*L. barbarum*	[40]
LBP-s-1	Rha:Ara:Xyl:Man:Glu:Gal:Gal A = 1.00:8.34:1.25:1.26:1.91:7.05:15.28	*L. barbarum*	[41]
p-LBP	Fuc:Rha:Ara:Gal:Glc:Xyl:Gal A:Glc A = 1.00:6.44:54.84:22.98:4.05:2.95:136.98:3.35	*L. barbarum*	[42]
Cp-2-A	Ara:Gal:Man:Rha:Glu = 6.02:2.71:1.00:0.70:0.67	*L. chinese*	[43,44]
Cp-2-B	Ara:Gal = 1:0.96	*L. chinese*	[43,44]
Hp-2-A	Ara:Gal = 5.2:1	*L. chinese*	[43,44]
Hp-2-B	Ara:Gal = 7.9:1	*L. chinese*	[43,44]

Table 1. *Cont.*

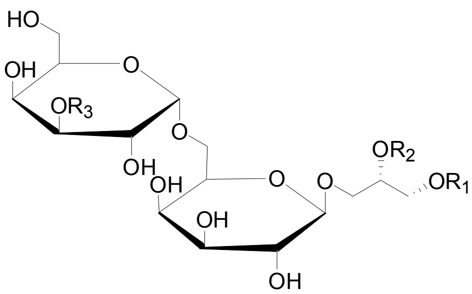
LBPs	Molar Ratio	Source	Reference
Hp-2-C	Ara:Gal = 1.2:1	*L. chinese*	[43,44]
Hp-0-A	Ara:Gal = 14:1	*L. chinese*	[43,44]
Cp-1-A	Ara:Xyl = 1:1	*L. chinese*	[45]
Cp-1-B	Ara	*L. chinese*	[45]
Cp-1-C	Ara:Gal = 3:1	*L. chinese*	[45]
Cp-1-D	Ara:Gal = 1:1	*L. chinese*	[45]
LRGP1	Rha:Ara:Xyl:Man:Glu:Gal = 0.65:10.71:0.33:0.67:1:10.41	*L. ruthenicum*	[46]
LRGP2	-	*L. ruthenicum*	[47]
LRGP3	Rha:Ara:Gal = 1.0:14.9:10.4	*L. ruthenicum*	[48]
LRGP4-A	Rha:Ara:Glu:Gal = 1:7.6:0.5:8.6	*L. ruthenicum*	[49]
LRGP5	Rha:Ara:Xyl:Gal:GalA = 1.0:2.2:0.5:1.2:4.7	*L. ruthenicum*	[50]
LRLP4-A	Rha:Ara:Gal = 1:10.3:5.3	*L. ruthenicum*	[47]
LBLP5-A	-	*L. ruthenicum*	[51]

2.2. Small Molecule Substances

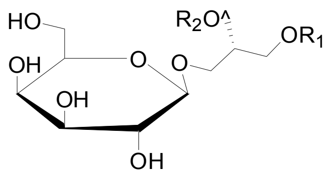
2.2.1. Glycerogalactolipids 1–22

At present, 17 compounds of this type, a series of glycerogalactolipids **1–17**, listed in Table 2, have been isolated and identified. Compounds **1–15** have been isolated and identified from the fruits of *L. barbarum* [52], whereas **16** and **17** were isolated from the fruits of *L. chinense* [53]. Compounds **18–22**, illustrated in Figure 2, were isolated from the root bark of *L. chinense* [54,55].

Table 2. Chemical structures of compounds **1–17**.

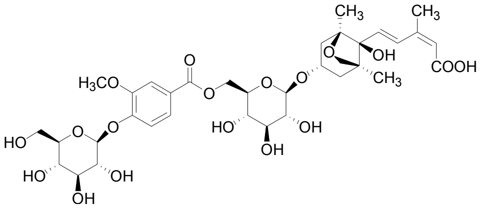


1–12

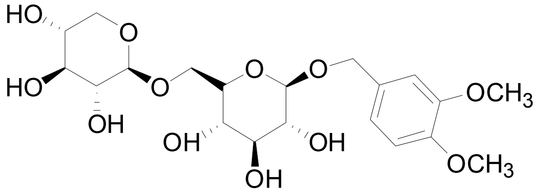


13–17

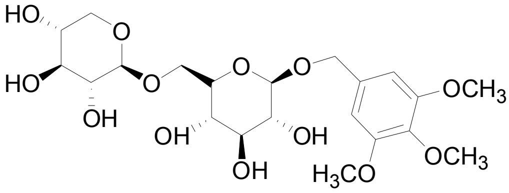
No.	Compounds	R_1	R_2	R_3	Source
1	Glycerogalactolipids A	Palmitoyl	Linolenoyl	Linolenoyl	*L. barbarum*
2	Glycerogalactolipids B	Palmitoyl	Linolenoyl	Linoleoyl	*L. barbarum*
3	Glycerogalactolipids C	Palmitoyl	Linolenoyl	Palmitoyl	*L. barbarum*
4	Glycerogalactolipids D	Palmitoyl	Linoleoyl	Palmitoyl	*L. barbarum*
5	Glycerogalactolipids E	Palmitoyl	Palmitoyl	Palmitoyl	*L. barbarum*
6	Glycerogalactolipids F	Palmitoyl	Palmitoyl	H	*L. barbarum*
7	Glycerogalactolipids G	Linolenoyl	Linolenoyl	H	*L. barbarum*
8	Glycerogalactolipids H	Linolenoyl	Linoleoyl	H	*L. barbarum*
9	Glycerogalactolipids I	Palmitoyl	Linolenoyl	H	*L. barbarum*
10	Glycerogalactolipids J	Palmitoyl	Linoleoyl	H	*L. barbarum*
11	Glycerogalactolipids K	Palmitoyl	Oleoyl	H	*L. barbarum*
12	Glycerogalactolipids L	Stearoyl	Linoleoyl	H	*L. barbarum*
13	Glycerogalactolipids M	Palmitoyl	Linolenoyl	–	*L. barbarum*
14	Glycerogalactolipids N	Palmitoyl	Linoleoyl	–	*L. barbarum*
15	Glycerogalactolipids O	Palmitoyl	Oleoyl	–	*L. barbarum*
16	Glycerogalactolipids P	Linolenoyl	Linolenoyl	–	*L. chinense*
17	Glycerogalactolipids Q	Linoleoyl	Linolenoyl	–	*L. chinense*



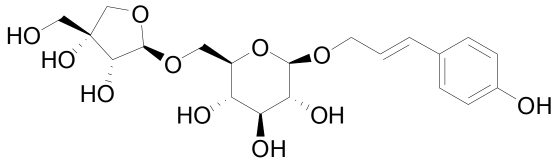
18 Lyciumoside A



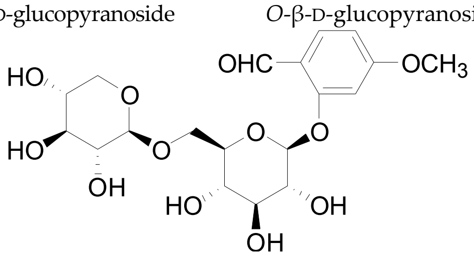
19 3′,4′-Dimethoxy-benzylalcohol-l-*O*-β-D-xylopyranosyl-(1 → 6)-*O*-β-D-glucopyranoside



20 3′,4′,5′-Trimethoxy-benzylalcohol-l-*O*-β-D-xylopyranosyl-(1 → 6)-*O*-β-D-glucopyranoside



21 4′-Hydroxystyrone-l-*O*-β-D-apiofuranosyl-(1 → 6)-*O*-β-D-glucopyranoside



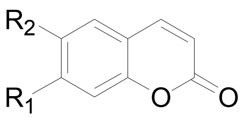
22 2-Hydroxy-4-methoxybenzaldehyde-2-*O*-β-D-glucopyraneosyl-l-6-*O*-β-D-xylopyranoside

Figure 2. Chemical structures of compounds **18**–**22**.

2.2.2. Phenylpropanoids **23**–**51**

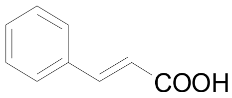
Four phenylpropanoids **23**–**26**, namely *E*-cinnamic acid (**23**), *E*-ferulic acid (**24**), *E*-coniferol (**25**) and isoscopoletin (**26**) are obtained from wolfberries [56–58]. Four phenylpropanoids, namely scopolin (**27**), fabiatrin (**28**), lyciumin (**29**), and 9-*O*-(β-D-glucopyranosyl)lyoniresinol (**30**) are obtained from the root bark of *L. chinense* [59–61]. 1-*O*-Methyl-4-*O*-*p*-*E*-coumaroyl-α-L-rhamnopyranoside (**31**) is obtained from the fruits of *L. ruthenicum* [62]. The chemical structures of compounds **23**–**33** are listed in Table 3 and Figure 3. In 2016, 11 phenylpropanoids **32**–**42** were isolated for the first time by Zhou et al. from *Lycium* [56], including 1-*O*-*E*-feruloyl-6-*O*-β-D-xylopyranosyl-β-D-glucopyranoside (**32**), 6-*O*-*E*-feruloyl-2-*O*-β-D-glucopyranosyl-α-D-glucopyranoside (**33**), 1-*O*-*E*-feruloyl-β-D-glucopyranoside (**34**), ethyl-4-*O*-β-D-glucopyranosyl-*E*-ferulate (**35**), ethyl *E*-ferulate (**36**), *E*-sinapinic acid (**37**), syringenin (**38**), *Z*-ferulic acid (**39**), phloretic acid (**40**), dihydroferulic acid (**41**), and ethyl dihydroferulate (**42**), along with the nine new lycibarbarphenylpropanoids A–I (compounds **43**–**51**) listed in Table 4.

Table 3. Chemical structures of compounds **26**–**28**.

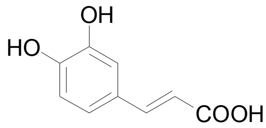


26–**28**

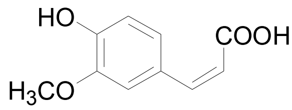
No.	Compounds	R_1(R)	R_2	Source
26	Isoscopoletin	OCH_3	OH	*L. barbarum*
27	Scopolin	*O*-β-D-Glc	OCH_3	*L. chinense*
28	Fabiatrin	*O*-β-D-Glc^6-β-D-Xyl	OCH_3	*L. chinense*



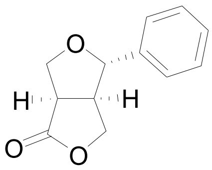
23 *E*-cinnamic acid



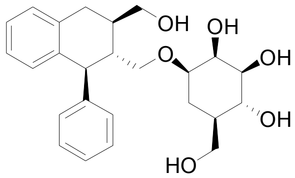
24 *E*-ferulic acid



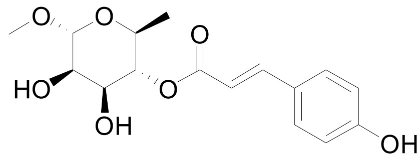
25 *Z*-coniferol



29 Lyciumin



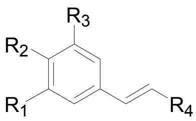
30 9-*O*-(β-D-glucopyranosyl)-lyoniresinol



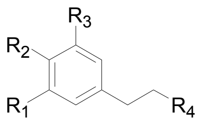
31 1-*O*-methyl-4-*O*-*p*-*E*-coumaroyl-α-L-rhamnopyranoside

Figure 3. Chemical structures of compounds **23–25**, **29–31**.

Table 4. Chemical structures of compounds **32–51**.



32–39, 43–51

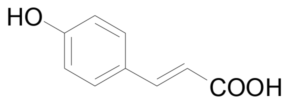


40–42

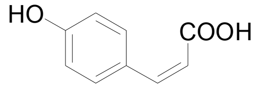
No.	Compounds	R_1	R_2	R_3	R_4	Source
32	1-*O*-*E*-feruloyl-6-*O*-β-D-xylopyranosyl-β-D-glucopyranoside	OCH_3	OH	H	COO-β-D-Glc^{6}-β-D-Xyl	*L. barbarum*
33	6-*O*-*E*-feruloyl-2-*O*-β-D-glucopyranosyl-α-D-glucopyranoside	OCH_3	OH	H	COO^{6}-α-D-Glc^{2}-β-D-Glc	*L. barbarum*
34	1-*O*-*E*-feruloyl-β-D-glucopyranoside	OCH_3	OH	H	COO-β-D-Glc	*L. barbarum*
35	Ethyl-4-*O*-β-D-glucopyranosyl-*E*-ferulate	OCH_3	*O*-β-D-Glc	H	$COOCH_2CH_3$	*L. barbarum*
36	Ethyl *E*-ferulate	OCH_3	OH	H	$COOCH_2CH_3$	*L. barbarum*
37	*E*-sinapinic acid	OCH_3	OH	OCH_3	COOH	*L. barbarum*
38	Syringenin	OCH_3	OH	OCH_3	CH_2OH	*L. barbarum*
39	*E*-ferulic acid	OCH_3	OH	H	COOH	*L. barbarum*
40	Phloretic acid	H	OH	H	COOH	*L. barbarum*
41	Dihydroferulic acid	OCH_3	OH	H	COOH	*L. barbarum*
42	Ethyl dihydroferulate	OCH_3	OH	H	$COOCH_2CH_3$	*L. barbarum*
43	Lycibarbarphenylpropanoids A	H	OH	H	COO-β-D-Glc^{3}-β-D-Glc	*L. barbarum*
44	Lycibarbarphenylpropanoids B	H	OH	H	COO-β-D-Glc^{4}-β-D-Glc	*L. barbarum*
45	Lycibarbarphenylpropanoids C	OCH_3	OH	H	COO-β-D-Glc^{3}-β-D-Glc	*L. barbarum*
46	Lycibarbarphenylpropanoids D	OCH_3	OH	H	COO-β-D-Glc^{4}-β-D-Glc	*L. barbarum*
47	Lycibarbarphenylpropanoids E	OCH_3	OH	H	CH_2O-β-D-Glc^{3}-β-D-Glc	*L. barbarum*
48	Lycibarbarphenylpropanoids F	H	*O*-β-D-Glc^{3}-β-D-Glc	H	$COOCH_2CH_3$	*L. barbarum*
49	Lycibarbarphenylpropanoids G	H	*O*-β-D-Glc^{4}-β-D-Glc	H	$COOCH_2CH_3$	*L. barbarum*
50	Lycibarbarphenylpropanoids H	OCH_3	*O*-β-D-Glc^{4}-β-D-Glc	H	$COOCH_2CH_3$	*L. barbarum*
51	Lycibarbarphenylpropanoids I	*O*-β-D-Glc	OH	H	$COOCH_2CH_3$	*L. barbarum*

2.2.3. Coumarins **52–61**

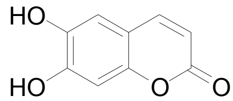
Nine coumarins, namely *E*-*p*-coumaric acid (**52**), *Z*-*p*-coumaric acid (**53**), esculetin (**54**), fabiatrin (**55**), scopolin (**56**), and scopoletin (**57**), have been reported, and three new coumarins, 6-*O*-*E*-*p*-coumaroyl-2-*O*-β-D-glucopyranosyl-α-D-glucopyranoside (**58**), ethyl-4-*O*-β-d-glucopyranosyl-*E*-*p*-coumarate (**59**), ethyl *E*-*p*-coumarate (**60**) and lycibarbarcoumarin A (**61**), have been obtained from the fruits of *L. barbarum* in 2016 [56]. Compounds **55** and **56** were isolated from the root bark and fruits of *L. chinense* [61], while **52**−**54** and **57** were isolated from the fruits of *L. barbarum* [63]. The chemical structures of these coumarins are listed in Figure 4 and Table 5.



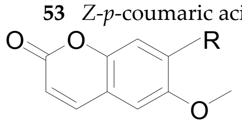
52 *E*-*p*-coumaric acid



53 *Z*-*p*-coumaric acid



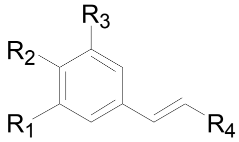
54 esculetin



55 Fabiatrin R=*O*-β-D-Glc⁶-β-D-Xyl
56 Scopolin R=*O*-β-D-Glc
57 Scopoletin R=OH
61 Lycibarbarcoumarin A R=*O*-β-D-Glc⁶-β-D-Xyl⁴-β-D-Glc

Figure 4. Chemical structures of compounds **52**–**57**, **61**.

Table 5. Chemical structures of compounds **58**–**60**.



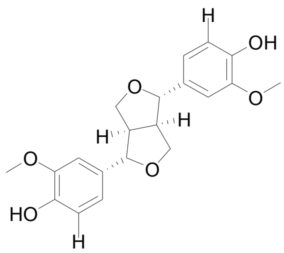
59–**61**

No.	Compounds	R_1	R_2	R_3	R_4	Source
58	6-*O*-*E*-*p*-coumaroyl-2-*O*-β-D-glucopyranosyl-α-D-glucopyranoside	H	OH	H	COO^6-α-D-Glc^2-β-D-Glc	*L. barbarum*
59	Ethyl-4-*O*-β-D-glucopyranosyl-*E*-*p*-coumarate	H	*O*-β-D-Glc	H	$COOCH_2CH_3$	*L. barbarum*
60	Ethyl *E*-*p*-coumarate	H	OH	H	$COOCH_2CH_3$	*L. barbarum*

2.2.4. Lignans **62**–**74**

Eight lignans, including pinoresinol (**62**), arctigenin (**63**), arctiin (**64**), medioresinol (**65**), syringaresinol (**66**), 4-*O*-(β-D-glucopyranosyl)syringaresinol (**67**), *threo*-1,2-bis(4-hydroxy-3-methoxyphenyl)-1,3-propanediol (**68**), and *erythro*-1,2-bis(4-hydroxy-3-methoxyphenyl)-1,3-propanediol (**69**), have been isolated from the fruits of *L. barbarum* [56]. (β)-Lyoniresinol 3-*O*-β-D-glucopyranoside (**70**), lyciumlignan A (**71**), lyciumlignan B (**72**), lyciumlignan C (**73**), and (7*R*,8*S*)-4,9,9′-trihydroxy-3,3′-dimethoxy-7′-en-8,4′-oxyneolignan-7-*O*-β-D-glucopyranoside (**74**) were obtained from the root bark of *L. chinense* [54,60,64]. Among them, **65**–**70** were first isolated from the fruits of *L. barbarum* in 2016 [56]. The chemical structures of these lignans are listed in Figure 5 and Table 6.

Table 6. Chemical structures of compounds **62** and **65**–**67**.



62, **65**–**67**

No.	Compounds	R_1	R_2	R_3	Source
62	Pinoresinol	H	OH	H	*L. barbarum*
65	Medioresinol	H	OH	OCH_3	*L. barbarum*
66	Syringaresinol	OCH_3	OH	OCH_3	*L. barbarum*
67	4-*O*-(β-D-glucopyranosyl)syringaresinol	OCH_3	*O*-β-D-Glc	OCH_3	*L. barbarum*

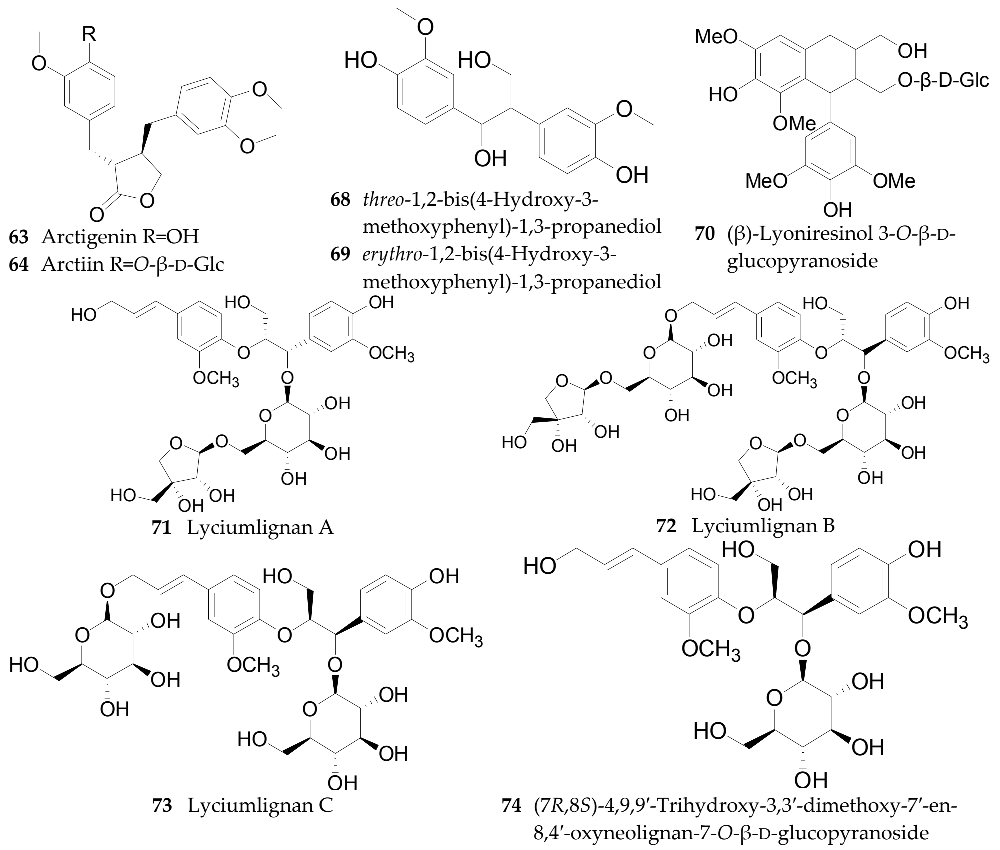
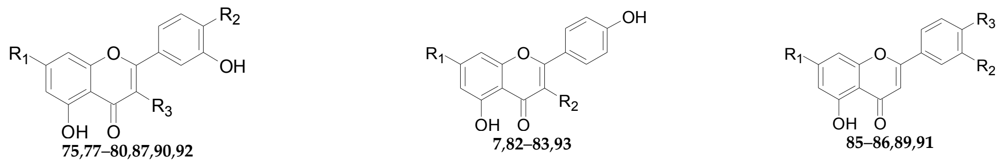


Figure 5. Chemical structures of compounds **63–64** and **68–74**.

2.2.5. Flavonoids 75–106

Twenty-seven flavonoids **75–101** have been reported from the genus *Lycium*, are listed in Tables 7 and 8 and Figures 6 and 7. Compound **75** was isolated from the flowers of *L. barbarum* [58], while **76–83** were identified from the fruits of *L. barbarum* [62,65–69]. Compound **84** was isolated from the fruits of *L. chinense* [70], whereas **85–91** were isolated from the leaves of *L. chinense* [62,66,68,71]. Compound **92** and **93** were isolated from the leaves of *L. halimifolium* [72]. Compounds **94–98** were isolated from the fruits of *L. ruthenicum* [16,62]. Compounds **99–101** were isolated from the root bark of *L. chinense* [54,73,74]. Additionally, Zhou et al. isolated five isoflavonoids, namely derrone (**102**), alpinumisoflavone (**103**), auriculasin (**104**), maackianin (**105**) and maackiain (**106**) from the fruits of *L. barbarum* [56,75,76].

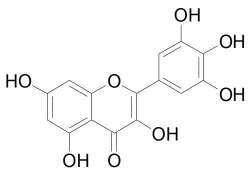
Table 7. Chemical structures of compounds **75–80**, **82–83**, **85–87** and **89–93**.



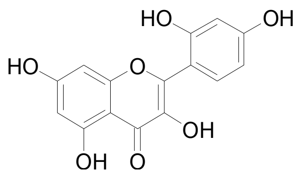
No.	Compounds	R_1	R_2	R_3	Source
75	Quercitrin	OH	OH	O-α-L-Rha	*L. barbarum*
76	Kaempferol	OH	OH	–	*L. barbarum*
77	Quercetin	OH	OH	OH	*L. barbarum*
78	Rutin	OH	OH	*O*-β-D-Glc^6-α-L-Rha	*L. barbarum*
79	Narcissoside	OH	OCH_3	*O*-β-D-Glc^6-α-L-Rha	*L. barbarum*
80	7-*O*-(β-D-Glucopyranosyl)-rutin	*O*-β-D-Glc	OH	*O*-β-D-Glc^6-α-L-Rha	*L. barbarum*
82	7-*O*-(β-D-Glucopyranosyl)-nicotiflorin	*O*-β-D-Glc	*O*-β-D-Glc^6-α-L-Rha	–	*L. barbarum*

Table 7. *Cont.*

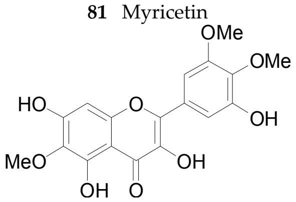
No.	Compounds	R_1	R_2	R_3	Source
83	7-*O*-(β-D-Glucopyranosyl)-3-*O*-[β-D-glucopyranosyl]-(1 → 2)-β-D-galactop	*O*-β-D-Glc	*O*-β-D-Glc^6-α-L-Glc	–	*L. barbarum*
85	Luteolin	OH	OH	OH	*L. chinense*
86	Acacetin	OH	H	OCH_3	*L. chinense*
87	7-*O*-(β-D-Glucopyranosyl)-3-*O*-[β-D-glucopyranosyl-(1 → 2)-β-D-galactopyranosyl]-quercetin	*O*-β-D-Glc	OH	*O*-β-D-Glc^2-β-D-Glc	*L. chinense*
89	7-*O*-[α-L-Rhamno-pyranosyl-(1 → 6)-β-D-glucopyranosyl]-acacetin	*O*-β-D-Glc^6-α-L-Rha	H	OCH_3	*L. chinense*
90	3-*O*-Sophoroside-quercetin	OH	OH	*O*-β-D-Glc^2-β-D-Glc	*L. chinense*
91	Apigenin	OH	H	OH	*L. chinense*
92	Isoquercitrin	OH	OH	*O*-β-D-Glc	*L. halimifolium*
93	Nicotiflorin	OH	*O*-β-D-Glc^6-α-L-Rha	–	*L. halimifolium*



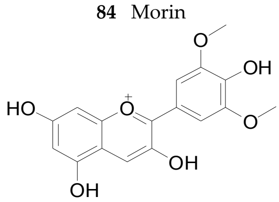
81 Myricetin



84 Morin



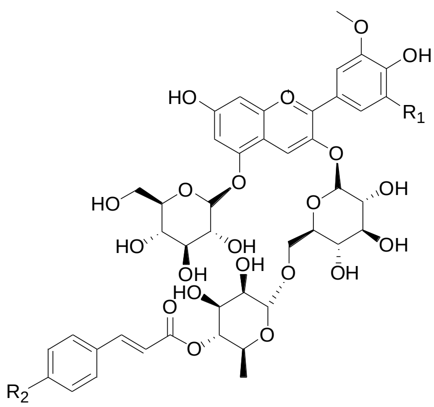
88 3,5,7,3′-Tetrahydroxy-6,4′,5′trimethoxyflavone



94 Malvidin

Figure 6. Chemical structures of compounds **81**, **84**, **88** and **94**.

Table 8. Chemical structures of compounds **95–98**.



No.	Compounds	R_1	R_2	Source
95	5-*O*-(β-D-Glucopyranosyl)-3-*O*-[4-*O*-*p*-*E*-coumaroyl-α-L-rhamnopyranosyl-(1 → 6)-β-D-glucopyranosyl]-peonidin	H	OH	*L. ruthenicum*
96	5-*O*-(β-D-Glucopyranosyl)-3-*O*-[4-*O*-*p*-*E*-coumaroyl-α-L-rhamnopyranosyl-(1 → 6)-β-D-glucopyranosyl]-petunidin	OH	OH	*L. ruthenicum*
97	5-*O*-(β-D-Glucopyranosyl)-3-*O*-[4-*O*-*p*-*Z*-coumaroyl-α-L-rhamnopyranosyl-(1 → 6)-β-D-glucopyranosyl]-malvidin	OCH_3	OH	*L. ruthenicum*
98	5-*O*-(β-D-Glucopyranosyl)-3-*O*-[4-*O*-*p*-*E*-(β-D-glucopyranoside)-coumaroyl-α-L-rhamnopyranosyl-(1 → 6)-β-D-glucopyranosyl]-petunidin	OH	*O*-β-D-Glc	*L. ruthenicum*

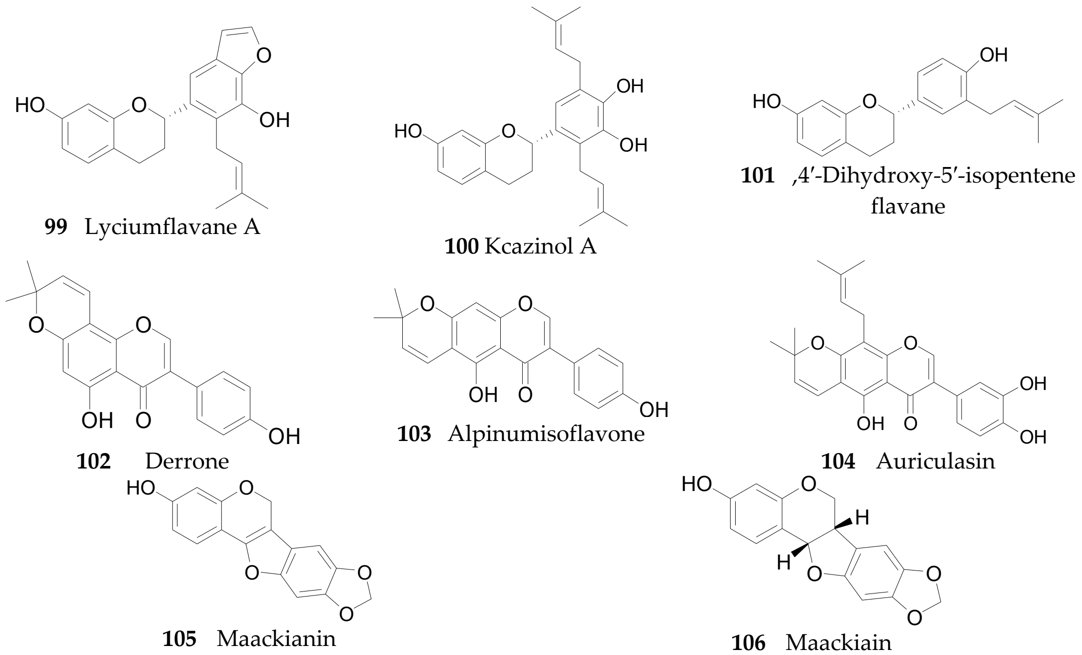


Figure 7. Chemical structures of compounds **99**–**106**.

2.2.6. Amides **107**–**143**

Sixteen amides **107**–**122** have been isolated from the root bark of *L. chinense* [9,54,60,77–80], 19 amides (**123**–**141**) have been isolated from the fruits of *L. barbarum* [81–88]. Meanwhile, two cerebrosides **142** and **143** have been obtained from fruits of *L. chinense* [89]. The chemical structures of these amides are shown in Figure 8.

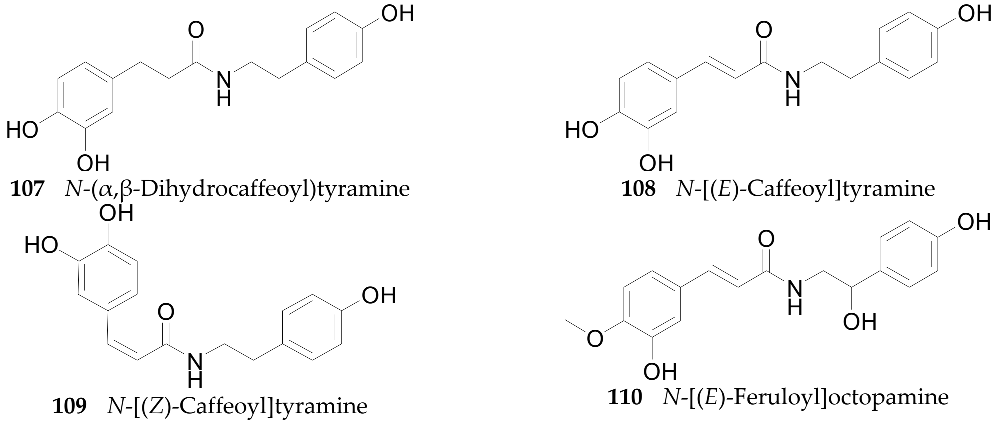
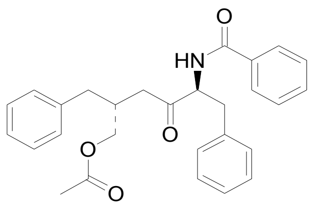
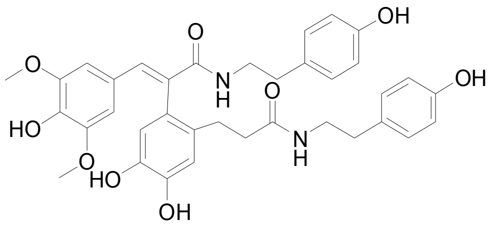


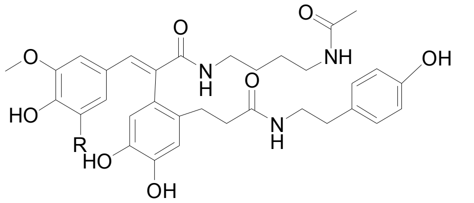
Figure 8. *Cont.*



111 Aurantiamide acetate

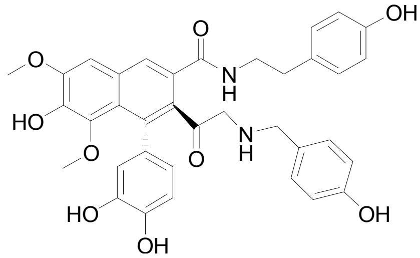


112 (*E*)-2-[4,5-Dihydroxy-2-[3-[2-(4-hydroxyphenyl) ethylamino]-3-oxopropyl]phenyl]-3-(4-hydroxy-3,5-dimethoxyphenyl)-*N*-[2-(4-hydroxyphenyl) ethyl]prop-2-enamide

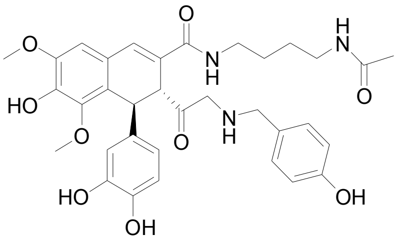


113 (*E*)-*N*-(4-Acetamidobutyl)-2-[4,5-dihydroxy-2-[3-[2-(4-hydroxyphenyl)ethylamino]-3-oxopropyl]-phenyl]-3-(4-hydroxy-3-methoxyphenyl)prop-2-enamide R=H

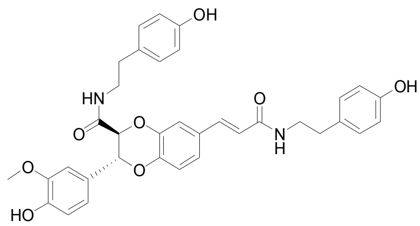
114 (*E*)-*N*-(4-Acetamidobutyl)-2-[4,5-dihydroxy-2-[3-[2-(4-hydroxyphenyl)ethylamino]-3-oxopropyl]-phenyl]-3-(4-hydroxy-3,5-dimethoxyphenyl)prop-2-enamide R=OCH_3



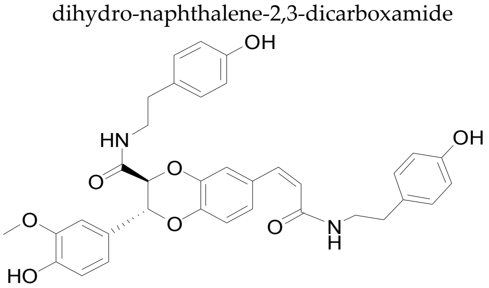
115 (1*R*,2*S*)-1-(3,4-Dihydroxyphenyl)-7-hydroxy-*N*2,*N*3-bis(4-hydroxyphenethyl)-6,8-dimethoxy-1,2-dihydro-naphthalene-2,3-dicarboxamide



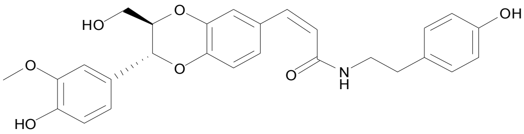
116 (1*S*,2*R*)-*N*3-(4-Acetamidobutyl)-1-(3,4-dihydroxy-phenyl)-7-hydroxy-*N*2-(4-hydroxyphenethyl)-6,8-dimethoxy-1,2-dihydro-naphthalene-2,3-dicarboxamide



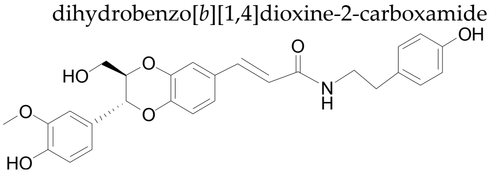
117 (2,3-*E*)-3-(3-Hydroxy-5-methoxyphenyl)-*N*-(4-hydroxyphenethyl)-7-{(*E*)-3-[(4-hydroxyphenethyl)-=amino]-3-oxoprop-1-en-1-yl}-2,3-dihydrobenzo-[*b*][1,4]dioxine-2-carboxamide



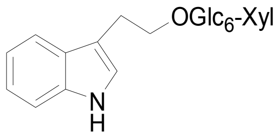
118 (2,3-*E*)-3-(3-hydroxy-5-methoxyphenyl)-*N*-(4-hydroxyphenethyl)-7-{(*Z*)-3-[(4-hydroxy-phenethyl)amino]-3-oxoprop-1-en-1-yl}-2,3-dihydrobenzo[*b*][1,4]dioxine-2-carboxamide



119 (*Z*)-3-{(2,3-*E*)-2-(4-hydroxy-3-methoxyphenyl)-3-hydroxymethyl-2,3-dihydrobenzo[*b*][1,4]dioxin-6-yl}-*N*-(4-hydroxyphenethyl)acrylamide

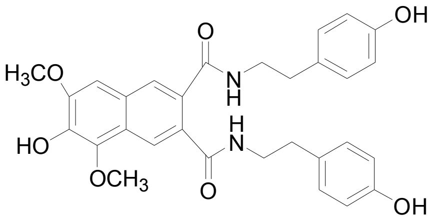


120 (*E*)-3-{(2,3-*E*)-2-(4-hydroxy-3-methoxyphenyl)-3-hydroxymethyl-2,3-dihydrobenzo[*b*][1,4] dioxin-6-yl}-*N*-(4-hydroxyphenethyl)-acrylamide

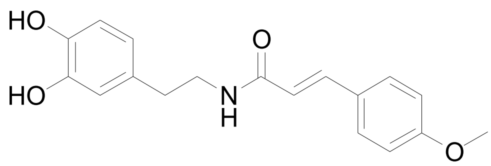


121 Indole glycoside

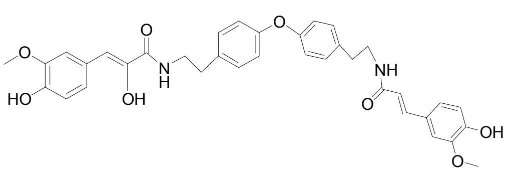
Figure 8. *Cont.*



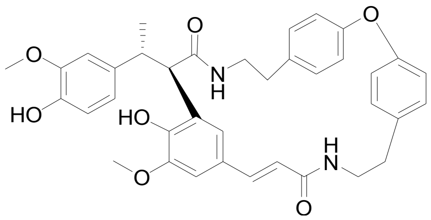
122 Lyciumamide D



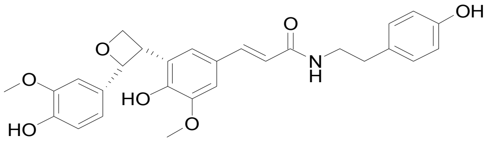
123 Lyciumide A



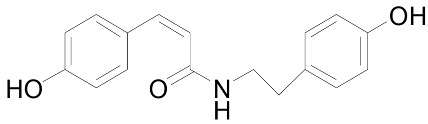
124 Lyciumamide A



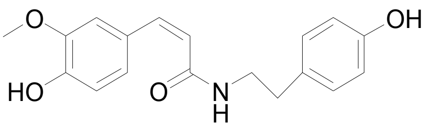
125 Lyciumamide B



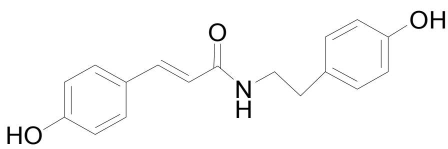
126 Lyciumamide C



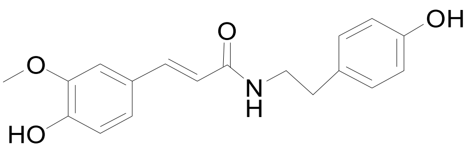
127 *N*-*Z*-*p*-coumaroyl-tyramine



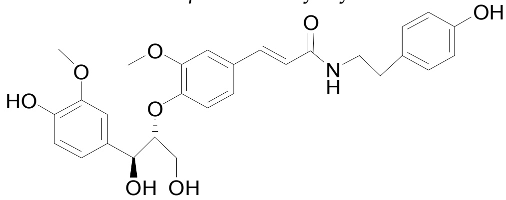
128 *N*-*Z*-feruloyl-tyramine



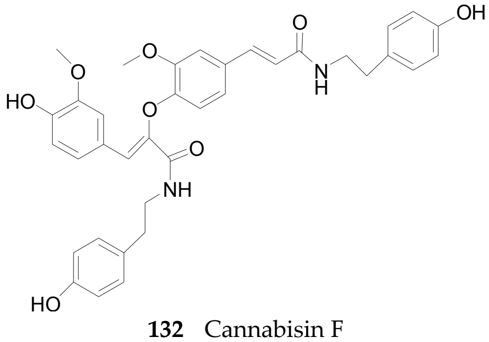
129 *N*-*E*-*p*-coumaroyl-tyramine



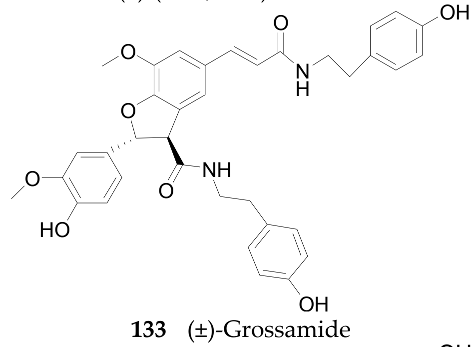
130 *N*-*E*-feruloyl-tyramine



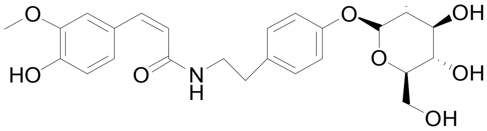
131 (±)-(7″*S**,8″*R**)-Canabisine H



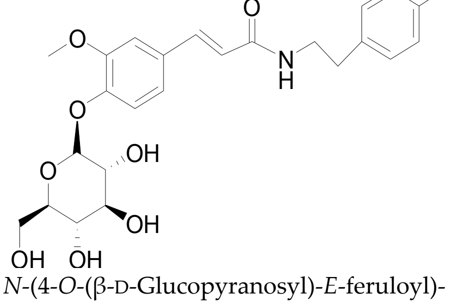
132 Cannabisin F



133 (±)-Grossamide

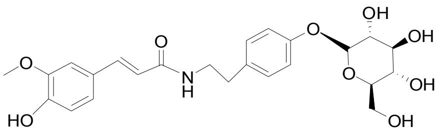


134 *N*-*Z*-feruloyl-4-*O*-(β-D-glucopyranosyl) tyramine

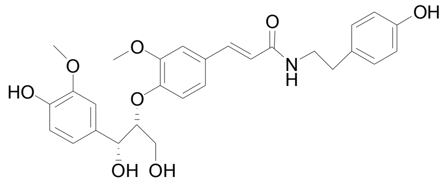


135 *N*-(4-*O*-(β-D-Glucopyranosyl)-*E*-feruloyl)-tyramine

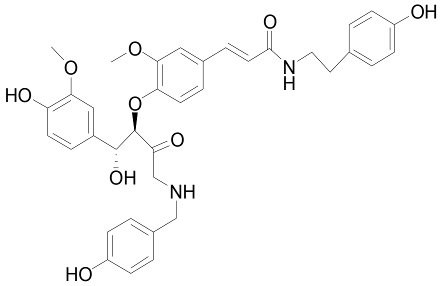
Figure 8. *Cont.*



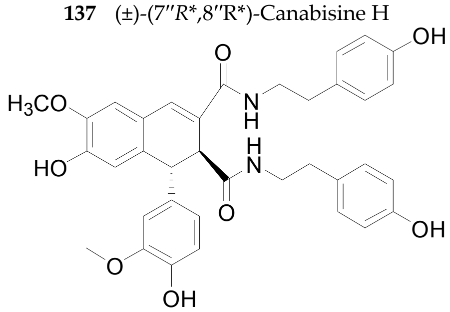
136 *N*-*E*-feruloyl-4-*O*-(β-D-glucopyranosyl)tyramine



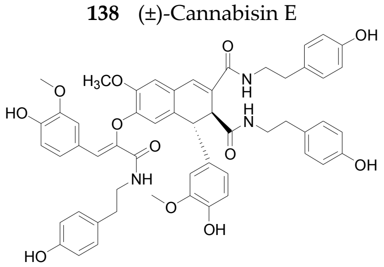
137 (±)-(7″*R**,8″R*)-Canabisine H



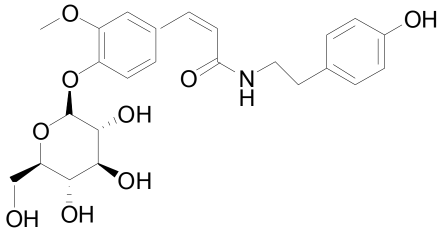
138 (±)-Cannabisin E



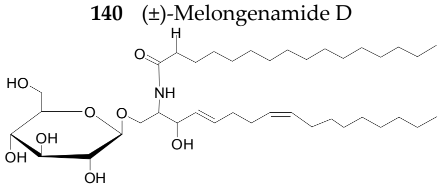
139 (±)-Cannabisin D



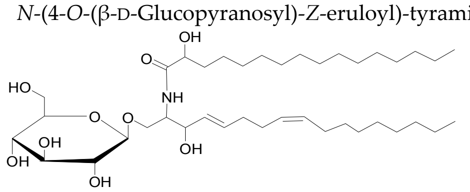
140 (±)-Melongenamide D



141 *N*-(4-*O*-(β-D-Glucopyranosyl)-*Z*-eruloyl)-tyramine



142 Cerebrosides A



143 Cerebrosides B

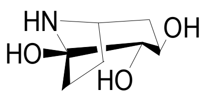
Figure 8. Chemical structures of compounds **107–143**.

2.2.7. Alkaloids **144–215**

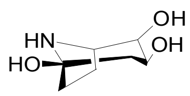
To date, 72 alkaloids have been identified, which can be classified into five categories: nortropane, imidazole, piperidine, pyrrole, spermine, tropane, and other alkaloids.

Nortropane Alkaloids

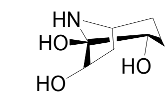
Fourteen nortropane alkaloids **144–157**, shiwn in Figure 9, have been isolated from the root bark of *L. chinense* [90].



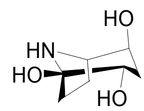
144 Calystegine A3



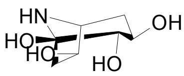
145 Calystegine A5



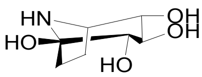
146 Calystegine A6



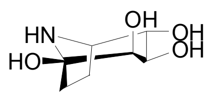
147 Calystegine A7



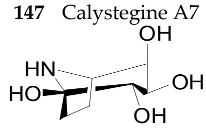
148 Calystegine B1



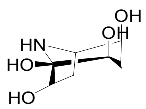
149 Calystegine B2



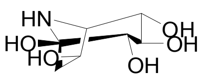
150 Calystegine B3



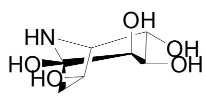
151 Calystegine B4



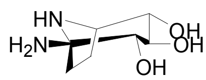
152 Calystegine B5



153 Calystegine C1

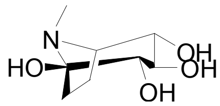


154 Calystegine C2



155 Calystegine N1

Figure 9. *Cont.*


156 *N*-Methylcalystegine B2

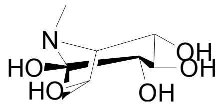
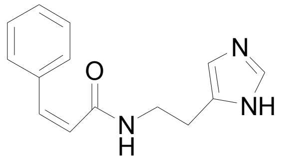
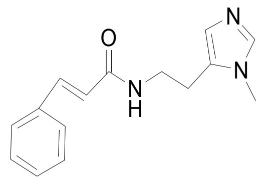

157 *N*-Methylcalystegine C1

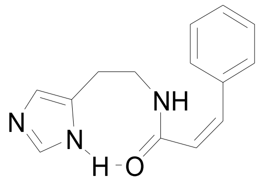
Figure 9. Chemical structures of compounds **144–157**.

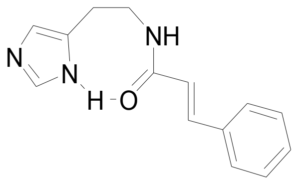
Imidazole Alkaloids

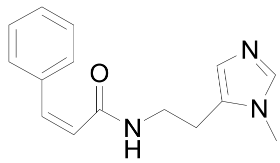
Six imidazole alkaloids **158–162** were detected in the leaves of *L. cestroides* [91]: Meanwhile, one imidazole, Na-[(*E*)-cinnamoyl]histamine (**163**), was obtained from the leaves of *L. barbarum* [66], listed in Figure 10.


158 Na-[(*Z*)-Cinnamoyl]histamine


159 Na-[(*E*)-Cinnamoyl]-*N*1-methylhistamine


160 (*Z*)-Quasibicyclic


161 (*E*)-Quasibicyclic


162 Na-[(*Z*)-Cinnamoyl]-*N*1-methylhistamine

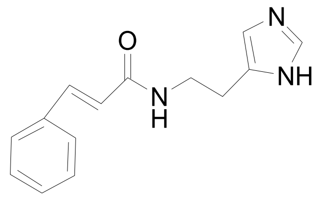
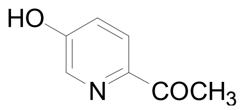
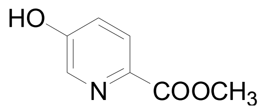

163 Na-[(*E*)-Cinnamoyl]-histamine

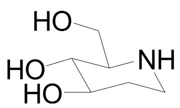
Figure 10. Chemical structures of compounds **158–163**.

Piperidine Alkaloids

5-hydroxy-2-pyridylmethyl ketone (**164**), methyl 5-hydroxy-2-pyridinecarboxylate (**165**), fagomine (**166**), and 6-deoxyfagomine (**167**), listed in Figure 11, have been isolated and identified from the genus *Lycium*; among them. Compounds **164** and **165** are from the fruits of *L. barbarum* [92], and **166** and **167** are from the root bark of *L. chinense* [90].


164 5-Hydroxy-2-pyridyl-methyl ketone


165 Methyl 5-hydroxy-2-pyridinecarboxylate


166 Fagomine

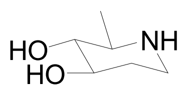
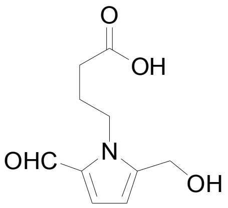

167 6-Deoxyfagomine

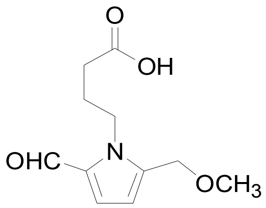
Figure 11. Chemical structures of compounds **164–167**.

Pyrrole Alkaloids

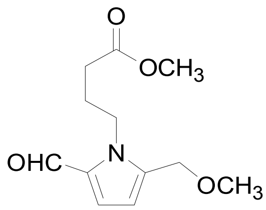
Thirteen pyrrole alkaloids **168–180** have been isolated from the fruits of *L. chinense* [93–95]. Likewise, 2-formyl-5-hydroxymethylpyrrole (**181**) and 2-formyl-5-methoxymethylpyrrole (**182**) were isolated from the fruits of *L. barbarum* [92]. Two pyrrolidine alkaloids, alkaloid I (**183**) and alkaloid II (**184**), are obtained from the root bark of *L. chinense* [96]. The chemical structures of these pyrrole alkaloids are listed in Figure 12.



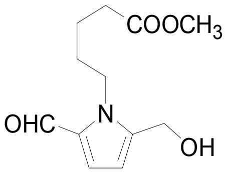
168 4-[2-Formyl-5-(hydroxymethyl)-1*H*-pyrrol-1-yl]butanoic acid



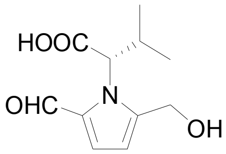
169 4-[2-Formyl-5-(methoxymethyl)-1*H*-pyrrol-1-yl]butanoic acid



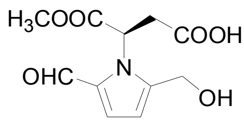
170 Methyl 4-[2-formyl-5-(methoxy-methyl)1*H*-pyrrol-1-yl]-butanoate



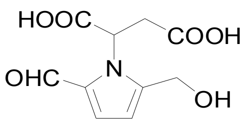
171 Methyl 4-[2-formyl-5-(hydroxy-methyl)-1*H*-pyrrol-1-yl]-butanoate



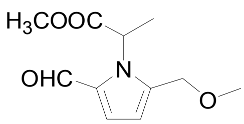
172 (2*S*)-[2-Formyl-5-(hydroxymethyl)-1*H*-pyrrol-1-yl]-3-methyl-butanoic acid



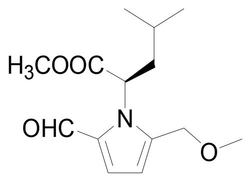
173 (2*R*)-[2-Formyl-5-(hydroxy-methyl)-1*H*-pyrrol-1-yl]-1-methoxy-1-oxo-butanoic acid



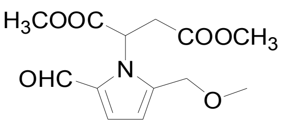
174 3-[2-Formyl-5-(hydroxymethyl)-1*H*-pyrrol-1-yl]-pentanedioic acid



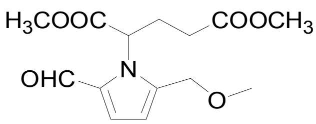
175 Methyl 2-[2-formyl-5-(methoxymethyl)-1*H*-pyrrol-1-yl]propanoate



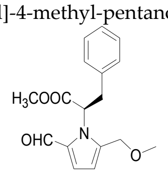
176 Methyl (2*R*)-[2-formyl-5-(methoxymethyl)-1*H*-pyrrol-1-yl]-4-methyl-pentanoate



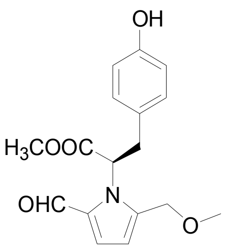
177 Dimethyl 2-[2-formyl-5-(methoxy-methyl)-1*H*-pyrrol-1-yl]-butane-dioate



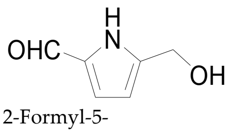
178 Dimethyl 2-[2-formyl-5-(methoxy-methyl)-1*H*-pyrrol-1-yl]-pentanedioate



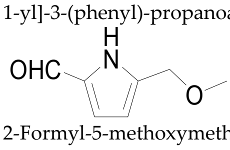
179 Methyl (2*R*)-[2-formyl-5-(methoxymethyl)-1*H*-pyrrol-1-yl]-3-(phenyl)-propanoate



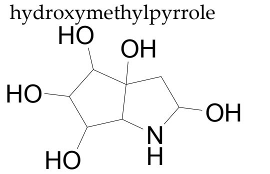
180 Methyl 2-[2-formyl-5-(methoxy-methyl)-1*H*-pyrrol-1-yl]-3-(4-hydroxyphenyl)-propanoate



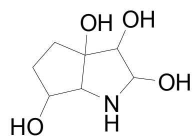
181 2-Formyl-5-hydroxymethylpyrrole



182 2-Formyl-5-methoxymethyl-pyrrole



183 Alkaloid I

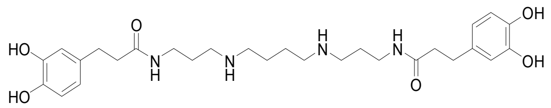


184 Alkaloid II

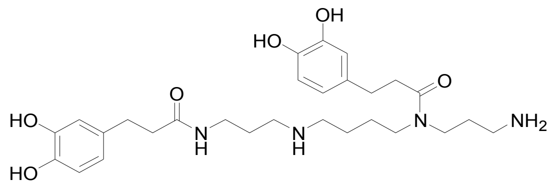
Figure 12. Chemical structures of compounds **168–184**.

Spermine Alkaloids

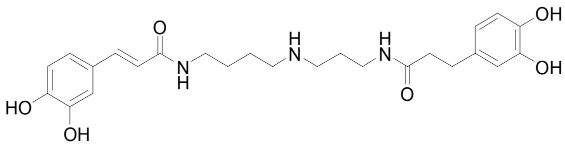
Nineteen spermine alkaloids have been found in the genus *Lycium*. Kukoamines A (**185**) and kukoamines B (**186**) are from the root bark of *L. chinense* [97,98], while *N*1-caffeoyl-*N*3-dihydrocaffeoyl spermidine (**187**) and lyrium spermidine A (**188**) are from the fruits of *L. ruthenicum* [62,99], listed in Figure 13. Another 15 spermine alkaloids, lycibarbarspermidine A–O (**189–203**), listed in Tables 9 and 10 and Figures 13–15, are from *L. barbarum* [100].



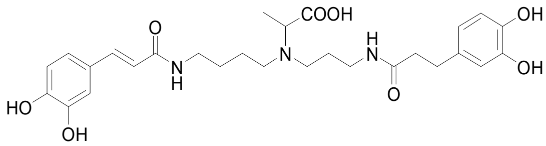
185 Kukoamines A



186 Kukoamines B



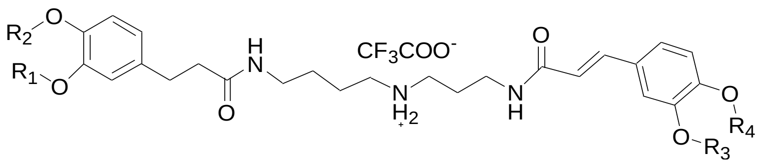
187 *N*1-Caffeoyl-*N*3-dihydrocaffeoyl spermidine



188 Lyrium spermidine A

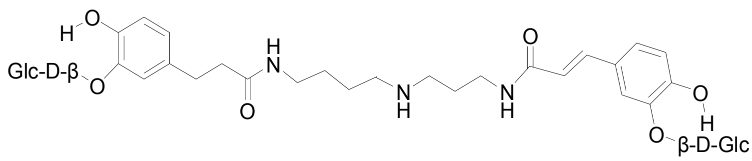
Figure 13. Chemical structures of compounds **185–188**.

Table 9. Chemical structures of compounds **189–193**.

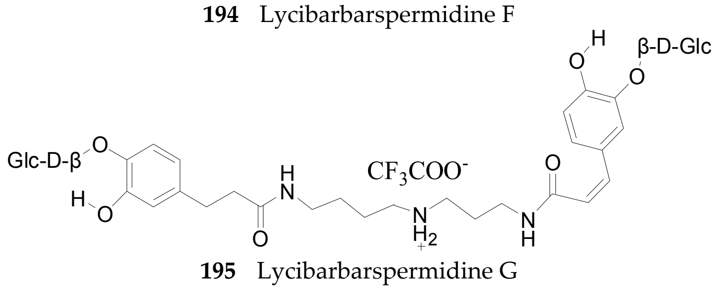


189–193

No.	Compounds	R_1	R_2	R_3	R_4	Source
189	Lycibarbarspermidine A	H	β-D-Glc	H	H	*L. barbarum*
190	Lycibarbarspermidine B	H	H	β-D-Glc	H	*L. barbarum*
191	Lycibarbarspermidine C	β-D-Glc	H	H	H	*L. barbarum*
192	Lycibarbarspermidine D	H	H	H	β-D-Glc	*L. barbarum*
193	Lycibarbarspermidine E	H	β-D-Glc	β-D-Glc	H	*L. barbarum*



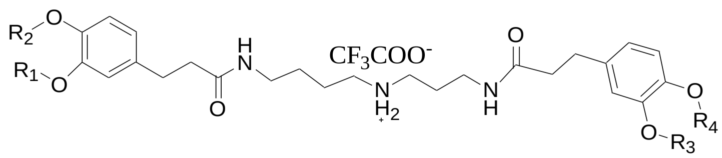
194 Lycibarbarspermidine F



195 Lycibarbarspermidine G

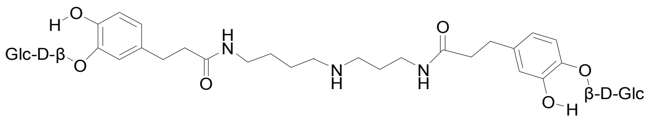
Figure 14. Chemical structures of compounds **194** and **195**.

Table 10. Chemical structures of compounds **196–200**.

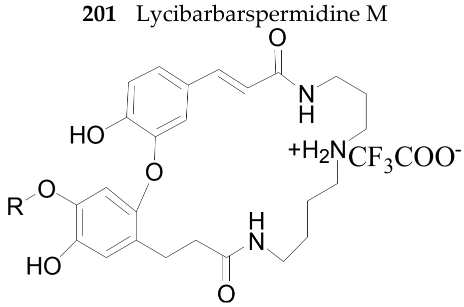


196–200

No.	Compounds	R_1	R_2	R_3	R_4	Source
196	Lycibarbarspermidine H	H	H	H	β-D-Glc	*L. barbarum*
197	Lycibarbarspermidine I	H	β-D-Glc	H	H	*L. barbarum*
198	Lycibarbarspermidine J	H	*H*	β-D-Glc	H	*L. barbarum*
199	Lycibarbarspermidine K	β-D-Glc	*H*	β-D-Glc	H	*L. barbarum*
200	Lycibarbarspermidine L	H	β-D-Glc	H	β-D-Glc	*L. barbarum*



201 Lycibarbarspermidine M



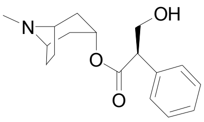
202 Lycibarbarspermidine N R = β-D-Glc
203 Lycibarbarspermidine O R = β-D-Glc[3]β-D-Glc

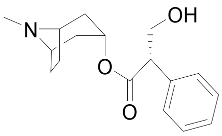
Figure 15. Chemical structures of compounds **201–203**.

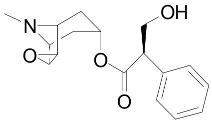
Tropane Alkaloids

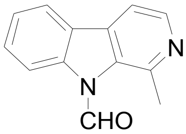
As we know, the genus *Lycium* has been used as both a medicine and a food for a long time in Asia, particularly in China. However, the safety of *Lycium* has been questioned for some time, especially after the detection of the three tropane alkaloids atropine (**204**), hyoscyamine (**205**), and scopolamine (**206**) [101]. Atropine and hyoscyamine were identified from the fruits of *L. barbarum* gathered in India, while scopolamine was identified from *L. halimifolium* at concentrations higher than the toxic dose. However, another scholar, seeking to verify these reports, demonstrated that the atropine content of *L. barbarum* from different sources was just 3.0 ppb—far below the poisoning dose [102]. It was demonstrated that none of the toxic compounds were detected in fruits, leaves, stems and roots of three *L. barbarum* varieties ('No. 1', 'New Big' and 'Amber Sweet Goji') by densitometric TLC analysis [103]. Through field investigation and model specimen inspections, the above three tropane alkaloids were determined to be from *Lycium europaeum* rather than the *L. barbarum*. Thus, the genus *Lycium* is likely non-toxic, and consumers can rest assured that its use is safe [104].

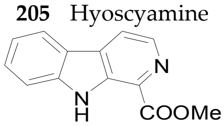
Other than the alkaloids that have been already mentioned, there are nine others that have been obtained from this genus, including 9-formylharman (**207**), 1-(methoxycarbonyl)-β-carboline (**208**), perlolyrine (**209**), choline (**210**), 1β-amino-3β,4β,5α-trihydroxycycloheptane (**211**), betaine hydrochloride (**212**), nicotianamine (**213**), betaine (**214**), and melatonin (**215**). Compounds **207–209** were isolated from the fruits of *L. chinense* [105], while **210–212** were isolated from the root bark of *L. chinense* [90]. Compound **213** was isolated from the leaves and flowers of *L. chinense* [106], and **214** and **215** were isolated from the fruits of *L. barbarum* [107,108]. The chemical structures of these tropane alkaloids are listed in Figure 16.

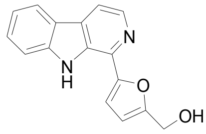

204 Atropine

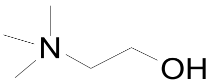

205 Hyoscyamine

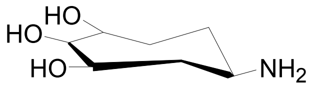

206 Scopolamine

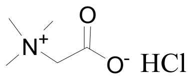

207 9-Formylharman

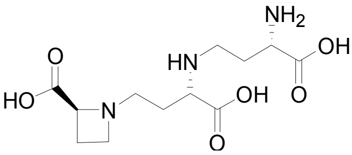

208 1-(Methoxycarbonyl)-β-carboline

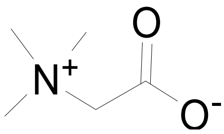

209 Perlolyrine


210 Choline


211 1β-Amino-3β,4β,5α-trihydroxycycloheptane


212 Betaine hydrochloride


213 Nicotianamine


214 Betaine

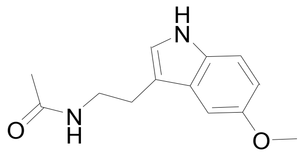
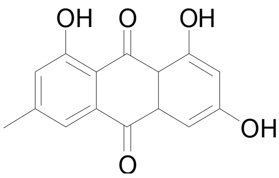
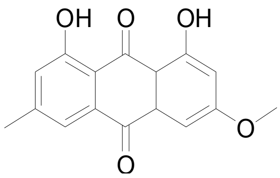

215 Melatonin

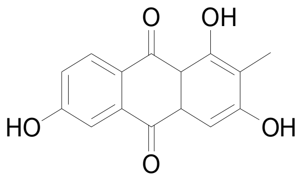
Figure 16. Chemical structures of compounds **204**–**215**.

2.2.8. Anthraquinones **216**–**219**

Four anthraquinones: emodin (**216**), physcion (**217**), 6-hydroxyrubiadin (**218**), and 3-*O*-(2-*O*-α-L-rhamnopyranosyl-6-*O*-acetyl-β-D-glucopyranosyl)-6-hydroxy-rubiadin (**219**), listed in Figure 17, have been obtained from the root bark of *L. chinense* [61,109].


216 Emodin


217 Physcion


218 6-Hydroxyrubiadin

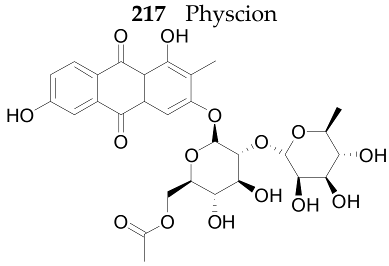

219 3-*O*-(2-*O*-α-L-Rhamnopyranosyl-6-*O*-acetyl-β-D-glucopyranosyl)-6-hydroxyrubiadin

Figure 17. Chemical structures of compounds **216**–**219**.

2.2.9. Organic Acids **220**–**251**

To this point, 32 organic acids, listed in Figure 18, have been identified from the genus *Lycium*, which can be classified into two groups: aliphatic acids **220**–**238** and aromatic acids and their derivatives **239**–**251**. Compounds **220**–**225** and **240**–**244** were isolated from the fruits of *L. barbarum* [56,63,65,107,110–112]; **239** and **245** were isolated from the leaves of *L. barbarum* [66];

226 was isolated from the root of *L. chinense* [113]; **227**, **248** and **249** were isolated from the fruits of *L. chinense* [70,114]; **228–233** and **248** were isolated from the leaves of *L. chinense* [115]; **234**, **235**, and **249–251** were isolated from the root bark of *L. chinense* [53,78,93,116,117], and **236–238** were isolated from the fruits of *L. urcomanicum* [118,119].

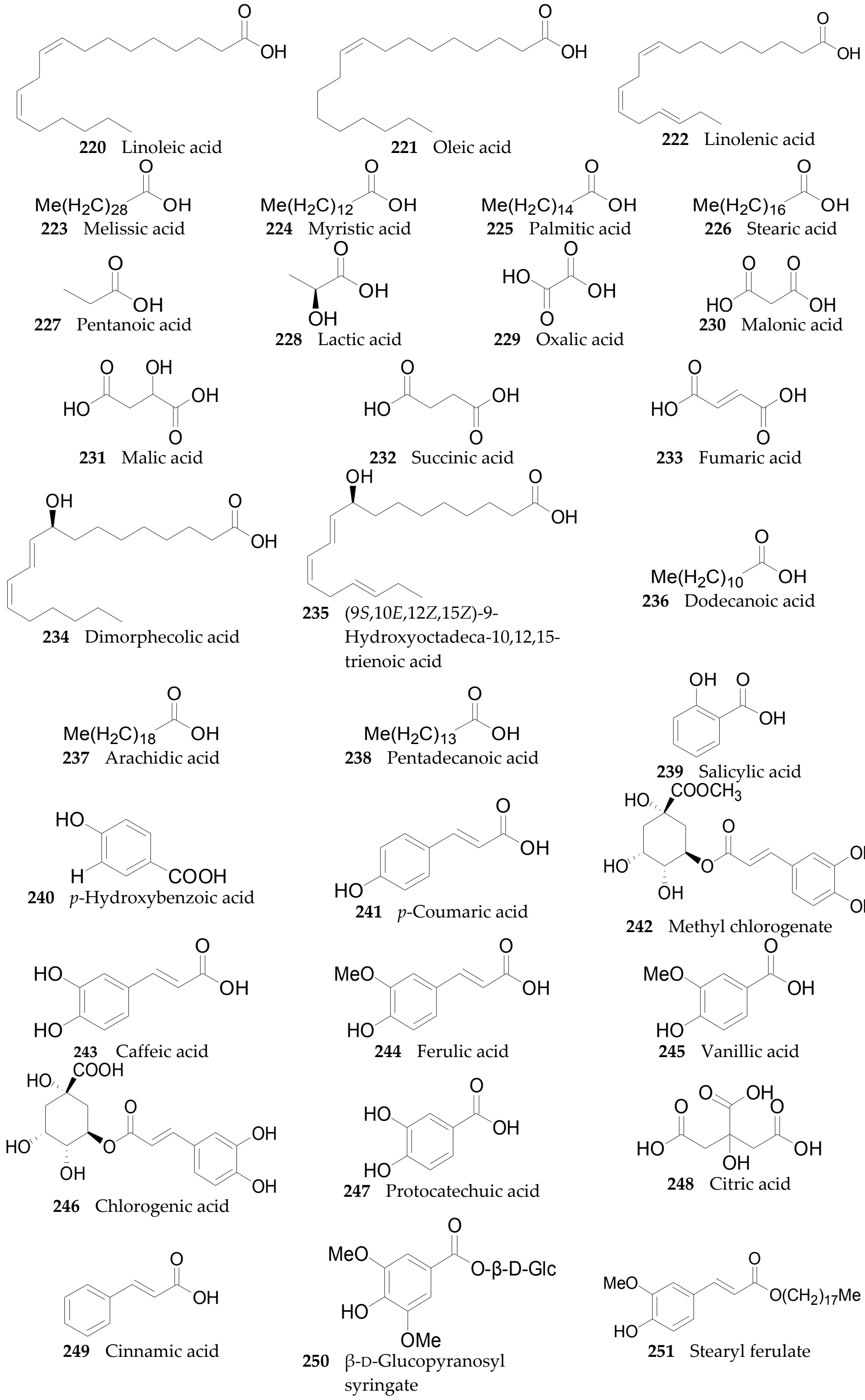
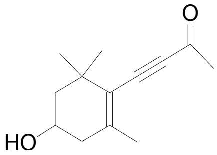


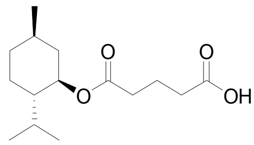
Figure 18. Chemical structures of compounds **220–251**.

2.2.10. Terpenoids **252–290**

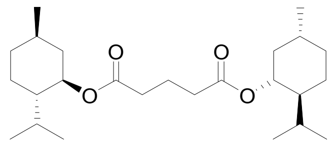
Thirty-seven terpenoids, listed in Figures 19–21 and Tables 11 and 12, have been found in the genus *Lycium*, mainly including monoterpenes **252–256**, sesquiterpenes **257–263**, diterpenoids **264–274**, and carotenoids **275–290**. Among them, carotenoids are one of the more important constituents of the *Lycium* fruits. Thus compounds **256** and **275–286** were isolated from the fruits of *L. barbarum* [120–123]; **253**, **254**, **258**, **259** and **287–290** were isolated from the fruits of *L. chinense* [120,121,124–126]; **252** and **264–272** were isolated from the leaves of *L. chinense* [127,128]; **255**, **258** and **273–274** were isolated from the root bark of *L. chinense* [80,116]; **260** and **261** were isolated from the leaves of *L. halimifolium* [23]; and **262** and **265** were isolated from the leaves of *L. barbarum* [129].



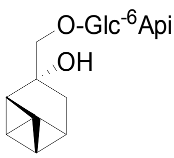
252 7,8-Dihydro-3-hydroxy-β-ionone



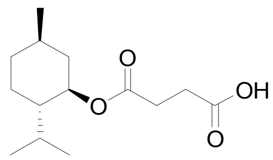
253 L-Monomethyl glutarate



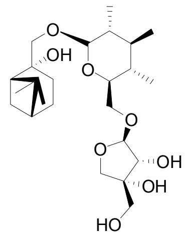
254 L-Dimethyl glutarate



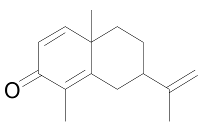
255 Monoterpene glycoside



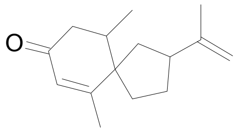
256 L-Monomethyl succinate



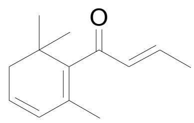
257 10-*O*-(β-D-Apiofuranosyl)-(1 → 6)-(β-D-glucopyranosyl)-pinanediol



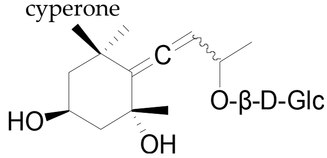
258 (-)-1,2-Didehydro-α-cyperone



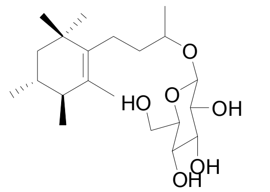
259 Solavetivone



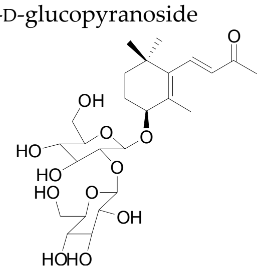
260 Damascenone



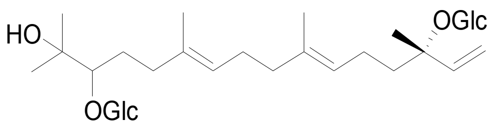
261 3-(2,4-Dihydroxy-2,6,6-trimethylcyclohexylidene)-1-methylprop-2-enyl-β-D-glucopyranoside



262 Lyciumionoside A



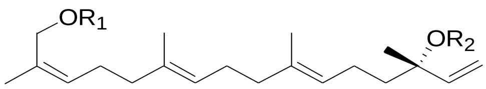
263 Lyciumionoside B



266 Lyciumosides III

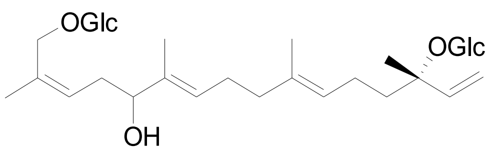
Figure 19. Chemical structures of compounds **252–263**, **266**.

Table 11. Chemical structures of compounds **264–265**, **267–270** and **272–273**.

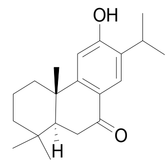


264–265, **267–270**,**272–273**

No.	Compounds	R_1	R_2	Source
264	Lyciumosides I	Glc	Glc	*L. chinense*
265	Lyciumosides II	Glc^2-Glc	Glc	*L. chinense*
267	Lyciumosides IV	Glc	Glc^4-Rha	*L. chinense*
268	Lyciumosides V	Glc^6-Rha	Glc	*L. chinense*
269	Lyciumosides VI	Glc^6-Rha	Glc^4-Rha	*L. chinense*
270	Lyciumosides VII	Glc^2-Rha(^{6}-Glc)	Glc	*L. chinense*
272	Lyciumosides IX	Glc	6-*O*-malonyl-Glc	*L. chinense*
273	Capsianoside II	Rha^3-Glc^6-Rha	Glc^2-Glc	*L. chinense*



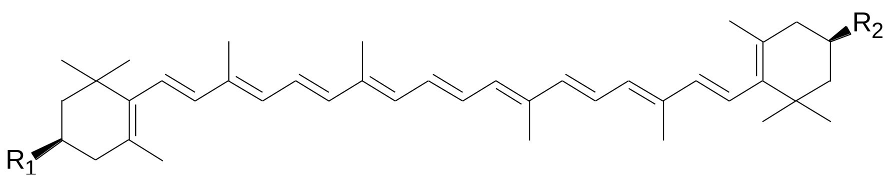
271 Lyciumosides VIII



274 Diterpene sugiol

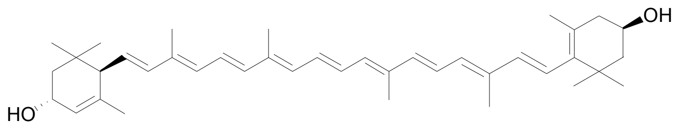
Figure 20. Chemical structures of compounds **271** and **274**.

Table 12. Chemical structures of compounds **275–282**.

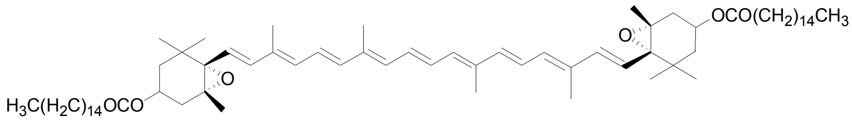


275–282

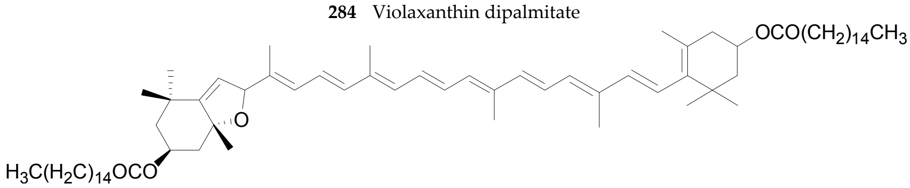
No.	Compounds	R_1	R_2	Source
275	β-Carotene	H	H	*L. barbarum*
276	β-Cryptoxanthin	OH	H	*L. barbarum*
277	Zeaxanthin	OH	OH	*L. barbarum*
278	Zeaxanthin monopalmitate	$OCO(CH_2)_{14}CH_3$	OH	*L. barbarum*
279	Zeaxanthin dipalmitate	$OCO(CH_2)_{14}CH_3$	$OCO(CH_2)_{14}CH_3$	*L. barbarum*
280	Zeaxanthin monomyristate	OH	$OCO(CH_2)_{12}CH_3$	*L. barbarum*
281	Zeaxanthin dimyristate	$OCO(CH_2)_{12}CH_3$	$OCO(CH_2)_{12}CH_3$	*L. barbarum*
282	β-Cryptoxanthin palmitate	$OCO(CH_2)_{14}CH_3$	H	*L. barbarum*



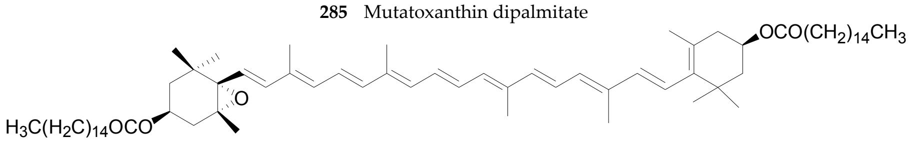
283 Lutin



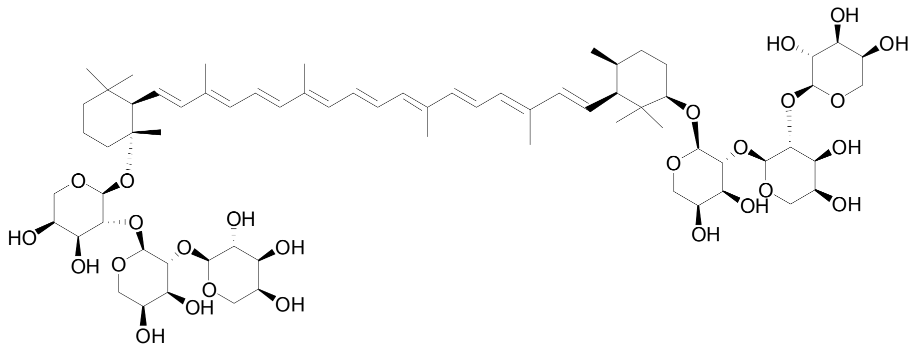
284 Violaxanthin dipalmitate



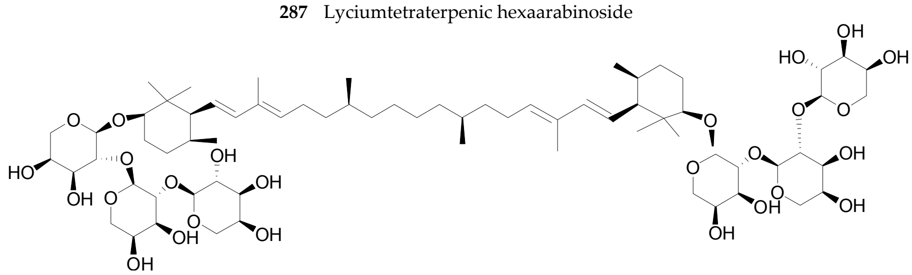
285 Mutatoxanthin dipalmitate



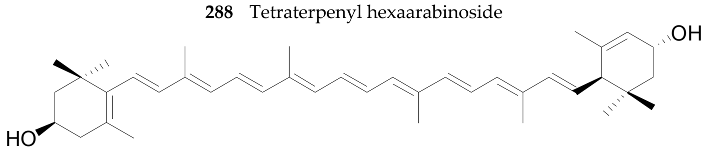
286 Antheraxanthin dipalmitate



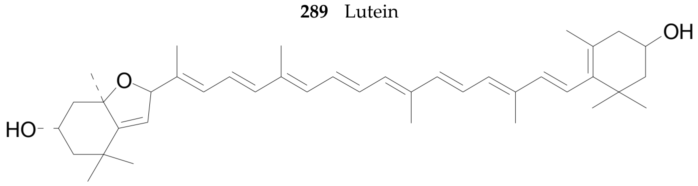
287 Lyciumtetraterpenic hexaarabinoside



288 Tetraterpenyl hexaarabinoside



289 Lutein



290 Mutatoxanthin

Figure 21. Chemical structures of compounds **283–290**.

2.2.11. Sterols, Steroids, and Their Derivatives 291–347

Fifty-seven sterols, steroids, and their derivatives **291–347**, listed in Figure 22, have been identified from the genus *Lycium*, mainly from the seeds and the fruits. Compounds **293** and **343** were identified from the flowers of *L. barbarum* [130], **291–292**; **295**, **298**, **319–324** and **337–339** were identified from the fruits of *L. chinense* [23,35,52,63,107,131]; **341 342**, **346** and **347** were identified from the leaves of *L. chinense* [132,133]; **336** and **340** were identified from the root bark of *L. chinense* [80,121]; **294** was identified from the seed of *L. ciliatum* [66]; all others were identified from the seed of *L. chinense* [134–137] **344** and **345** were identified from the seeds of *L. barbarum* [138].

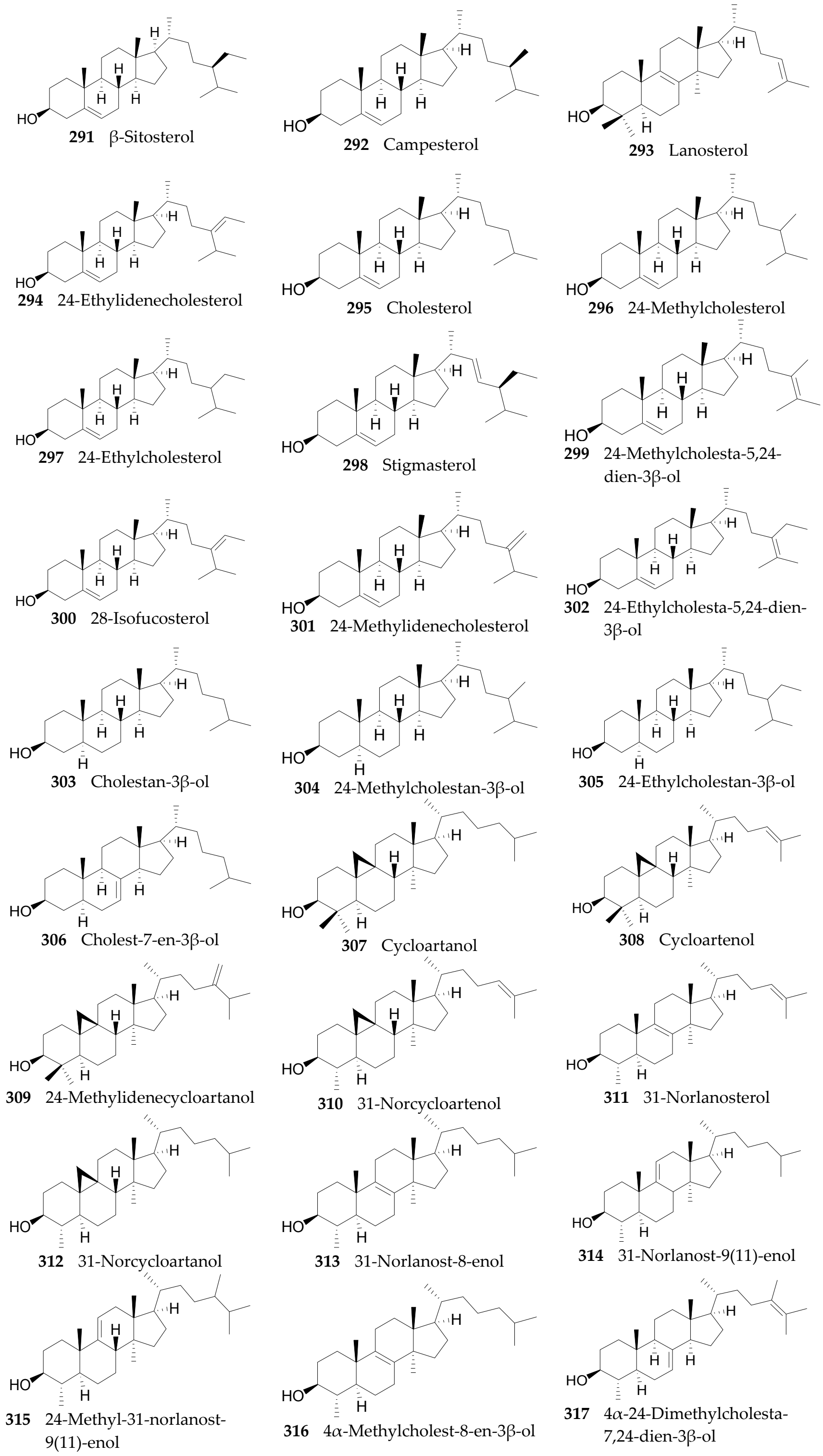
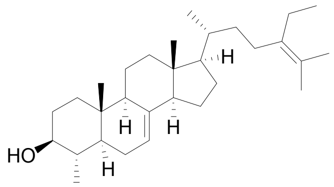
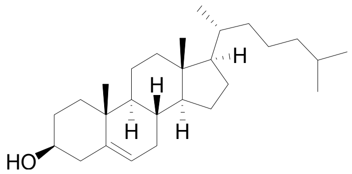


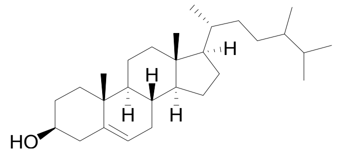
Figure 22. *Cont.*



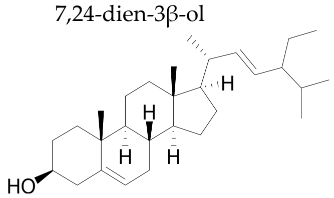
318 24-Ethyl-4α-methylcholesta-7,24-dien-3β-ol



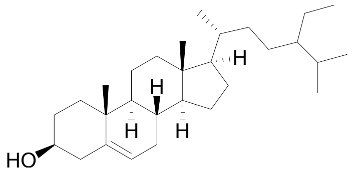
319 Cholest-5-en-3β-ol



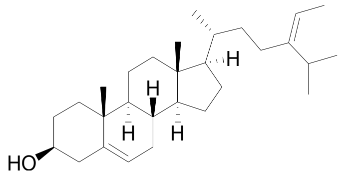
320 24-Methylcholest-5-en-3β-ol



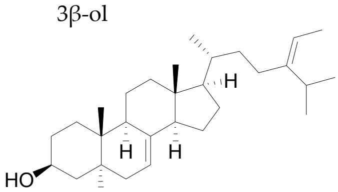
321 24-Ethylcholesta-5,22-dien-3β-ol



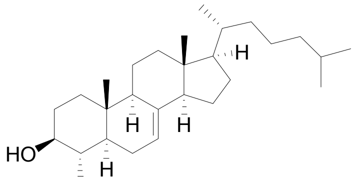
322 24-Ethylcholest-5-en-3β-ol



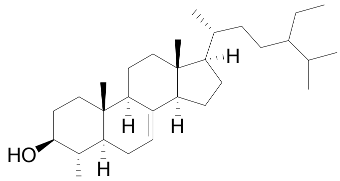
323 24-Ethylidenecholest-5-en-3β-ol



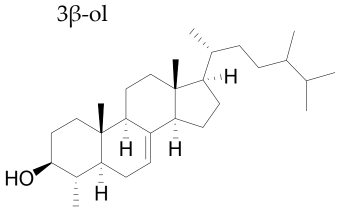
324 24-Ethylidenecholest-7-en-3β-ol



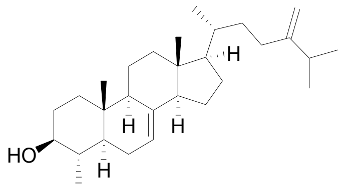
325 Lophenol



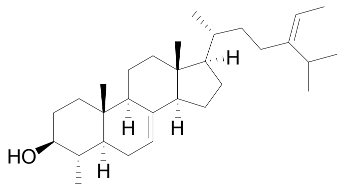
326 24-Ethyllophenol



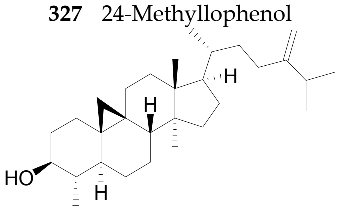
327 24-Methyllophenol



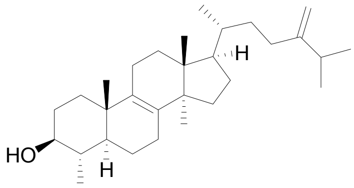
328 Gramisterol



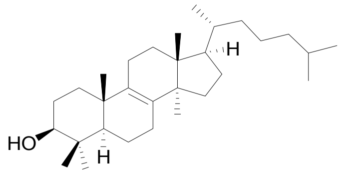
329 Citrostadienol



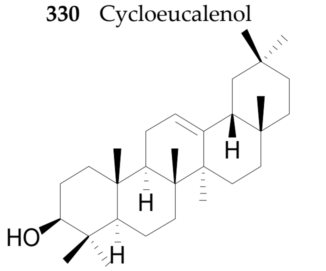
330 Cycloeucalenol



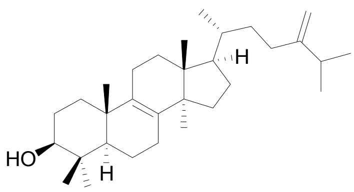
331 Obtusifoliol



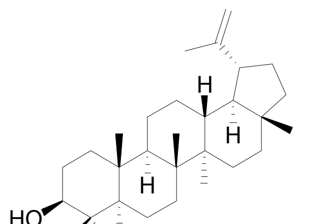
332 Lanost-8-enol



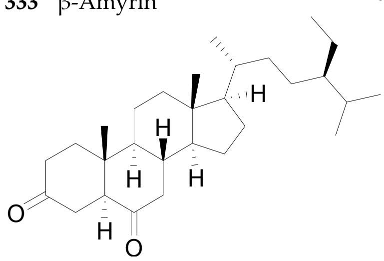
333 β-Amyrin



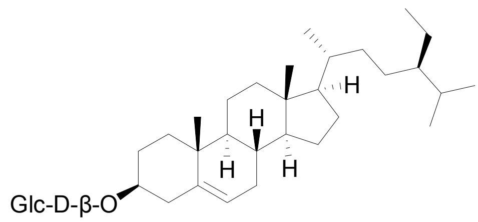
334 24-Methylenelanost-8-enol(24-methylenelanost-8-en-3β-ol)



335 Lupeol

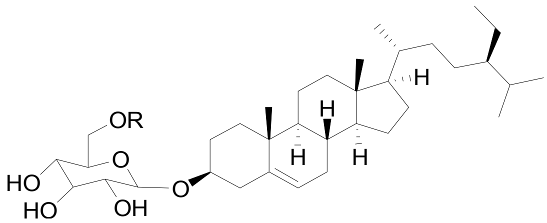


336 5α-Stigmastane-3,6-dione

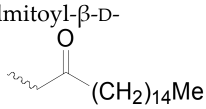


337 β-Sitosterol β-D-glucopyranoside

Figure 22. *Cont.*

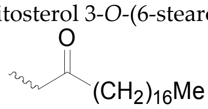


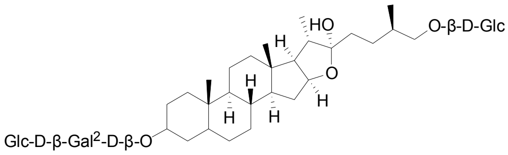
338 β-Sitosterol 3-*O*-(6-palmitoyl-β-D-glucopyranoside) R =



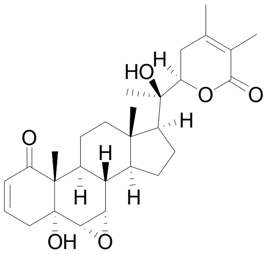
339 β-Sitosterol 3-*O*-(6-stearoyl-β-D-glucopyranoside)

R =

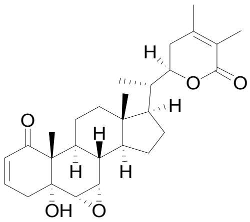




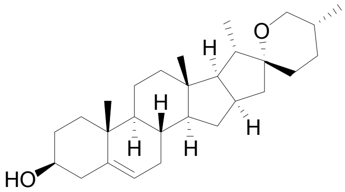
340 Furostanol glycoside R_1 = β-D-Gal²-β-D-Glc,R_2 = β-D-Glc



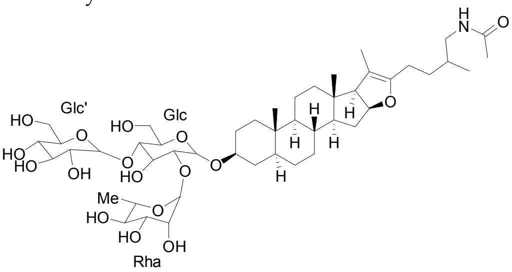
341 Lyciumsubstanz A



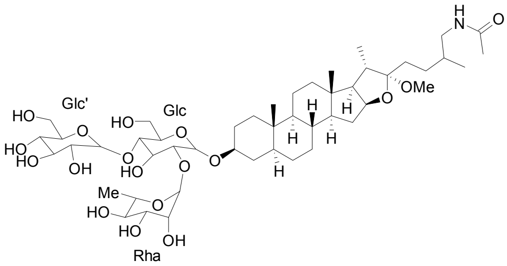
342 Lyciumsubstanz B



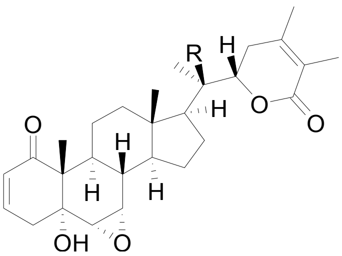
343 Diosgenin



344 Lycioside A



345 Lycioside B

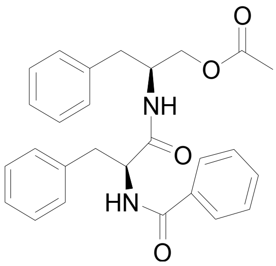


346 Withanolide A R=OH
347 Withanolide B R=H

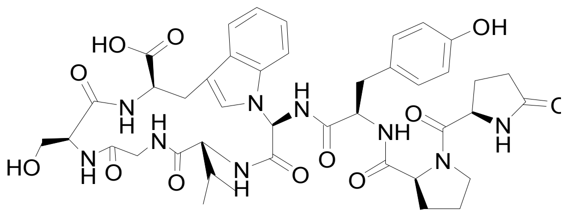
Figure 22. Chemical structures of compounds **291**–**347**.

2.2.12. Peptides **348–352**

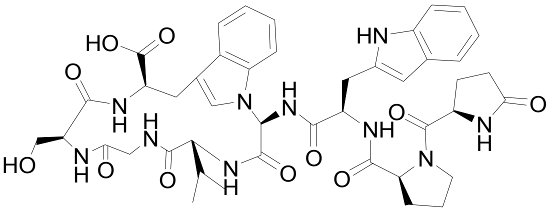
Five peptides have been isolated from the root bark of *L. chinense* [80,139], including one dipeptide, lyciumamide (**348**), and four octapeptides, called lyciumins A–D (compounds **349–350**), illustrated in Figure 23.



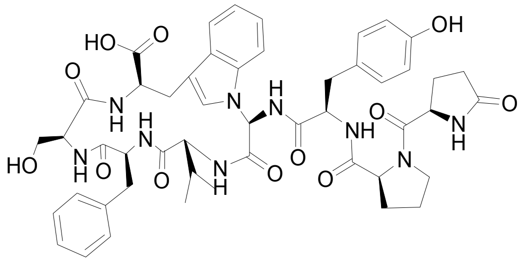
348 Lyciumamide



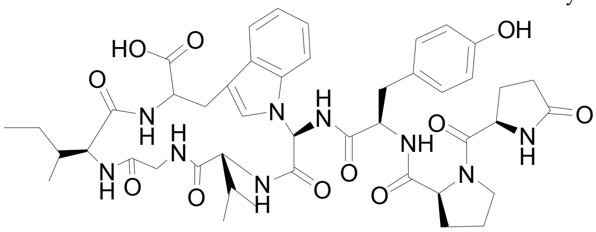
349 Lyciumins A



350 Lyciumins B



351 Lyciumins C

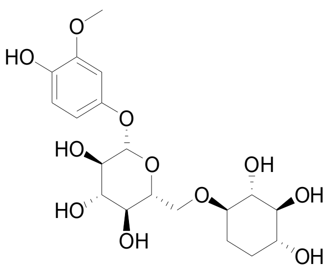


352 Lyciumins D

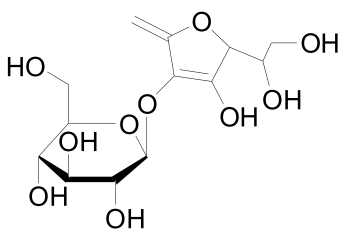
Figure 23. Chemical structures of compounds **348**–**352**.

2.2.13. Other Compounds 353–355

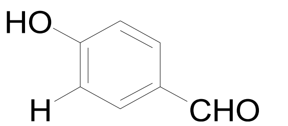
Other than what has already been mentioned, a few other chemical constituents, listed in Figure 24, were also isolated from the genus *Lycium*. Digupigan A (**353**), 2-*O*-(β-D-glucopyranosyl)ascorbic acid (**354**) and *p*-hydroxybenzaldehyde (**355**) also have been obtained from the root bark of *L. chinense*, the fruits of *L. chinense*, and the fruits of *L. barbarum* [75,76,121,137,140,141], respectively. Many minerals, amino acids, and proteins have also been found in the genus *Lycium*, such as Ca, Mg, Zn, Fe, aminoethanesulfonic acid, γ-aminobutyric acid (GABA), Mn-SOD, etc. [121,142,143].



353 Digupigan A



354 2-*O*-(β-D-Glucopyranosyl)-ascorbic acid



355 *p*-Hydroxybenzaldehyde

Figure 24. Chemical structures of compounds **353**–**355**.

3. Discussion

Lycium species are of valuable medicinal, nutritional and functional significance, and have been studied in terms of their chemical compounds. Phytochemical investigations on eight different species, have resulted in the isolation of at least **355** constituents up to July of 2016. Research on chemical compounds has concentrated mainly on *L. barbarum* and *L. chinense*. Therefore, future phytochemistry research should be focused on the other species in *Lycium* genus. In addition, diverse plant parts (i.e., the flowers, leaves, seeds) have also been testified to contain new constituents, most of which possess the novel chemical structures. Polysaccharides play a particularly significant role in exerting pharmacological actions. A specific class of polysaccharides, abbreviated as LBP, is used as biomarker in the 2015 Chinese Pharmacopoeia as a measure by which wolfberry is qualified. At present, LBP in products or in pharmacological studies usually are polysaccharide mixtures with heterogeneity and polydispersity. On the other hand, development of new separation, detection techniques will greatly benefit the phytochemical isolation and structural elucidation of LBP. There is a growing recognition that not only the LBP, but also the plant secondary metabolites may have the potential active ingredients, while most of the research on goji berry was LBP rather than small molecule substances, so more intensive studies of goji berry are required to shed some light on these compounds.

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Conflicts of Interest: The authors declare no conflict of interest.

References

1. Zhang, Z.Y.; Lu, A.M.; D'Arcy, W.G. *Flora of China. Volume 17: Verbenaceae through Solanaceae*; Science Press: Beijing, China; Missouri Botanical Garden Press: St. Louis, MO, USA, 1994; pp. 301–304.
2. Chinese Pharmacopoeia Commission. *Pharmacopoeia of the People's Republic of China Part I*; Chemical Industry Press: Beijing, China, 2015.
3. Yuenshan, H.; Yu, M.S.; Suetyi, Y.; Kwokfai, S.; Waihung, Y. Polysaccharides from wolfberry antagonizes glutamate excitotoxicity in rat cortical neurons. *Cell. Mol. Neurobiol.* **2009**, *29*, 1233–1244.
4. Yu, M.S.; Wong, Y.Y.; So, K.F.; Fang, J.N.; Yuen, W.H.; Chang, C.C. New polysaccharide from Nerium indicum protects neurons via stress kinase signaling pathway. *Brain Res.* **2007**, *1153*, 221. [CrossRef] [PubMed]
5. Bie, M.; Lv, Y.; Ren, C.; Xing, F.; Cui, Q.; Xiao, J.; So, K.F. *Lycium barbarum* polysaccharide improves bipolar pulse current-induced microglia cell injury through modulating autophagy. *Cell Trans.* **2015**, *24*, 419–428. [CrossRef] [PubMed]
6. Li, H.Y.; Ruan, Y.W.; Kau, P.W.; Chiu, K.; Chang, R.C.; Chan, H.H.; So, K.F. Effect of *Lycium barbarum* (Wolfberry) on alleviating axonal degeneration after partial optic nerve transection. *Cell Trans.* **2015**, *24*, 403–417. [CrossRef] [PubMed]
7. Yu, M.; Ho, Y.; So, K.; Yuen, W.; Chang, R. Cytoprotective effects of *Lycium barbarum* on cultured neurons against reducing stress on the endoplasmic reticulum. *Int. J. Mol. Med.* **2006**, *17*, 1157–1161. [PubMed]
8. Ye, Z.; Huang, Q.; Ni, H.X.; Wang, D. Cortex Lycii Radicis extracts improve insulin resistance and lipid metabolism in obese-diabetic rats. *Phytotherapy Res.* **2008**, *22*, 1665–1670. [CrossRef] [PubMed]
9. Xie, L.W.; Atanasov, A.G.; Guo, D.A.; Malainer, C.; Zhang, J.X.; Zehl, M.; Guan, S.H.; Heiss, E.H.; Urban, E.; Dirsch, V.M. Activity-guided isolation of NF-κB inhibitors and PPARγ agonists from the root bark of *Lycium chinense Miller*. *J. Ethnopharmacol.* **2014**, *152*, 470–477. [CrossRef] [PubMed]
10. Behl, T.; Kotwani, A. Chinese herbal drugs for the treatment of diabetic retinopathy. *J. Pharm. Pharmacol.* **2016**, *69*, 223–235. [CrossRef] [PubMed]
11. Donno, D.; Beccaro, G.L.; Mellano, M.G.; Cerutti, A.K.; Bounous, G. Goji berry fruit (*Lycium* spp.): Antioxidant compound fingerprint and bioactivity evaluation. *J. Funct. Foods* **2015**, *18*, 1070–1085. [CrossRef]
12. Donno, D.; Mellano, M.G.; Raimondo, E.; Cerutti, A.K.; Prgomet, Z.; Beccaro, G.L. Influence of applied drying methods on phytochemical composition in fresh and dried goji fruits by HPLC fingerprint. *Eur. Food Res. Technol.* **2016**, *242*, 1961–1974. [CrossRef]
13. Horszwald, A.; Andlauer, W. Characterisation of bioactive compounds in berry juices by traditional photometric and modern microplate methods. *J. Berry Res.* **2011**, *1*, 189–199.

14. Yuan, G.; Ren, J.; Ouyang, X.; Wang, L.; Wang, M.; Shen, X.; Zhang, B.; Zhu, B. Effect of Raw Material, Pressing and Glycosidase on the Volatile Compound Composition of Wine Made From Goji Berries. *Molecules* **2016**, *21*, 1324. [CrossRef] [PubMed]
15. Hongli, J.; Yanfang, L.; Zhimou, G.; Fan, Y.; Jixia, W.; Xiaolong, L.; Xiaojun, P.; Xinmiao, L. High-performance liquid chromatography separation of *cis-trans* anthocyanin isomers from wild *Lycium ruthenicum Murr.* employing a mixed-mode reversed-phase/strong anion-exchange stationary phase. *J. Agric. Chem.* **2015**, *63*, 500.
16. Jin, H.; Zhao, J.; Zhou, W.; Shen, A.; Yang, F.; Liu, Y.; Guo, Z.; Zhang, X.; Tao, Y.; Peng, X. Preparative separation of a challenging anthocyanin from *Lycium ruthenicum Murr.* by two-dimensional reversed-phase liquid chromatography/hydrophilic interaction chromatography. *RSC Adv.* **2015**, *5*, 62134–62141. [CrossRef]
17. Potterat, O. Goji (*Lycium barbarum* and *L. chinense*): Phytochemistry, pharmacology and safety in the perspective of traditional uses and recent popularity. *Planta Med.* **2010**, *76*, 7. [CrossRef] [PubMed]
18. Amagase, H.; Farnsworth, N.R. A review of botanical characteristics, phytochemistry, clinical relevance in efficacy and safety of *Lycium barbarum* fruit (Goji). *Food Res. Int.* **2011**, *44*, 1702–1717. [CrossRef]
19. Kulczyński, B.; Gramzamichałowska, A. Goji berry (*Lycium barbarum*): Composition and health effects—A review. *Pol. J. Food Nutr. Sci.* **2016**, *66*, 67–76.
20. Wang, Q.; Chen, S.Q.; Zhang, Z.H. Determination of polysaccharide content in medlar. *J. China Pharm. Univ.* **1991**, *22*, 67–68.
21. Wu, D.T.; Lam, S.C.; Cheong, K.L.; Feng, W.; Lin, P.C.; Long, Z.R.; Lv, X.J.; Jing, Z.; Ma, S.C.; Li, S.P. Simultaneous determination of molecular weights and contents of water-soluble polysaccharides and their fractions from *Lycium barbarum* collected in China. *J. Pharm. Biomed. Anal.* **2016**, *129*, 210–218. [CrossRef] [PubMed]
22. Zou, S.; Zhang, X.; Yao, W.; Niu, Y.; Gao, X. Structure characterization and hypoglycemic activity of a polysaccharide isolated from the fruit of *Lycium barbarum* L. *Carbohydr. Polym.* **2010**, *80*, 1161–1167. [CrossRef]
23. Redgwell, R.J.; Curti, D.; Wang, J.; Dobruchowska, J.M.; Gerwig, G.J.; Kamerling, J.P.; Bucheli, P. Cell wall polysaccharides of Chinese Wolfberry (*Lycium barbarum*): Part 1. Characterisation of soluble and insoluble polymer fractions. *Carbohydr. Polym.* **2011**, *84*, 1344–1349. [CrossRef]
24. Xie, J.H.; Tang, W.; Jin, M.L.; Li, J.E.; Xie, M.Y. Recent advances in bioactive polysaccharides from *Lycium barbarum* L. Zizyphus jujuba Mill, *Plantago* spp. and *Morus* spp.: Structures and functionalities. *Food Hydrocoll.* **2016**, *60*, 148–160. [CrossRef]
25. Wu, D.T.; Cheong, K.L.; Deng, Y.; Lin, P.C.; Wei, F.; Lv, X.J.; Long, Z.R.; Zhao, J.; Ma, S.C.; Li, S.P. Characterization and comparison of polysaccharides from *Lycium barbarum* in China using saccharide mapping based on PACE and HPTLC. *Carbohydr. Polym.* **2015**, *134*, 12. [CrossRef] [PubMed]
26. Näf, R.; Velluz, A.; Thommen, W. Isolation of a glucosidic precursor of damascenone from *Lycium halimifolium* mil. *Tetrahedron Lett.* **1990**, *31*, 6521–6522. [CrossRef]
27. Peng, X.; Tian, G. Structural characterization of the glycan part of glycoconjugate LbGp2 from *Lycium barbarum* L. *Carbohydr. Res.* **2001**, *331*, 95. [CrossRef]
28. Huang, L.; Lin, Y.; Tian, G.; Ji, G. Isolation, purification and physico-chemical properties of immunoactive constituents from the fruit of *Lycium barbarum* L. *Acta Pharm. Sin.* **1998**, *33*, 512–516.
29. Huang, L.J.; Tian, G.Y.; Ji, G.Z. Structure elucidation of glycan of glycoconjugate LbGp3 isolated from the fruit of *Lycium barbarum* L. *J. Asian Nat. Prod. Res.* **1999**, *1*, 259–267. [CrossRef] [PubMed]
30. Peng, X.M.; Huang, L.J.; Qi, C.H.; Zhang, Y.X.; Tian, G.Y. Studies on chemistry and immuno- modulating mechanism of a glycoconjugate from *Lycium barbarum* L. *Chin. J. Chem.* **2001**, *19*, 1190–1197. [CrossRef]
31. Peng, X.M.; Qi, C.H.; Tian, G.Y.; Zhang, Y.X. Physico-chemical Properties and Bioactivities of a Glycoconjugate LbGp5B from *Lycium barbarum* L. *Chin. J. Chem.* **2010**, *19*, 842–846. [CrossRef]
32. Gan, L.; Hua, Z.S.; Liang, Y.X.; Bi, X.H. Immunomodulation and antitumor activity by a polysaccharide-protein complex from *Lycium barbarum*. *Int. Immunopharmacol.* **2004**, *4*, 563. [CrossRef] [PubMed]
33. Zhao, C.; Li, R.; He, Y.; Guohui, C. Studies on the chemistry of Gouqi polysaccharides. *J. Beijing Med. Univ.* **1997**, *29*, 231–232.
34. Duan, C.L.; Qiao, S.Y.; Wang, N.L.; Zhao, Y.M.; Qi, C.H.; Yao, X.S. Studies on active polysaccharides from *Lycium barbarum*. *Yaoxue Xuebao* **2001**, *36*, 196–199.

35. Chen, Z.; Tan, K.H.; Tay, S.S.; Chan, S.H. Activation of T lymphocytes by polysaccharide-protein complex from a Chinese medicinal nutrient, *Lycium barbarum* L. *Int. Immunopharmacol.* **2008**, *8*, 1663–1671. [CrossRef] [PubMed]
36. Ke, M.; Zhang, X.J.; Han, Z.H.; Yu, H.Y.; Lin, Y.; Zhang, W.G.; Sun, F.H.; Wang, T.J. Extraction, purification of *Lycium barbarum* polysaccharides and bioactivity of purified fraction. *Carbohydr. Polym.* **2011**, *86*, 136–141. [CrossRef]
37. Zhao, C.J.; He, Y.Q.; Li, R.Z. Chemistry and Pharmacological Activity of Peptidoglycan from *Lycium barbaruml*. *Chin. Chem. Lett.* **1996**, *7*, 1009–1010.
38. Redgwell, R.J.; Curti, D.; Wang, J.; Dobruchowska, J.M.; Gerwig, G.J.; Kamerling, J.P.; Bucheli, P. Cell wall polysaccharides of Chinese Wolfberry (*Lycium barbarum*): Part 2. Characterisation of arabinogalactan-proteins. *Carbohydr. Polym.* **2011**, *84*, 1075–1083. [CrossRef]
39. Liu, H.; Fan, Y.; Wang, W.; Liu, N.; Zhang, H.; Zhu, Z.; Liu, A. Polysaccharides from *Lycium barbarum* leaves: Isolation, characterization and splenocyte proliferation activity. *Int. J. Biol. Macromol.* **2012**, *51*, 417–422. [CrossRef] [PubMed]
40. Sun, Y.; Sun, W.; Guo, J.; Hu, X.; Gong, G.; Huang, L.; Cao, H.; Wang, Z. Sulphation pattern analysis of chemically sulphated polysaccharide LbGp1 from *Lycium barbarum* by GC-MS. *Food Chem.* **2015**, *170*, 22. [CrossRef] [PubMed]
41. Zhu, J.; Liu, W.; Yu, J.; Zou, S.; Wang, J.; Yao, W.; Gao, X. Characterization and hypoglycemic effect of a polysaccharide extracted from the fruit of *Lycium barbarum* L. *Carbohydr. Polym.* **2013**, *98*, 8–16. [CrossRef] [PubMed]
42. Wei, L.; Liu, Y.; Rui, Z.; Yu, J.; Lu, W.; Pan, C.; Yao, W.; Gao, X. Structure characterization, chemical and enzymatic degradation, and chain conformation of an acidic polysaccharide from *Lycium barbarum* L. *Carbohydr. Polym.* **2016**, *147*, 114–124.
43. Qin, X.; Yamauchi, R.; Aizawa, K.; Inakuma, T.; Kato, K. Structural features of arabinogalactan-proteins from the fruit of *Lycium chinense* Mill. *Carbohydr. Res.* **2001**, *333*, 79–85. [CrossRef]
44. Qin, X.E. Isolation and Characteristics of Araban Isolated from the Fruitof *Lycium chinense* Mill. *Food Sci.* **2003**, *24*, 52–56.
45. Qin, X.; Yamauchi, R.; Aizawa, K.; Inakuma, T.; Kato, K. Isolation and Characterization of Arabinogalactan-protein from the Fruit of *Lycium chinense* Mill. *J. Appl. Glycosci.* **2000**, *47*, 155–161. [CrossRef]
46. Peng, Q.; Lv, X.; Xu, Q.; Li, Y.; Huang, L.; Du, Y. Isolation and structural characterization of the polysaccharide LRGP1 from *Lycium ruthenicum*. *Carbohydr. Polym.* **2012**, *90*, 95–101. [CrossRef] [PubMed]
47. Liu, Y.; Gong, G.; Sun, Y.; Gu, X.; Huang, L.; Wang, Z. Isolation, structural characterization, and immunological activity of a polysaccharide LRLP4-A from the leaves of *Lycium ruthenicum*. *J. Carbohydr. Chem.* **2016**, *35*, 40–56. [CrossRef]
48. Peng, Q.; Song, J.; Lv, X.; Wang, Z.; Huang, L.; Du, Y. Structural Characterization of an Arabinogalactan-Protein from the Fruits of *Lycium ruthenicum*. *J. Agric. Food Chem.* **2012**, *60*, 9424. [CrossRef] [PubMed]
49. Lv, X.; Wang, C.; Cheng, Y.; Huang, L.; Wang, Z. Isolation and structural characterization of a polysaccharide LRP4-A from *Lycium ruthenicum* Murr. *Carbohydr. Res.* **2013**, *365*, 20. [CrossRef] [PubMed]
50. Peng, Q.; Xu, Q.; Yin, H.; Huang, L.; Du, Y. Characterization of an immunologically active pectin from the fruits of *Lycium ruthenicum*. *Int. J. Biol. Macromol.* **2014**, *64*, 69. [CrossRef] [PubMed]
51. Gong, G.; Fan, J.; Sun, Y.; Wu, Y.; Liu, Y.; Sun, W.; Zhang, Y.; Wang, Z. Isolation, structural characterization, and antioxidativity of polysaccharide LBLP5-A from *Lycium barbarum* leaves. *Process Biochem.* **2015**, *51*, 314–324. [CrossRef]
52. Jung, K.; Chin, Y.W.; Kim, Y.C.; Kim, J. Potentially hepatoprotective glycolipid constituents of *Lycium chinense* fruits. *Arch. Pharm. Res.* **2005**, *28*, 1381–1385. [CrossRef] [PubMed]
53. Gao, Z.; Ali, Z.; Khan, I.A. Glycerogalactolipids from the fruit of *Lycium barbarum*. *Phytochemistry* **2008**, *69*, 2856–2861. [CrossRef] [PubMed]
54. Yang, Y.N.; An, Y.W.; Zhan, Z.L.; Xie, J.; Jiang, J.S.; Feng, Z.M.; Ye, F.; Zhang, P.C. Nine new compounds from the root bark of *Lycium chinense* and their α-glucosidase inhibitory activity. *RSC Adv.* **2016**, *7*, 805–812. [CrossRef]
55. Msonthi, J.; Toyota, M.; Marston, A.; Hostettmann, K. A Novel Phenolic Glycoside from Mondia whytei. *Bull. Chem. Soc. Ethiop.* **1989**, *5*, 618.

56. Zhou, Z.Q.; Xiao, J.; Fan, H.X.; Yu, Y.; He, R.R.; Feng, X.L.; Kurihara, H.; So, K.F.; Yao, X.S.; Gao, H. Polyphenols from wolfberry and their bioactivities. *Food Chem.* **2016**, *214*, 644. [CrossRef] [PubMed]
57. Feng, M.L.; Wang, S.F.; Zhang, X.X. Chemical constituents in fruits of *Lycium barbarum*. *Chin. Tradit. Herb. Drugs* **2013**, *44*, 265–268.
58. Mocan, A.; Vlase, L.; Vodnar, D.C.; Gheldiu, A.M.; Oprean, R.; Crișan, G. Antioxidant, Antimicrobial Effects and Phenolic Profile of *Lycium barbarum* L. Flowers. *Molecules* **2015**, *20*, 15060–15071. [CrossRef] [PubMed]
59. Li, X.-N.; Chu, C.; Tong, S.-Q.; Cheng, D.-P.; Yan, J.-Z. A new furolactone-type lignan from *Lycium chinense*. *Nat. Prod. Res.* **2013**, *27*, 750–752. [CrossRef] [PubMed]
60. Han, S.H.; Lee, H.H.; Lee, I.S.; Moon, Y.H.; Woo, E.R. A new phenolic amide from *Lycium chinense Miller*. *Arch. Pharm. Res.* **2002**, *25*, 433. [CrossRef] [PubMed]
61. Wei, X.L.; Liang, J.Y. Chemical Study on the Root Barks of Mill. *J. China Pharm. Univ.* **2002**, *33*, 271–273.
62. Zhao, J.; Xu, F.; Ji, T.; Li, J. A New Spermidine from the Fruits of *Lycium ruthenicum*. *Chem. Nat. Compd.* **2014**, *50*, 880–883. [CrossRef]
63. Xie, C.; Xu, L.Z.; Li, X.M.; Li, K.M.; Zhao, B.H.; Yang, S.L. Studieds on Chemical Constituents in Fruit of *Lycium barbarum* L. *China J. Chin. Mater. Med.* **2001**, *26*, 323.
64. Ma, J.; Tan, C.; Zhu, D. Glycosidic constituents from *Carpesium cernuum* L. *J. Asian Nat. Prod. Res.* **2008**, *10*, 565. [CrossRef] [PubMed]
65. Inbaraj, B.S.; Lu, H.T. Simultaneous determination of phenolic acids and flavonoids in *Lycium barbarum* Linnaeus by HPLC-DAD-ESI-MS. *J. Pharm. Biomed. Anal.* **2009**, *51*, 549–556. [CrossRef] [PubMed]
66. Yao, X.; Peng, Y.; Xu, L.J.; Li, L.; Wu, Q.L.; Xiao, P.G. ChemInform Abstract: Phytochemical and Biological Studies of *Lycium* Medicinal Plants. *Chem. Biodiv.* **2011**, *8*, 976–1010. [CrossRef] [PubMed]
67. Le, K.; Chiu, F.; Ng, K. Identification and quantification of antioxidants in Fructus lycii. *Food Chem.* **2007**, *105*, 353–363. [CrossRef]
68. Miean, K.H.; Mohamed, S. Flavonoid (myricetin, quercetin, kaempferol, luteolin, and apigenin) content of edible tropical plants. *J. Agric. Food Chem.* **2001**, *49*, 3106–3112. [CrossRef] [PubMed]
69. Xie, C.; Xu, L.Z.; Yang, X.J. Advances in chemical constituents of *Lycium*. *Int. J. Tradit. Chin. Med.* **1994**, 9–13.
70. Qian, J. The efficiency of flavonoids in polar extracts of *Lycium chinense* Mill fruits as free radical scavenger. *Food Chem.* **2004**, *87*, 283–288. [CrossRef]
71. Zou, Y.H. Flavones in Leaves of *Lycium chinense*. *J. Instrum. Anal.* **2002**, *21*, 76–78.
72. Christen, P.; Kapetanidis, I. Flavonoids from *Lycium halimifolium1*. *Planta Med.* **1987**, *53*, 571. [CrossRef] [PubMed]
73. Nomura, T.; Hano, Y. Compounds of *Broussonetia papyrifera* (L.) Vent. 2. Structures of Two New Isoprenylated Flavans, Kazinols A and B. *Heterocycles* **1985**, *23*, 2835–2842. [CrossRef]
74. Lee, D.; Bhat, K.P.L.; Fong, H.H.S.; Farnsworth, N.R.; Pezzuto, J.M.; Kinghorn, A.D. Aromatase Inhibitors from Broussonetia papyrifera. *J. Nat. Prod.* **2001**, *64*, 1286–1293. [CrossRef] [PubMed]
75. Williams, R.B.; O'Neil-Johnson, M.; Williams, A.J.; Wheeler, P.; Pol, R.; Moser, A. Dereplication of natural products using minimal NMR data inputs. *Organ. Biomol. Chem.* **2015**, *13*, 9957–9962. [CrossRef] [PubMed]
76. Dewick, P.M.; Ward, D. Isoflavone precursors of the pterocarpan phytoalexin maackiain in Trifolium pratense. *Phytochemistry* **1978**, *17*, 1751–1754. [CrossRef]
77. Lee, D.G.; Park, Y.; Kim, M.R.; Jung, H.J.; Seu, Y.B.; Hahm, K.S.; Woo, E.R. Anti-fungal effects of phenolic amides isolated from the root bark of *Lycium chinense*. *Biotechnol. Lett.* **2004**, *26*, 1125–1130. [CrossRef] [PubMed]
78. Niitsu, K.; Ikeya, Y.; Sato, T.; Katayama, N.; Fukuyama, K.; CHIN, M.; Taguchi, H.; Mitsuhashi, H. Studies on the Crude Drug Containing the Angiotensin I Converting Enzyme Inhibitors (II): On the Active Principles of Fritillaria verticillata WILLDENOW var. thumber gii BAKER. *Jpn. J. Pharmacogn.* **1987**, *41*, 174–179.
79. Zhang, J.X.; Guan, S.H.; Feng, R.H.; Wang, Y.; Wu, Z.Y.; Zhang, Y.B.; Chen, X.H.; Bi, K.S.; Guo, D.A. Neolignanamides, lignanamides, and other phenolic compounds from the root bark of *Lycium chinense*. *J. Nat. Prod.* **2013**, *76*, 51–58. [CrossRef] [PubMed]
80. Yahara, S.; Shigeyama, C.; Ura, T.; Wakamatsu, K.; Yasuhara, T.; Nohara, T. Cyclic Peptides, Acyclic Diterpene Glycosides and Other Compounds from *Lycium chinense* Mill. *Chem. Pharm. Bull.* **1993**, *41*, 703–709. [CrossRef] [PubMed]
81. Zou, C.; Zhao, Q.; Chen, C.X. The Structure of Lyciumide A. *Acta Bot. Yunnanica* **1999**, *21*, 378–380.

82. Zhou, Z.Q. *Studies on Bioactive Constituents of Lycium Barbarum for the Treatment of Alzheimer's Disease*; Jinan University: Guangzhou, China, 2016.
83. Kim, D.K.; Lim, J.P.; Jin, W.K.; Park, H.W.; Eun, J.S. Antitumor and antiinflammatory constituents from celtis sinensis. *Arch. Pharm. Res.* **2005**, *28*, 39–43. [CrossRef] [PubMed]
84. Kai, G.; Ma, D.; Yan, C.; Tian, X.; Lu, Y.; Du, X.; Tang, H.; Chen, J. Three New Dimers and Two Monomers of Phenolic Amides from the Fruits of *Lycium barbarum* and Their Antioxidant Activities. *J. Agric. Food Chem.* **2015**, *63*, 1067–1075.
85. Ma, J.; Jones, S.H.; Hecht, S.M. Phenolic acid amides: A new type of DNA strand scission agent from Piper caninum. *Bioorgan. Med. Chem. Lett.* **2004**, *12*, 3885–3889. [CrossRef] [PubMed]
86. Zhao, G.; Hui, Y.; Rupprecht, J.K.; Mclaughlin, J.L.; Wood, K.V. Additional bioactive compounds and trilobacin, a novel highly cytotoxic acetogenin, from the bark of Asimina triloba. *J. Nat. Prod.* **1992**, *55*, 347–356. [CrossRef] [PubMed]
87. Zhu, L.H.; Huang, X.S.; Ye, W.C.; Zhou, G.X. Study on Chemical Constituents of *Alocasia macrorrhiza* (L.) Schott. *Chin. Pharm. J.* **2012**, *47*, 1029–1031.
88. Li, Y.Z.; Tong, A.P.; Huang, J. Two New Norlignans and a New Lignanamide from Peperomia tetraphylla. *Chem. Biodiv.* **2012**, *9*, 769–776. [CrossRef] [PubMed]
89. Kim, S.Y.; Choi, Y.H.; Huh, H.; Kim, J.; Kim, Y.C.; Lee, H.S. New antihepatotoxic cerebroside from *Lycium chinense* fruits. *J. Nat. Prod.* **1997**, *60*, 274–276. [CrossRef] [PubMed]
90. Asano, N.; Kato, A.; Miyauchi, M.; Kizu, H.; Tomimori, T.; Matsui, K.; Nash, R.J.; Molyneux, R.J. Specific alpha-galactosidase inhibitors, *N*-methylcalystegines—Structure/activity relationships of calystegines from *Lycium chinense*. *Eur. J. Biochem.* **1997**, *248*, 296–303. [CrossRef] [PubMed]
91. Chiale, C.A.; Cabrera, J.; Juliani, H.R. NαCinnamoylhistamine derivates from *Lycium cestroides*. *Phytochemistry* **1990**, *29*, 688–689. [CrossRef]
92. Li, J.; Pan, L.; Naman, C.B.; Deng, Y.; Chai, H.; Keller, W.J.; Kinghorn, A.D. Pyrrole Alkaloids with Potential Cancer Chemopreventive Activity Isolated from a Goji Berry-Contaminated Commercial Sample of African Mango. *J. Agric. Food Chem.* **2014**, *62*, 5054–5060. [CrossRef] [PubMed]
93. Chin, Y.W.; Lim, S.W.; Kim, S.H.; Shin, D.Y.; Suh, Y.G.; Kim, Y.B.; Kim, Y.C.; Kim, J. Hepatoprotective pyrrole derivatives of *Lycium chinense* fruits. *Bioorgan. Med. Chem. Lett.* **2003**, *34*, 79–81. [CrossRef]
94. Youn, U.J.; Lee, J.Y.; Kil, Y.-S.; Han, A.-R.; Chae, C.H.; Ryu, S.Y.; Seo, E.-K. Identification of new pyrrole alkaloids from the fruits of *Lycium chinense*. *Arch. Pharm. Res.* **2015**, *39*, 321–327. [CrossRef] [PubMed]
95. Joung Youn, U.; Kil, Y.S.; Nam, J.W.; Jin Lee, Y.; Kim, J.; Lee, D.; Lee, J.H.; Seo, E.K. New Pyrrole Alkaloids with Bulky N-Alkyl Side Chains Containing Stereogenic Centers from *Lycium chinense*. *Helv. Chim. Acta* **2013**, *96*, 1482–1487. [CrossRef]
96. Yamada, H.; Nagai, T.; Abayomi, S.A.; Otani, I. New Alkaloid and Glucosidase Inhibitor Comprising the Same Alkaloid as Active Ingredient. 04-208264. **1992**, *7*, 29.
97. Funayama, S.; Yoshida, K.; Konno, C.; Hikino, H. Structure of kukoamine A, a hypotensive principle of *Lycium chinense* root barks1. *Tetrahedron Lett.* **1980**, *21*, 1355–1356. [CrossRef]
98. Funayama, S.; Zhang, G.R.; Nozoe, S. Kukoamine B, a spermine alkaloid from *Lycium chinense*. *Phytochemistry* **1995**, *38*, 1529–1531. [CrossRef]
99. Zhang, J.; Guan, S.; Sun, J.; Liu, T.; Chen, P.; Feng, R.; Chen, X.; Wu, W.; Yang, M.; Guo, D.A. Characterization and profiling of phenolic amides from Cortex Lycii by ultra-high performance liquid chromatography coupled with LTQ-Orbitrap mass spectrometry. *Anal. Bioanal. Chem.* **2015**, *407*, 581–595. [CrossRef] [PubMed]
100. Zhou, Z.-Q.; Fan, H.-X.; He, R.-R.; Xiao, J.; Tsoi, B.; Lan, K.-H.; Kurihara, H.; So, K.-F.; Yao, X.-S.; Gao, H. Lycibarbarspermidines A–O, new dicaffeoylspermidine derivatives from wolfberry, with activities against Alzheimer's disease and oxidation. *J. Agric. Food Chem.* **2016**, *64*, 2223–2237. [CrossRef] [PubMed]
101. Harsh, M.L. Tropane alkaloids from *Lycium barbarum* Linn. in vivo and in vitro. *Curr. Sci.* **1989**, *58*, 817–818.
102. Adams, M.; Wiedenmann, M.; Tittel, G.; Bauer, R. HPLC-MS trace analysis of atropine in *Lycium barbarum* berries. *Phytochem. Anal.* **2006**, *17*, 279. [CrossRef] [PubMed]
103. Kokotkiewicz, A.; Migas, P.; Stefanowicz, J.; Luczkiewicz, M.; Krauze-Baranowska, M. Densitometric TLC analysis for the control of tropane and steroidal alkaloids in *Lycium barbarum*. *Food Chem.* **2016**, *221*, 535–540. [CrossRef] [PubMed]

104. Yong, P. Pharmacognostical Study of *Lycium* Species. Ph.D. Thesis, Hong Kong Baptist University, Hong Kong, China, 2005.
105. Han, B.H.; Park, J.H.; Park, M.H.; Han, Y.N. Studies on the alkaloidal components of the fruits of *Lycium chinense*. *Arch. Pharm. Res.* **1985**, *8*, 249–252. [CrossRef]
106. Noma, M.; Noguchi, M. Occurrence of nicotianamine in higher plants. *Phytochemistry* **1976**, *15*, 1701–1702. [CrossRef]
107. He, J.; Yan, C.T.; Liang, Y.X. A Survey of Chemical Constituents of *Lycium barbarum* Fruit. *Chin. Wild Plant Resour.* **1997**, *1*, 8–11.
108. Chen, G.; Huo, Y.; Tan, D.-X.; Liang, Z.; Zhang, W.; Zhang, Y. Melatonin in Chinese medicinal herbs. *Life Sci.* **2003**, *73*, 19–26. [CrossRef]
109. Li, Y.B.; Li, P.; Tu, T.F.; Chang, H.T. Isolation and identification of chemical constituents Digupi. *Chin. Tradit. Herb. Drugs* **2004**, *35*, 1100–1101.
110. Wang, Q.; Yue, Y.; He, S.P.; Chen, Y.Y. Chemical Constituents of the Fruit of *Licium barbarum* L. *J. Chin. Pharm. Sci.* **1998**, *7*, 218–220.
111. Altintas, A.; Kosar, M.; Kirimer, N.; Baser, K.H. C.; Demirci, B. Composition of the essential oils of *Lycium barbarum* and *L. ruthenicum* fruits. *Chem. Nat. Compd.* **2006**, *42*, 24–25. [CrossRef]
112. Zhu, X.; Dong, X.; Wang, Y.; Peng, J.; Luo, S. Phenolic compounds from Viburnum cylindricum. *Helv. Chim. Acta* **2005**, *88*, 339–342. [CrossRef]
113. Maldoni, B.E.; Dartayet, G. Estudio del extracto de eter de petroleo de la raiz de *Lycium chilense*. *Rev. Latinoam. Quim* **1988**, *19*, 15.
114. Lee, H.J.; Ahn, H.J.; Kang, C.S.; Choi, J.C.; Choi, H.J.; Lee, K.G.; Kim, J.I.; Kim, H.Y. Naturally occurring propionic acid in foods marketed in South Korea. *Food Control* **2010**, *21*, 217–220. [CrossRef]
115. Kim, S.Y.; Lee, K.H.; Chang, K.S.; Bock, J.Y.; Jung, M.Y. Taste and flavor compounds in box thorn (*Lycium chinense* Miller) leaves. *Food Chem.* **1997**, *58*, 297–303. [CrossRef]
116. Noguchi, M.; Mochida, K.; Shingu, T.; Fujitani, K.; Kozuka, M. Sugiol and 5α-Stigmastane-3,6-dione from the Chinese Drug "Ti-ku-p′i" (Lycii radicis cortex). *J. Nat. Prod.* **1985**, *48*, 342–343. [CrossRef]
117. Zhou, X.W.; Xu, G.J.; Wang, Q. Studies on the Chemical Constituents in Roots of *Lycium chinense* Mill. *China J. Chin. Mater. Med.* **1996**, *21*, 675–676.
118. Aslanov, S.M.; Mamedova, M.É. Fatty-acid composition of the oil of the seeds and flesh with peel of the fruit of *Lycium turcomanicum*. *Chem. Nat. Compd.* **1985**, *21*, 796. [CrossRef]
119. Aslanov, S.M.; Mamedova, M.É. Fatty-acid composition of the oil of seeds, pulp and peel oil from the fruit of *Lycium turcomanicum*. *Khim. Prir. Soedin.* **1985**, *8*, 835.
120. Hiserodt, R.D.; Adedeji, J.; John, T.V.; Dewis, M.L. Identification of Monomenthyl Succinate, Monomenthyl Glutarate, and Dimenthyl Glutarate in Nature by High Performance Liquid Chromatography-Tandem Mass Spectrometry. *J. Agric. Food Chem.* **2004**, *52*, 3536–3541. [CrossRef] [PubMed]
121. Chi, Z.S. [Chemical constituents of fructus Lycii and folium Lycii (I)—Nutrients in fructus Lycii and folium Lycii]. *Zhong Yao Tong Bao* **1986**, *11*, 41. [PubMed]
122. Li, Z.; Peng, G.H.; Zhang, S.H. Composition and content of carotenoids in Fructus Lycii. *J. Plant Resour. Environ.* **1999**, *8*, 57–58.
123. Inbaraj, B.S.; Lu, H.; Hung, C.F.; Wu, W.B.; Lin, C.L.; Chen, B.H. Determination of carotenoids and their esters in fruits of *Lycium barbarum* Linnaeus by HPLC–DAD–APCI–MS. *J. Pharm. Biomed. Anal.* **2008**, *47*, 812–818. [CrossRef] [PubMed]
124. Sannai, A.; Fujimori, T.; Katō, K. Isolation of (−)-1,2-dehydro-α-cyperone and solavetivone from *Lycium chinense*. *Phytochemistry* **1982**, *21*, 2986–2987. [CrossRef]
125. Chung, I.M.; Ali, M.; Kim, E.H.; Ahmad, A. New tetraterpene glycosides from the fruits of *Lycium chinense*. *J. Asian Nat. Prod. Res.* **2013**, *15*, 136–144. [CrossRef] [PubMed]
126. Piao, M.; Murata, Y.; Zhu, B.; Shimoishi, Y.; Tada, M. Changes in Carotenoid Content and its Composition during Maturation of Fructus lycii Fruits. *Jpn. J. Food Chem.* **2005**, *12*, 35–39.
127. Sannai, A.; Fujimori, T.; Uegaki, R.; Akaki, T. Isolation of 3-hydroxy-7,8-dehydro-beta-ionone from *Lycium chinense* M. *Agric. Biol. Chem.* **1984**, *48*, 1629–1630. [CrossRef]
128. Terauchi, M.; Kanamori, H.; Nobuso, M.; Yahara, S.; Nohara, T. Detection and determination of antioxidative components in *Lycium chinense*. *Shoyakugaku Zashhi* **1997**, *51*, 387–391.

129. Wang, Y.; Zhao, B.; Ma, H.R.; Aisa, H.A. Two new sesquiterpenoid glycosides from the leaves of *Lycium barbarum*. *J. Asian Nat. Prod. Res.* **2016**, *18*, 871. [CrossRef] [PubMed]
130. Harsh, M.L.; Nag, T.N. Diosgenin and phytosterols from *Lycium barbarium* Linn. *NAG Actuar. Sci.* **1981**, *50*, 235.
131. Maldoni, B.E. Sterols in the fruits of *Lycium chilense*. *Fitoterapia* **1993**, *64*, 470.
132. Hänsel, R.; Huang, J.T. *Lycium chinense*, II: A semiquantitative assay of the withanolides (author's transl). *Arch. Pharm.* **1977**, *310*, 35–38. [CrossRef]
133. Hansel, R.; Huang, J.T.; Rosenberg, D. Zwei Withanolide aus *Lycium chinense*. *Arch. Pharm.* **1975**, *308*, 653–654. [CrossRef]
134. Jeong, T.M.; Yang, M.S.; Nah, H.H. Sterol compositions in three solanaceous seed oils. *J. Korean Agric. Chem. Soc.* **1978**, *21*, 51–57.
135. Itoh, T.; Tamura, T.; Matsumoto, T. 4-Desmethylsgerols in the seeds of Solanaceae. *Steroids* **1977**, *30*, 425–433. [CrossRef]
136. Itoh, T.; Tamura, T.; Matsumoto, T. Triterpene alcohols in the seeds of solanaceae. *Phytochemistry* **1977**, *16*, 1723–1726. [CrossRef]
137. Itoh, T.; Ishii, T.; Tamura, T.; Matsumoto, T. Four new and other 4α-methylsterols in the seeds of Solanaceae. *Phytochemistry* **1978**, *17*, 971–977. [CrossRef]
138. Wang, K.; Sasaki, T.; Li, W.; Li, Q.; Wang, Y.; Asada, Y.; Kato, H.; Koike, K. Two novel steroidal alkaloid glycosides from the seeds of *Lycium barbarum*. *Chem. Biodiv.* **2011**, *8*, 2277. [CrossRef] [PubMed]
139. Noguchi, M.; Mochida, K.; Shingu, T.; Kozuka, M.; Fujitani, K. The constituents of the Chinese drug "ti-ku-'pi". I. Isolation and constitution of Lyciumamide, a new dipeptide. *Chem. Pharm. Bull.* **1984**, *32*, 3584. [CrossRef] [PubMed]
140. Chu, Q.; Liang, F.; Miao, L.; Ye, J. Study on Bioactive Ingredients inCortex Lyciiby Capillary Zone Electrophoresis with Amperometric Detection. *Chin. J. Anal. Chem.* **2005**, *33*, 1611–1614.
141. Toyodaono, Y.; Maeda, M.; Nakao, M.; Yoshimura, M.; Sugiuratomimori, N.; Fukami, H. 2-*O*-(beta-D-Glucopyranosyl)ascorbic acid, a novel ascorbic acid analogue isolated from *Lycium* fruit. *J. Agric. Food Chem.* **2004**, *52*, 2092–2096. [CrossRef] [PubMed]
142. Chen, T.Q.; Wang, Q.; Gong, S.L.; Wu, J.K.; Yu, X.S.; Lin, S.W. Analysis of Amino Acids in Chinese Wolfberry. *J. China Pharm. Univ.* **1991**, *1*, 53–55.
143. Cheng, G.Y.; Wei, J.C.; Zou, Y.Z.; Wu, G.R.; Lu, L. Purification of Copper and Zinc Superoxide Dismutase from *Lycium barbarum* Fruit and Its Properties. *J. Nanjing Norm. Univ. (Nat. Sci. Ed.)* **1991**, *14*, 82–92.