Naturally Occurring Cinnamic Acid Sugar Ester Derivatives

Yuxin Tian 1,†, Weirui Liu 1,†, Yi Lu 2, Yan Wang 1, Xiaoyi Chen 1, Shaojuan Bai 1, Yicheng Zhao 1, Ting He 1, Fengxue Lao 3, Yinghui Shang 3, Yu Guo 3 and Gaimei She 1,*

1 School of Chinese Pharmacy, Beijing University of Chinese Medicine, Beijing 100102, China; tianyuxin1216@163.com (Y.T.); liuweirui2012@126.com (W.L.); 18739908461@163.com (Y.W.); chenxiaofly1209@163.com (X.C.); shaojuanbai@163.com (S.B.); zhaoyicheng0824@163.com (Y.Z.); 13580771726@163.com (T.H.)
2 School of Basic Medicine, Beijing University of Chinese Medicine, Beijing 100102, China; luyi780707@hotmail.com
3 Beijing Key Laboratory of Bioactive Substances and Functional Foods, Beijing Union University, Beijing 100191, China; Fengxue@buu.edu.cn (F.L.); Yinghui@buu.edu.cn (Y.S.); guoyu@buu.edu.cn (Y.G.)
* Correspondence: shegaimei@126.com; Tel.: +86-10-8473-8628
† These authors contributed equally to this work.

Academic Editor: Derek J. McPhee
Received: 30 September 2016; Accepted: 12 October 2016; Published: 24 October 2016

Abstract: Cinnamic acid sugar ester derivatives (CASEDs) are a class of natural product with one or several phenylacrylic moieties linked with the non-anomeric carbon of a glycosyl skeleton part through ester bonds. Their notable anti-depressant and brains protective activities have made them a topic of great interest over the past several decades. In particular the compound 3′,6-disinapoylsucrose, the index component of Yuanzhi (a well-known Traditional Chinese Medicine or TCM), presents antidepressant effects at a molecular level, and has become a hotspot of research on new lead drug compounds. Several other similar cinnamic acid sugar ester derivatives are reported in traditional medicine as compounds to calm the nerves and display anti-depression and neuroprotective activity. Interestingly, more than one third of CASEDs are distributed in the family Polygalaceae. This overview discusses the isolation of cinnamic acid sugar ester derivatives from plants, together with a systematic discussion of their distribution, chemical structures and properties and pharmacological activities, with the hope of providing references for natural product researchers and draw attention to these interesting compounds.

Keywords: cinnamic acid sugar ester derivatives; phytochemistry; pharmacological activity; traditional Chinese medicine

1. Introduction

As a class of natural products, cinnamic acid sugar ester derivatives (CASEDs) have become a research focus owing to their structural diversity, together with distinctive and remarkable pharmacodynamic actions, such as anti-depression, anti-cancer, anti-oxidant, anti-inflammatory and anti-viral activities [1–5]. They have one or more phenylacrylic (Ph-CH=CH-CO-) moieties or their derivatives linked to the non-anomeric carbon skeletons of the glycosyl part through ester linkage-bonds. The phenylacrylic group, also named cinnamic acid part, may usually contain hydroxyl or methoxy substituted groups (Figure 1). The aglycone group is the core structure, and includes monosaccharides, disaccharides, trisaccharides, tetrasaccharides, pentasaccharides, hexosaccharides, heptasaccharides and more. There are one or several -OH groups on the non-anomeric carbon skeleton, connected with the cinnamic acid moiety.
Since 1968 [6], more than 330 CASEDs have been found in the medicinal plants of the families Polygalaceae, Scrophulariaceae, Liliaceae, Oleaceae, Bignoniaceae, Polygonaceae, Orobanchaceae, Rosaceae, Lamiaeae, Labiatae, Gesneriaceae, Rubiaceae, Cruciferae, Plantaginaceae, Verbenaceae, Magnoliaceae, Amaranthaceae, Smilaceae, Sterculiaceae, Hymenophyllaceae and Asclepiadaceae (Table 1). Interestingly, more than one third of CASEDs are distributed in the family Polygalaceae, which is used for tranquilizing the mind and promoting intelligence as in Traditional Chinese Medicine (TCM) [1]. Yuanzhi, the dried root of Polygala tenuifolia, a representative plant from the Polygalaceae, is a well-known TCM used for its sedative, psychotic, cognitive and depressant effects. It is used in the clinic for tranquilizing and reinforcing the mind, and is commonly applied to physical and mental illness.

| Family              | Number | Family     | Number |
|---------------------|--------|------------|--------|
| Aselepiadaceae      | 1      | Gesneriaceae | 8      |
| Hymenophyllaceae    | 1      | Labiatae   | 11     |
| Sterculiaceae       | 1      | Lamiaeae   | 11     |
| Amaranthaceae       | 2      | Rosaceae   | 13     |
| Smilaceae           | 3      | Orobanchaceae | 16    |
| Magnoliaceae        | 3      | Polygonaceae | 19     |
| Rubiaceae           | 5      | Oleaceae   | 20     |
| Plantaginaceae      | 6      | Bignoniaceae | 22     |
| Cruciferae          | 6      | Liliaceae  | 34     |
| Verbenaceae         | 7      | Scrophulariaceae | 58    |
| Polygalaceae        | 126    |            |        |
Molecules 2016, 21, 1402

The oligosaccharide cinnamic acid esters are regarded as the predominant active antidepressant ingredients. 3',6-Disinapoylsucrose (DISS, 73), as the index component of Yuanzhi, has been studied to the level of the molecular mechanism of its antidepressant effects, representing a hotspot of research on new drug precursor compounds [7]. There are also other multiple reports [8,9] on the antidepressant effects of sibiricose A5 (28) and tenuifoliside A (51). There are additionally several active compounds from Scrophulariae Radix, Rehmannia Radix, Smilacis China Rhizoma, which according to common wisdom, calm the nerves with anti-depression and neuroprotective activity (Table 2).

Up to now, there is no relevant literature that analyzes all those Csed compounds systematically. Therefore, this paper is aimed at systematically clarifying the distribution, chemical structures and pharmacological activities of CASEds, in the hope of drawing more researchers’ attention to these interesting substances.

2. Chemical Constituents

Cinnamic acid sugar ester derivatives (CASEds) are an important type of natural product. Structurally, they have a glycosyl linked with the phenylacrylic group using ester bonds. The glycosyl part maybe contain one, or several sugar units, which are attached via an -OH group to another -OH by condensation reactions. So far, glucopyranosyl, rhamnopyranosyl, fructofuranosyl, arabinopyranosyl, galactopyranosyl, apiofuranosyl, xylopypyanosyl, lyxopyranosyl, allopypyanosyl, fucopyranosyl and lactopyranosyl moieties have been reported to occur in CASEds. The glycosyl portion usually has an anomic carbon of one sugar connected to the C-2, C-3 and C-4 of the other glycosyl group. Here, the non-anomeric carbon of the glycosyl part connected (Table 3).

Up to now, there has been no detailed research on the extraction procedures for these chemical constituents. Generally, the crude extracts wer prepared with different concentrations of methanol, ethanol or acetone-water solution by the impregnation method, refluxing extraction or decoction method [10–111]. Then the extracts were evaporated in a rotary evaporator to yield a syrupy residue. This residue was suspended in H2O and extracted successively with petroleum ether, CHCl3, EtOAc and H2O-satd n-BuOH [10,14,15,22]. The different extracts were then fractionated on different chromatographic columns with different mobile phases. Thereinto, silica gel CC was the most commonly used positive phase chromatographic column and eluted with petroleum ether, petroleum ether–EtOAc CHCl3–EtOAc, CHCl3–MeOH, CHCl3–MeOH–H2O with various ratios [10,11,22,30]. Mitsubishi Diaion HP-20, Diaion HP20SS, Chromatorex ODS, different types of macroporous resin and MCI columns were the reverse phase chromatography columns, which were used widely, eluted with a step-gradient of MeOH–H2O or EtOH–H2O (10%–100%), respectively. Sephadex LH-20 was also commonly used [19,31]. Some oligosachariches were isolated by preparative HPLC (Develosil Lep-ODS) [11]. Preparative TLC and recycle semi-preparative HPLC were often used to further purify samples [15].
Table 2. The Principal Compounds of CASEDs Distributed in TCMs.

| No. | Name in TCM | Sources | Traditional Effect | Medicinal Parts | Compounds | Activity | Refs. |
|-----|-------------|---------|---------------------|-----------------|-----------|----------|-------|
| 1   | Rehmannia glutinosa var. Purpurea | Ligustrum purpurascens, Sterculia foetida, Osmanthus asiaticus | Clearing heat and cooling blood, promoting the secretion of saliva or body fluid | Root | 124, 125, 131, 133, 136, 138, 207–212 | PKC inhibitory activity, antiinflammatory effects, antiviral activity, antibacterial activity | [19] |
| 2   | Scrophularia buergeriana | Scrophularia buergeriana | Common wisdom calms the nerves, restoring normal coordination between heart and kidney. Expectoration, subsidence of a swelling | Root | 51, 52, 72, 73, 280–290, 292, 321–324 | Anti-depression activity, neuroprotective activity | [10–12] |
| 3   | Smilacis China Rhizoma | Smilax bracteata, Paraboea glutinosa, L. Syphilis, gout, and rheumatism | Syphilis, gout, and rheumatism | Root | 28–30, 50, 51, 73, 75, 78, 88 | Anti-inflammation activity, neuroprotective activity, antioxidant activity | [13] |
| 4   | Scrophularia ningpoensis | Scrophularia ningpoensis | Clearing heat and cooling blood, nourishing yin to reduce pathogenic fire, detoxicating and resolving a mass | Root | 39, 40, 45, 47, 79, 98, 101, 107 | Anticancer activity | [14] |
| 5   | Scrophularia buergeriana | Scrophularia buergeriana | Clearing heat and cooling blood, nourishing yin to reduce pathogenic fire, detoxicating and resolving a mass | Root | 38, 41, 42, 45–47, 105, 106 | Antioxidative activity | [15] |
| 6   | Scrophularia buergeriana | Scrophularia buergeriana | Neuroprotective | Root | 11, 12, 13, 15 | Neuroprotective | [18] |

Table 3. Cinnamic Acid Sugar Ester Derivatives.

| No. | Name                                | Source                              | Refs. |
|-----|-------------------------------------|-------------------------------------|-------|
| 1   | 6-O-Caffeoyl-1-O-p-coumaroyl-β-D-glucopyranose | Prunus buergeriana; Prunus sissi; Rubus sanctus | [20] |
| 2   | 1,6-Di-O-caffeoyl-β-D-glucopyranose  | Prunus buergeriana; Coussarea hydrangeifolia | [20,21] |
| 3   | Osmanthuside E                      | Osmanthus asiaticus                 | [22] |
| 4   | 1,6-Diferuloyl glucose              | Sterculia foetida                   | [23] |
| 5   | Eutigoside A                        | Ligusterum purpurascens             | [24] |
| 6   | Osmanthuside A                      | Ligusterum purpurascens             | [24] |
| 7   | 2-(3,4-Dihydroxyphenyl)-ethyl-(6-O-caffeoyl)-β-D-glucopyranoside or calceolariside B | Calceolaria hypericina, Prunus buergeriana; Phacelia glutinosa | [25,26] |
| 8   | 3,4-Dihydroxystilbene-3β-O-glucopyranoside or calceolariside A or derhamnosylverbacoside | Trichomanes reniforme Forst F; Calceolaria hypericina; Lantana camara L. | [25,27,28] |
| 9   | 1′-O-β-D-(1-Hydroxy-4-oxo-2,5-cyclohexadien)-ethyl-6′-O-caffeoylglucopyranoside or calceolariside D | Calceolaria hypericina | [25] |
| 10  | 2-(3-Methylenedioxyphenyl)-ethyl-(6-O-caffeoyl)-β-D-glucopyranoside | Prunus buergeriana | [29] |
| 11  | 4-O-(E)-p-Methoxy-cinnamoyl-α-L-rhamno-pyranoside or buergeriside C | Scrophularia buergeriana | [18] |
| 12  | 2-O-Acetyl-3-O-(E)-p-methoxy-cinnamoyl-α-L-rhamno-pyranoside or buergeriside B | Scrophularia buergeriana | [18] |
| 13  | 2-O-Acetyl-3,4-di-O-(E)-p-methoxy-cinnamoyl-α-L-rhamno-pyranoside or buergeriside A | Scrophularia buergeriana | [18] |
| 14  | 3-O-Acetyl-2-O-p-methoxy-cinnamoyl-α(L)-β-rhamno-pyranoside or ningnoicose D | Scrophularia ningpoensis | [16] |
| 15  | 2-O-Acetyl-3-O-(Z)-p-methoxy-cinnamoyl-α-L-rhamno-pyranoside or buergeriside B | Scrophularia buergeriana | [18] |
| 16  | 6-O-p-Coumaryl-β-D-glucopyranoside   | Prunus buergeriana                  | [20] |
| 17  | 6-O-Caffeoyl-β-D-glucopyranoside    | Prunus buergeriana; Prunus sissi    | [20,29] |
| 18  | 6-O-[E]-Sinapoyl-α- and β-β-D-glucopyranoside | Cynanchum hancocki | [30] |
| 19  | O-Acetylglucoses                    | Ligusterum purpurascens             | [24] |
| 20  | 3,6-di-O-Caffeoyl-(α/β)-glucose    | Rubus sanctus | [31] |
| No. | Name                                                                 | Source                                                                 | Refs. |
|-----|----------------------------------------------------------------------|-----------------------------------------------------------------------|-------|
| 21  | 6-O-Feruloyl-β-D-glucopyranosyl-(1→6)-glucitol or globularitol       | Globularia orientalis                                                  | [32]  |
| 22  | [2R]-[6-O-Caffeoyl]-β-D-glucopyranosyloxy]-benzenoacetoxitride or grayanin | *Prunus* huergeneriana                                                 | [20]  |
| 23  | Scrophyloside A                                                       | Neopicrorhiza scrophulariflora                                         | [33]  |
| 24  | Scrophyloside B                                                       | Neopicrorhiza scrophulariflora                                         | [33]  |
| 25  | Hexane-1,2,3,4,5-pentanol 1-O-β-(6-O-(E)-feruloyl) glucopyranoside or paederol A | *Paederia scandens*                                                   | [34]  |
| 26  | Butane-1,2,3,4-tetraol 1-O-β-(6-O-(E)-feruloyl) glucopyranoside or paederol B | *Paederia scandens*                                                   | [34]  |
| 27  | Kaempferol 3-O-β-D-(6-O-p-E-Coumaryl)-glucopyranoside                | Fœliclia floridana                                                    | [35]  |
| 28  | 3-O-Feruloylsucrose or sibiricose A                                   | *Trillium kamtschaticum, Polygala sibirica*                          | [13,36]|
| 29  | 3′-Sinapoyl sucrose or sibiricose A                                   | Polygala sibirica, Polygala tricornis                                | [13,37,38]|
| 30  | 3-O-[(E)-3,4,5-Trimethoxycinamoyl]-β-D-fructofuranosyl-(2→1)-α-D-glucopyranoside or glomeratose A | Polygala sibirica, Polygala tricornis, Polygala glomerata          | [13,37,38]|
| 31  | 3,6-Di-p-coumaryl sucrose or lapiathosides D                          | Polygonum lapathiösum                                                  | [39]  |
| 32  | Heronioside A                                                        | *Trillium kamtschaticum, Smilax glabra*                               | [36,40]|
| 33  | Parsipolyiode F                                                       | *Paris polyphila var. yunnanensis*                                    | [41]  |
| 34  | β-D-(1-Sinapoyl-3-feruloyl)-α-D-glucopyranoside                      | *Polygala chamaebuxus*                                               | [42]  |
| 35  | β-D-(1-Acetyl-3-feruloyl)-fructofuranosyl-α-D-glucose pyranoside     | *Polygala chamaebuxus*                                               | [42]  |
| 36  | β-D-(1,3-Dinapoyl)-fructofuranosyl-α-D-glucose pyranoside            | *Polygala chamaebuxus*                                               | [42]  |
| 37  | β-D-(1,3,6-Trp-p-Coumaryl)-fructofuranosyl-α-D-glucopyranoside or hydropiperoside | Polygonum hydropiperatum; Polygonum hydropiper                      | [39,43]|
| 38  | (1,3,Di-p-Coumaryl-1,6-D-feruloyl)-β-D-fructofuranosyl-(2→1)-α-D-glucopyranoside or smilaside G | *Smilax bracteata*                                                  | [15]  |
| 39  | 1-p-Coumaryl-3,6-diferuloyl sucrose or smilaside C                   | *Smilax chinensis*                                                   | [14]  |
| 40  | 1-p-Coumaryl-3,6-diferuloyl-4-acetyl sucrose or smilaside D          | *Smilax chinensis*                                                   | [14]  |
| 41  | (3-O-Coumaryl-1,6-O-diferuloyl)-β-D-fructofuranosyl-(2→1)-α-D-glucopyranoside or smilaside J | *Smilax bracteata*                                                  | [15]  |
| 42  | 1,3,6-O-Triferuloyl-β-D-fructofuranosyl-(2→1)-α-D-glucopyranoside or smilaside L | *Smilax bracteata*                                                  | [15]  |
| 43  | 3-O-[(E)-3,4,5-Trimethoxycinamoyl]-β-D-fructofuranosyl-(2→1)-(6-O-acetyl)-α-D-glucopyranoside or tricornose A | Polygala tricornis                                                  | [37]  |
| 44  | Regaloside A                                                         | *Trillium kamtschaticum*                                             | [36]  |
| 45  | 6′-Acetly-3,6-diferuloylsucrose or helonioside B                      | *Smilax chinensis, Smilax bracteata, Polygonum perfoliatum, Heterosmilax erythrotha | [14,15,44,45]|
| 46  | (1,3-O-di-p-Coumaryl-1,6-D-feruloyl)-β-D-fructofuranosyl-(2→1)-(6-O-acetyl)-α-D-glucopyranoside or smilaside I | *Smilax bracteata*                                                  | [15]  |
| 47  | 1-p-Coumaryl-3,6-diferuloyl-6′-acetyl sucrose or smilaside E         | *Smilax chinensis, Smilax bracteata*                                 | [14,15]|
| 48  | Reiniose C                                                           | *Polygala reinii Fr.et Sav*                                          | [46]  |
| 49  | 6-O-Benzoyl-3′-O-3,4,5-trimethoxycinamoyl-sacrose or                 | *Polygala tricornis; Polygala glomerata; Polygala reinii Fr.et Sav     | [37,38,46]|
|     | 3-O-[(E)-3,4,5-Trimethoxy-cinnamoyl]-β-D-fructofuranosyl-(2→1)-(6-O-benzoyl)-α-D-glucopyranoside or 3-O-[(E)-3,4,5-Trimethoxy-cinnamoyl]-β-D-fructofuranosyl-(2→1)-(6-O-benzoyl)-α-D-glucopyranoside | *Polygala reinii Fr.et Sav*                                          | [37,38,46]|
|     | 3′-Sinapoyl-6-benzoyl sucrose or 6-O-benzoyl-3′-O-sinapoylsucrose 6-O-benzoyl-3′-O-sinapoylsucrose or 3-O-[(E)-3′-O-4-hydroxy-3,5-dimethoxyphenyl)-1-oxoprop-2-etyl]-β-D-fructofuranosyl 6-O-benzoyl-α-D-glucopyranoside | *Polygala sibirica, Polygala tricornis, Polygala telephoidesWilld.* | [13,37,47]|

Table 3. Cont.
| No. | Name                                                                 | Source                                                                 | Refs. |
|-----|----------------------------------------------------------------------|------------------------------------------------------------------------|-------|
| 51  | β-0-3-[O-(3,4,5-Trimethoxycinnamoyl]-fructo-furanosyl-α-D-β-D-fructofuranosyl-6-β-D-glucopyranoside or tenuifoliside A | Polygala tenusifolia; Polygala sibirica                                | [10–13] |
| 52  | β-0-3-[O-Sinapoyl]-fructofuranosyl-6-β-D-glucopyranoside or tenuifoliside B | Polygala tenuifolia                                                    | [10]  |
| 53  | Sabinoside A                                                         | Scrophularia ningpoensis Hems.                                        | [17]  |
| 54  | 3-O-(E)-Sinapoyl-β-0-3-[O-(6-β-D-glucopyranoside or glomeratose B | Polygala glomerata                                                    | [38]  |
| 55  | 3-O-[E]-3,4,5-Trimethoxycinnamoyl]-β-0-3-[O-(6-β-D-glucopyranoside or glomeratose C | Polygala glomerata                                                    | [38]  |
| 56  | 3,4-O-β-0-Diferuloyl-fructofuranosyl-6-O-α-D-[o-p-coumaroyl]-glucopyranoside | Monnina obtusifolia H.B.K.                                           | [48]  |
| 57  | 6'-O-p-Coumarylhydropiperoside or vanicoside D                     | Polygonum pensylvanicum                                              | [49]  |
| 58  | 1,3,6'-Fruc-o-p-coumaryl-6-feruloyl sucrose or diboside A           | Fagopyrum dibotrys (D. Dom.) Hara.                                   | [50]  |
| 59  | 6-O-Caffeoyl-β-0-3-[O-(6-β-D-glucopyranoside | Scrophularia ningpoensis Hems. Globularia orientalis                  | [17,23] |
| 60  | 3,4-O-β-0-Diferuloyl-fructofuranosyl-6-O-α-D-(caffeoyl)-glucopyranoside | Monnina obtusifolia H.B.K.                                           | [48]  |
| 61  | Reinoise A                                                          | Polygala reinii Fr.e. Sav                                            | [46]  |
| 62  | 6-O-Feruloyl-β-0-3-[O-(6-β-D-glucopyranoside or tenuifoliside B | Globularia orientalis; Polygala arillata                              | [32,51] |
| 63  | 1,6'-Diferuloyl-3,6-di-p-coumarylsucrose or lapathoside A           | Polygonum lapathifolium                                              | [39]  |
| 64  | 1,6',6'-Triferuloyl-3-p-coumaryl sucrose or Lapathoside B           | Polygonum lapathifolium                                              | [39]  |
| 65  | 6'-Feruloyl-3,6-di-p-coumaryl sucrose or lapathoside C              | Polygonum lapathifolium                                              | [39]  |
| 66  | 6'-Feruloyl-1,6-di-p-coumaryl sucrose or hydropiperoside A          | Polygonum hydrophyllum L.                                           | [52]  |
| 67  | Vanicoside B                                                        | Polygonum perfoliatum; Polygonum pensylvanicum                       | [44,53] |
| 68  | 4-Acetyl-3,6'-diferuloylsucrose                                     | Lilium speciosum var. rubrum; Lilium longiflorum                      | [54,55] |
| 69  | 6-Acetyl-3,6'-diferuloylsucrose                                     | Lilium speciosum var. rubrum                                         | [54]  |
| 70  | 4,6-Diacetyl-3,6'-diferuloylsucrose                                 | Lilium speciosum var. rubrum                                         | [54]  |
| 71  | 3,6'-Diferuloylsucrose                                              | Lilium speciosum var. rubrum                                         | [54,55] |
| 72  | β-0-[3-O-(3,4,5-Trimethoxycinnamoyl]-fructo-furanosyl-α-D-β-D-glucopyranoside or tenuifoliside C | Polygala tenusifolia; Polygala tricorns; Polygala glomerata; Polygala glucopyranoside or tenuifoliside C | [10,37,38,46,56] |
| 73  | 3'-Fruc-sucrose or 3-O-[E]-sinapoyl-β-0-3-[O-(6-β-D-glucopyranoside | Polygala tenusifolia; Polygala sibirica; Polygala tricorns; Polygala glomerata; Polygala virgata | [10,13,37,38,46,57,58] |
| 74  | β-0-3,4,5-Disinapoylfructofuranosyl-α-0-3,4,5-Disinapoylfructofuranosyl-6-β-D-glucopyranoside | Scrophularia longipedunculata; Polygala virgata | [37]  |
| 75  | 6-O-Sinapoylsucrose or sibiricoside A                               | Polygona sibirica                                                   | [13]  |
| 76  | 3-O-Feruloyl-6-β-D-fructofuranosyl-6-O-sinapoyl-α-D-glucopyranoside | Polygala reinii Fr.e. Sav                                            | [46]  |
| 77  | 3-O-[E]-3,4,5-Trimethoxycinnamoyl]-β-0-3-[O-(6-β-D-glucopyranoside or glomeratose D | Polygala glomerata                                                    | [38]  |
| 78  | 6-O-3,4,5-Trimethoxycinnamoyl sucrose or sibiricoside A             | Polygona sibirica                                                   | [13]  |
| No. | Name                                                      | Source                                      | Refs. |
|-----|-----------------------------------------------------------|---------------------------------------------|-------|
| 79  | 3,6-Diferuloyl-4',6'-diacetylsucrose or smilaside A       | Smilax china                                | [14]  |
| 80  | 3-O-[(E)-3,4,5-Trimethoxycinnamoyl]-β-0-fructofuranosyl(2→1)-(4-O-acetyl)-(6-O-benzoyl)-α-D-glucopyranoside or tricorniases B | Polygala tricornis                          | [37]  |
| 81  | 4'-Acetyl-3,6'-diacetylsucrose                           | Lilium speciosum var. rubrum               | [54]  |
| 82  | β-D-(3-O-Sinapoyl)fructofuranosyl-α-D-(4-O-acetyl-6-O-sinapoyl)glucopyranoside | Polygala virgata                           | [58]  |
| 83  | Resinose B                                               | Polygala reinii Fr.et Sav                  | [46]  |
| 84  | 4'-O-Benzoyl-3',4,5-trimethoxycinnamoylsucrose or [3-O-(3,4,5-trimethoxycinnamoyl)]-β-D-fructofuranosyl(4-O-benzoyl)-α-D-glucopyranoside | Polygala tricornis; Polygala reinii Fr.et Sav | [37,46] |
| 85  | (3,6-Diferuloyl)-β-D-fructofuranosyl(2→1)-(4-O-p-coumaroyl-6-O-acetyl)-α-D-glucopyranoside or quiquesetinerviusside D | Calamus quiquesetinervius Burret           | [4]    |
| 86  | (3,6-Diferuloyl)-β-D-fructofuranosyl(2→1)-(4-O-feruloyl)-α-D-glucopyranoside or quiquesetinerviusside A | Calamus quiquesetinervius Burret           | [4]    |
| 87  | (3,6-Diferuloyl)-β-D-fructofuranosyl(2→1)-(4-O-feruloyl)-6-O-acetyl)-α-D-glucopyranoside or quiquesetinerviusside B | Calamus quiquesetinervius Burret           | [4]    |
| 88  | 3',4'-O-Dsinapoylsucrose or sibiricose A_4               | Polygala sibrica                           | [13]  |
| 89  | 1-O-Acetyl-3-O-p-coumaroyl-β-D-fructofuranosyl-3,6-di-O-acetyl-α-D-glucopyranoside | Prunus padus                               | [58]  |
| 90  | (3,6-Di-O-feruloyl)-β-D-fructofuranosyl(3,6-di-O-acetyl)-α-D-glucopyranoside | Smilax glabra                              | [40]  |
| 91  | 3',O-Acetylvanicoside B or vanicoside F                  | Polygonum pensylvanicum                   | [49]  |
| 92  | 6',3'-Diacetyl-3,6'-diferylolsucrose                     | Lilium speciosum var. rubrum               | [54]  |
| 93  | 4,6',2'-Triacetyl-3,6'-diferylolsucrose                  | Lilium speciosum var. rubrum               | [54]  |
| 94  | β-D-(3-O-Sinapoyl)fructofuranosyl-α-D-(3-O-acetyl-6-O-sinapoyl)glucopyranoside | Polygala virgata                           | [59]  |
| 95  | Heterosmilaside                                          | Heterosmilax erythrantha                  | [45]  |
| 96  | 1-O-Acetyl-3-O-p-coumaroyl-β-D-fructofuranosyl-3,4,6-tri-O-acetyl-α-D-glucopyranoside | Prunus padus                               | [58]  |
| 97  | 1,2',6'-Triacetyl-3,6'-diferylolsucrose                  | Polygonum perfoliatum; Smilax china; Heterosmilax erythrantha | [44]  |
| 98  | 2',6'-Diacetyl-3,6'-diferylolsucrose                     | Polygonum perfoliatum; Smilax china; Heterosmilax erythrantha | [14,44,45] |
| 99  | 1,3,4,5,6,7-Hexaene-2',6'-diacetylsucrose or smilaside F | Smilax chinu                               | [14]  |
| 100 | Smilaside B                                              | Smilax glabra                              | [40]  |
| 101 | Smilaside E                                              | Smilax chinu; Smilax glabra                | [14,40]|
| 102 | Vanicoside A                                             | Polygonum perfoliatum; Polygonum pensylvanicum | [44,53]|
| 103 | 2'-Acetyl-1,6'-diferuloyl-3,6-di-p-coumaroyl sucrose or hydropiperoside B | Polygonum hydrophorum L.                 | [52]  |
| 104 | 2'-O-Acetyldropiperoside or vanicoside C                 | Polygonum pensylvanicum                   | [49]  |
| 105 | 1-O-p-Coumaroyl-3,6-O-diferuloyl-β-D-fructo-furanosyl(2→1)-(2-O-acetyl)-α-D-glucopyranoside or smilaside K | Smilax bractea                            | [15]  |
| 106 | (1,3,4,5,6,7-Hexaene-2',6'-diacetyl-β-D-fructo-furanosyl(2→1)-(2-O-acetyl)-α-D-glucopyranoside or smilaside H | Smilax bractea                            | [15]  |
| 107 | 3,6-Diferuloyl-2'-acetyl sucrose or smilaside B          | Smilax chinu                               | [14]  |
| 108 | 2',6'-Diacetyl-3,6'-diferylolsucrose or smiglaside C     | Smilax glabra; Polygonum perfoliatum       | [40,44]|

Table 3. Cont.
| No. | Name                                                                 | Source                      | Refs.       |
|-----|----------------------------------------------------------------------|-----------------------------|-------------|
| 110 | 1,2',4',6'-Tetraethyl-3,6-diferuloylucose                             | Polygonum perfoliatum       | [44]        |
| 111 | Smiglaside A                                                          | Smilax glabra               | [40]        |
| 112 | Smiglaside D                                                          | Smilax glabra               | [40]        |
| 113 | 4'-O-Acetylvanicoside A or vanicoside E                              | Polygonum pungensicum       | [49]        |
| 114 | (3,6, O-Diferuloyl)-β-D-fructofuranosyl(2→1)(4-O-p-coumaroyl-2-O-acetyl)-α-D-glucopyranoside or quisquetinerviuss E | Calamus quiquesetinervius Burret | [4] |
| 115 | (3,6, O-Diferuloyl)-β-D-fructofuranosyl(2→1)(4-O-feruloyl-2-O-acetyl)-α-D-glucopyranoside or quisquetinerviuss C | Calamus quiquesetinervius Burret | [4] |
| 116 | 3-O-p-Coumaryl-β-D-fructofuranosyl(2,3,4,6-tetra-O-acetyl-α-D-glucopyranoside | Prunus padus               | [58]        |
| 117 | 1-O-Acetyl-3-O-p-coumaryl-β-D-fructofuranosyl(2,3,4,6-tri-O-acetyl-α-D-glucopyranoside | Prunus padus               | [58]        |
| 118 | β-D-(1-O-Acetyl-3,6-O-p-E-dicoumaryl)-fructo-fruroanosyl-α-D-(4'-O-acetyl-2'-O-p-E-coumaryl)-glucopyranoside | Furoelachius floridana     | [35]        |
| 119 | 2-Feruloyl- O-D-glucopyranosyl(1'→2)-3,6-O-feruloyl-β-D-fructofuranoside | Paris polyphylla var. yunnanensis | [61]    |
| 120 | 3-O-Caffeoyl-β-D-fructofuranosyl(2,3,4,6-tetra-O-acetyl-α-D-glucopyranoside | Prunus ssori               | [24]        |
| 121 | Magnoloside A                                                         | Magnolia obovata Thumb      | [62]        |
| 122 | β-D-Hydroxopenaldehyde O-α-l-rhamno-pyranosyl(1→3)-6-O-trans-p-coumaryl-β-D-glucopyranoside or osmanthuside B₆ | Osmanthus asiaticus, Liguistrum purpurascens | [22,24]   |
| 123 | β-D-Hydroxopenaldehyde O-α-l-rhamno-pyranosyl(1→3)-4-O-cis-p-coumaryl-β-D-glucopyranoside or osmanthuside D | Osmanthus asiaticus        | [22]        |
| 124 | Jionoside D                                                           | Rehmannia glutinosa var. Purpurea, Scrophularia nodosa L. | [19,63]   |
| 125 | 2-Phenylethyl O-α-l-rhamno-pyranosyl(1→3)-4-O-coffeeyl-β-D-glucopyranoside or jionoside C | Rehmannia glutinosa var. Purpurea | [19] |
| 126 | Osmanthuside B                                                        | Liguistrum purpurascens, cistanche saloa | [24,64]   |
| 127 | Lipidoside A-H                                                        | Liguistrum purpurascens     | [24]        |
| 128 | Isoverbascoside                                                      | Lantana camara L., Pedicularis artexleri, Pedicularis strata, Markhamia stipulate, Fernandea adenphylla, Markhamia lutea, Scrophularia scorodonum | [15,29,65–69] |
| 129 | Scrphularia nodosa L.                                                 |                             | [63]        |
| 130 | 6'-O-(E)-Cinnamoyl verbascoside                                     | Osmanthus austroleadonica   | [65]        |

**Table 3. Cont.**

| No. | Name                                                                 | Source                      | Refs.       |
|-----|----------------------------------------------------------------------|-----------------------------|-------------|
| 131 | Acteoside or verbascoside                                           | Rehmannia glutinosa var. Purpurea, Liguistrum purpurascens, Calecolaria hypericoma, Lantana camara L., Scrophularia nodosa L., Pedicularis artexleri, Pedicularis strata, Markhamia stipulate, Fernandea adenphylla, Markhamia lutea, Scrophularia scorodonum, Pentstemon serrulatus Menz, Aeginetia indica Linan, Pedicularis lasiophyae, Lagotis stolonifera, Conandron ramosioides, Paulownia tomentosa stem, Ptoloma grandiflora, Pedicularis spatula, Pedicularis bugijora, cistanche saloa, Brandisia linearia | [15,19,24,25,29,63,66–84] |
| No. | Name                                                                 | Source                                                                 | Refs.                        |
|-----|----------------------------------------------------------------------|------------------------------------------------------------------------|------------------------------|
| 132 | cis-Acteoside or ciscacteoside                                       | Scrophularia ningpoensis Hemsl; Scrophularia nodosa L.; Penstemon serrulatus Menz. | [17,63,71]                   |
| 133 | Cistanoside C or leucosceptoside A or trans-leucosceptoside A        | Rehmannia glutinosa var. Purpurea; Fernandoa adenophylla; Penstemon serrulatus Menz, Pedicularis bangijora; cistanche saliva; Lamiophilus rotata | [19,69,71,79,85,86]          |
| 134 | cis-Leucosceptoside A                                               | Penstemon serrulatus Menz.                                            | [71]                         |
| 135 | 2′,3′,4′-Diacetyl acteoside                                         | Aeginetia indica Linn                                                  | [72]                         |
| 136 | 2′-Acetyl acteoside                                                 | Rehmannia glutinosa var. Purpurea; cistanche saliva; Aeginetia indica Linn, Brandisia lancei | [19,64,72,82]                |
| 137 | 1′-O-β-D-(3-Methoxy-4-hydroxy-β-phenyl)-ethyl-6′-O-feruloyl-α-L-(2-acetyl)-rhamnosyl-(1→3)′-4′-acetylglucopyranoside or pedicularioside E | Pedicularis lasiophrys                                                | [73]                         |
| 138 | Martynoside or trans-martynoside                                    | Rehmannia glutinosa var. Purpurea; Pedicularis arselaerti; Fernandoa adenophylla; Penstemon serrulatus Menz, Paulownia tomentosa stem; Galeopsis pubescens | [19,66,69,71,76,87]          |
| 139 | cis-Martynoside                                                     | Penstemon serrulatus Menz.                                            | [71]                         |
| 140 | 2-(4-Hydroxy-3-methoxyphenyl)ethyl O-α-L-rhamnopyranosyl-(1→3)-O-(4-O-feruloyl)-β-D-glucopyranoside or cistanoside D | cistanche saliva; Pedicularis arselaerti; Pedicularis lasiophrys; Pedicularis bangijora | [64,66,73,79]                |
| 141 | 2-(3′,4′-Dihydroxyphenyl)ethanol 1-O-β-D-xylosyl-(1→3)-β-D-(4-cafeyl)-glucoside or conandroside | Conandron ramosioides                                                | [74]                         |
| 142 | Isonenioside A                                                     | Paraboea glutinosa; Lantana camara L.                                 | [27,29]                      |
| 143 | Calceolarioside E                                                  | Paraboea glutinosa; Lantana camara L.                                 | [27,29]                      |
| 144 | Plantamajoside                                                     | Lagotis stolonfera                                                   | [75]                         |
| 145 | Icositanoside F                                                    | Ligustrum purpurascens                                               | [24]                         |
| 146 | α-L-Rhamnopyranosyl(1→3)-O-(4-O-cafeoyl)-β-D-glucopyranosor cistanoside F | cistanche saliva                                                      | [85]                         |
| 147 | 3-Hydroxy-4-methoxy-β-phenylethoxy-O-α-L-rhamnopyranosyl-(1→3)-6-O-feruloyl-β-D-glucopyranoside or isomartynoside | Galeopsis pubescens                                                 | [87]                         |
| 148 | 1′-O-β-D-(3′,4′-Dihydroxy-β-phenyl)-ethyl-4′-O-cafeoyl-β-D-xylopyranosyl-(1′→3′)-D-glucopyranoside or calceolarioside C | Calceolaria hypericin                                                | [25]                         |
| 149 | 4-Cinnamoyl desxylosyl mussatoside                                  | Musatia                                                              | [88]                         |
| 150 | 1-O-trans-caffeoyl-2′-O-trans-sinapoylgentiobiose.                 | Wasabia japonica Matsumura                                          | [89]                         |
| 151 | 1-O-trans-Feruloyl-2′-O-trans-sinapoylgentiobiose.                  | Wasabia japonica Matsumura                                          | [89]                         |
| 152 | 1,2′-di-O-trans-sinapoylgentiobiose.                               | Wasabia japonica Matsumura                                          | [89]                         |
| 153 | 1′-(3′,4′,5′-methoxy)-O-trans-cinnamoyl-2′-O-trans-feruloyl gentiobiose | Wasabia japonica Matsumura                                          | [89]                         |
| 154 | 1′-(3′,4′-Dihydroxy-5′-methoxy)-O-trans-cinnamoyl-2′-O-trans-sinapoylgentiobiose | Wasabia japonica Matsumura                                          | [89]                         |
| 155 | 1,2′-Dc-(3′,4′-dihydroxy-5′-methoxy)-O-trans-cinnamoyl gentiobiose  | Wasabia japonica Matsumura                                          | [89]                         |
| No. | Name                                                                 | Source                                                                 | Refs. |
|-----|----------------------------------------------------------------------|------------------------------------------------------------------------|-------|
| 156 | (5-O-E-Caffeoyl)-β-D-apio-D-furanosyl-(1→5)-β-D-glucopyranosyl benzoic acid ester or psycroside | *Pydina hispida*                                                        | [90]  |
| 157 | Crenatoside                                                           | *Orobanche crenata*                                                    | [91]  |
| 158 | Campeoside II or orobanchoside                                       | *Paulownia tomentosa stem; Orobanche crenata*                          | [76,91] |
| 159 | Campeoside I                                                          | *Paulownia tomentosa stem*                                             | [76]  |
| 160 | Ligurobustoside C                                                    | *Ligustrum purpurascens*                                               | [24]  |
| 161 | Ligurobustoside I                                                    | *Ligustrum purpurascens*                                               | [24]  |
| 162 | 1-O-{6-[O-{3-O-[E,E](β,β′,α′,α′-Sinapoyl)-β,β′-fructo-furanosyl]}-α-D-glucopyranoside intramolecular ester or glomeratose E | *Polygala glomerata*                                                   | [38]  |
| 163 | 3-O-{E-Sinapoyl}-β-D-fructofuranosyl(1→2)[β-D-glucopyranosyl(1→2)[6-O-(E)-sinapoyl]-α-D-glucopyranoside or tricornose F | *Polygala tricornis*                                                   | [37]  |
| 164 | 3-O-{E,3,4,5-Trimethoxycinnamoyl}-β-D-fructo-furanosyl(2→1)[β-D-glucopyranosyl(1→2)[6-O-(E)-sinapoyl]-α-D-glucopyranoside or tricornose F | *Polygala tricornis*                                                   | [37]  |
| 165 | 3-O-{E,3,4,5-Trimethoxycinnamoyl}-[4-O-(E)-feruloyl]-β-D-fructofuranosyl(2→1)[β-D-glucopyranosyl(1→2)[6-O-(E)-sinapoyl]-α-D-glucopyranoside or tricornose F | *Polygala tricornis*                                                   | [37]  |
| 166 | 3-O-{E,3,4,5-Trimethoxycinnamoyl}-[4-O-(E)-sinapoyl]-β-D-fructofuranosyl(2→1)[β-D-glucopyranosyl(1→2)[6-O-(E)-sinapoyl]-α-D-glucopyranoside or tricornose E | *Polygala tricornis*                                                   | [37]  |
| 167 | Reiniose E                                                           | *Polygala reinii F et Sav*                                             | [46]  |
| 168 | Reiniose F                                                            | *Polygala reinii F et Sav*                                             | [46]  |
| 169 | O-β-D-Glucopyranosyl(1→3)-6-O-feruloyl-α,D-glucopyranosyl β-D-fructofuranoside or arillatose C | *Polygala arilata*                                                     | [51]  |
| 170 | O-β-D-Glucopyranosyl(1→3)-6-O-sinapoyl-α,D-glucopyranoside or arillatose D   | *Polygala arilata*                                                     | [51]  |
| 171 | O-β-β-D-Glucopyranosyl(1→3)-α,D-glucopyranosyl-3′-O-feruloylβ-D-fructofuranoside or arillatose E | *Polygala arilata*                                                     | [51]  |
| 172 | O-β-β-D-Glucopyranosyl(1→3)-α,D-glucopyranosyl-3′-O-sinapoylβ-D-fructofuranoside or arillatose F | *Polygala arilata*                                                     | [51]  |
| 173 | 3-Feruloyl-4-acetyl-6′(13′-O-β-D-glucopyranosyl)feruloylsucrose         | *Lilium longiflorum*                                                   | [55]  |
| 174 | Reiniose D                                                            | *Polygala reinii F et Sav; Polypala fallax*                            | [46,92]|
| 175 | Dalmaisoise A                                                         | *Polypala dalmatiana*                                                  | [93]  |
| 176 | 3,4-Dihydroxyphenylethan-4-O-trans-caffeoyl-β-D-apiofuranosyl(1→3)-β-D-apiofuranosyl(1→5)-β-D-glucopyranoside or paroboside B | *Paraboea glutinosa*                                                   | [27]  |
| 177 | 3,4-Dihydroxyphenylethan-4-O-trans-caffeoyl-β-D-apiofuranosyl(1→3)-β-D-apiofuranoside or paroboside A | *Paraboea glutinosa*                                                   | [27]  |
| 178 | 2-(3,4-Dihydroxyphenethyl)3,6-O-bis(β-D-apiofuranosyl)-4-O-caffeoylβ-D-glucopyranoside or paucifoside | *Lysionotus pauciflorus*                                               | [94]  |
| 179 | γ′-O-β-D-(3,4-Dihydroxy-β-phenyl)-ethyl-4′-O-caffeoylβ-D-apiosyl(1→3)-α-L-rhamnosyl(1→6′)-glucopyranoside or pedicularoside A | *Pedicularis strata; Markhamia lutea; Pedicularis strata pall ssp. arachnoidea; Pedicularis spicata* | [5,67,77,78]|
| 180 | γ′-O-β-D-(3,4-Dihydroxy-β-phenyl)-ethyl-4′-O-feruloylβ-D-apiosyl(1→3)-α-L-rhamnosyl(1→6′)-glucopyranoside or pedicularoside M | *Pedicularis strata pall ssp. arachnoidea*                             | [27]  |
| No. | Name                                                                 | Source                                                                 | Refs.          |
|-----|----------------------------------------------------------------------|------------------------------------------------------------------------|----------------|
| 181 | 1′-O-β-D-(4-hydroxy-4-methoxy-β-phenyl)ethyl-4′-feruloyl-β-D-apiosyl(1′→3′)-α-L-rhamnosyl(1′→6′)-glucopyranoside or pedicularioside N | Pedicularis artesacri; Pedicularis striata pall ssp. arachnoidea         | [66,77]        |
| 182 | 1′-O-β-D-(4-Methoxy-4-hydroxy-β-phenyl)ethyl-4′-O-feruloyl-β-D-apiosyl(1′→3′)-α-L-rhamnosyl(1′→6′)-glucopyranoside or pedicularioside H | Pedicularis spicata                                                   | [78]           |
| 183 | 3,4-Dihydroxy-β-phenylethoxy-O-[α-arabinopyranosyl(1′′′→2′′)-α-rhamnopyranosyl(1′′′→3′′)-6′′-O-caffeoyl-β-glucopyranoside] or markhamioside C | Markhamia stipulata                                                 | [68]           |
| 184 | Ehrenoside                                                            | Veronica pectinata var. glandulosa; Aragoa cundinamaricensis          | [75,95,96]     |
| 185 | 3,4-Dihydroxy-β-phenylethoxy-O-[α-arabinopyranosyl(1′′′→2′′)-α-rhamnopyranosyl(1′′′→3′′)-4-O-caffeoyl-6-O-acetyl-β-glucopyranoside or markhamioside D | Markhamia stipulata                                                 | [68]           |
| 186 | 2-[3′,4′-Dihydroxyphenyl]ethyl-α-L-arabinopyranosyl(1′→3′-[α-L-rhamnopyranosyl(1′→3′)]4-O-trans-feruloyl)-β-D-glucopyranoside or verpectoside A | Veronica pectinata var. glandulosa                                   | [95]           |
| 187 | Lagotoside                                                             | Lagotis stolmifera                                                   | [75]           |
| 188 | 3,4-Dihydroxy-β-phenylethoxy-O-[β-D-apiofuranosyl(1→2)-α-rhamnopyranosyl(1→3′-5′)-4-O-caffeoyl-β-glucopyranoside] or verpectoside E | Markhamia stipulata ; Fernandoa adenophylla                           | [68,69]        |
| 189 | 1′-O-3,4-Dihydroxyphenyl[ethyl β-D-apiofuranosyl(1′→2)-α-L-rhamnopyranosyl(1′→3′)-4-O-caffeoyl]-6-O-acetyl-β-D-glucopyranoside sideor luteoside A | Markhamia stipulata; Markhamia lutea                                | [5,68]         |
| 190 | 1′-O-(3,4-Dihydroxyphenyl[ethyl β-D-apiofuranosyl(1′→2)-α-L-rhamnopyranosyl(1′→3′)-6-O-caffeoyl]-β-D-glucopyranoside or luteoside B | Markhamia stipulata; Markhamia lutea                                | [5,68]         |
| 191 | 1′-O-(3,4-Dihydroxyphenyl[ethyl β-D-apiofuranosyl(1′→2)-α-L-rhamnopyranosyl(1′→3′)-6-O-caffeoyl]-β-D-glucopyranoside or luteoside C | Markhamia lutea                                                     | [5]            |
| 192 | 3-Hydroxy-4-methoxy-β-phenylethoxy-O-[β-D-apiofuranosyl(1′′′→2′′′)-α-rhamnopyranosyl(1′′′→3′′′)-6′′′-O-feruloyl]-β-D-glucopyranoside or luteoside B | Markhamia stipulata                                                 | [68]           |
| 193 | 3,4-Dihydroxy-β-phenylethoxy-O-[β-D-galactopyranosyl(1′′′→2′′′)-α-rhamnopyranosyl(1′′′→3′′′)-4-O-caffeoyl]-6′′′-O-acetyl-β-D-glucopyranoside or luteoside E | Markhamia stipulata                                                 | [68]           |
| 194 | 2-[3′,4′-Dihydroxyphenyl]ethyl-β-D-glucopyranosyl(1′→2)-α-L-rhamnopyranosyl(1′→3′)-4-O-trans-caffeoyl]-β-D-glucopyranoside or verpectoside B | Veronica pectinata var. glandulosa                                   | [95]           |
| 195 | 2-[3′,4′-Dihydroxyphenyl]ethyl-β-D-glucopyranosyl(1′→2)-α-L-rhamnopyranosyl(1′→3′)-4-O-trans-caffeoyl]-β-D-glucopyranoside or verpectoside C | Veronica pectinata var. glandulosa                                   | [95]           |
| 196 | 1′-O-β-D-(4-Methoxy-4-hydroxy-phenyl)ethyl-α-L-rhamnosyl(1′→3′)-α-L-arabinosyl(1′→4′)-6′-O-feruloyl]-β-glucopyranoside or pedicularioside I | Pedicularis fungiorea                                               | [79]           |
| 197 | Angoroside A                                                           | Scrophularia nodosa L.; Scrophularia scorodonia                       | [63,70]        |
| 198 | Scrophuloside B1                                                       | Scrophularia nodosa L.                                                | [63]           |
| 199 | Scrophuloside B2                                                       | Scrophularia nodosa L.                                                | [63]           |
| 200 | 3,4-Dihydroxy-β-phenylethoxy-O-[α-L-arabinopyranosyl(1′→6′)-α-L-rhamnopyranosyl(1′→3′)-4-O-feruloyl]-β-D-glucopyranoside or angoroside D | Scrophularia scorodania                                             | [70]           |
Table 3. Cont.

| No. | Name                                      | Source                        | Refs. |
|-----|------------------------------------------|-------------------------------|-------|
| 201 | Angoroside C                             | Scrophularia nodosa L.        | [63]  |
| 202 | Forthysioside B                          | Markhamia lutea               | [5]   |
| 203 | 6′-β-D-Apiofuranosyl cistanoside C       | Lamiophlomis rotata           | [86]  |
| 204 | Lamiophlomiside A                        | Lamiophlomis rotata           | [86]  |
| 205 | cis-Lamiophlomiside A                    | Lamiophlomis rotata           | [86]  |
| 206 | Forsythoside B                           | Plonis grandiflora; Plonis fruticosa | [80]  |
| 207 | 6′-β-D-Apiofuranosyl cistanoside C       | Lamiophlomis rotata           | [86]  |
| 208 | alyssonoside                             | Plonis grandiflora; Plonis fruticosa | [80]  |
| 209 | 2-(3,4-Dihydroxyphenyl)ethyl O-α-L-rhamno-pyranosyl-(1→3)-[β-α-L-rhamnopyranosyl-(1→6)](4-O-p-coumaroyl)-β-D-glucopyranoside or jionoside E | Rehmannia glutinosa var. Purpurea | [19]  |
| 210 | Purpureaside C                           | Rehmannia glutinosa var. Purpurea | [19,63]|
| 211 | Jionoside A1                             | Rehmannia glutinosa var. Purpurea | [19]  |
| 212 | Jionoside B1                             | Rehmannia glutinosa var. Purpurea | [19]  |
| 213 | Jionoside B2                             | Rehmannia glutinosa var. Purpurea | [19]  |
| 214 | Echinacoside                             | Ligustrum purpurascens; cistanche salvia | [24,81]|
| 215 | 2-(4-Hydroxy-3-methoxyphenyl)ethyl O-α-L-rhamnopyranosyl-(1→3)-O-[β-α-L-rhamnopyranosyl-(1→6)](4-O-coumaroyl)-β-D-glucopyranoside or cistanoside A | Ligustrum purpurascens | [81]  |
| 216 | 2-(4-Hydroxy-3-methoxyphenyl)ethyl O-α-L-rhamnopyranosyl-(1→3)-O-[β-α-L-rhamnopyranosyl-(1→6)](4-O-coumaroyl)-β-D-glucopyranoside or cistanoside B | Ligustrum purpurascens | [81]  |
| 217 | Poliioside                               | Brandisia lancei              | [82]  |
| 218 | β-(3′,4′-Dihydroxyphenyl)-ethyl-2-(O-acetyl)-(3,6-O-di-α-L-rhamnopyranosyl-(4-O-coumaroyl)-β-D-glucopyranoside or brandioside | Brandisia lancei              | [82]  |
| 219 | Arratioside                              | Scrophularia nodosa L.        | [63]  |
| 220 | 1-O-3,4-(Dihydroxyphenyl)ethyl-β-D-apiofuranosyl-(1→4)-α-L-rhamnopyranosyl-(1→3)-4-O-coumaroyl-β-D-glucopyranoside or myricoside | Markhamia lutea; Picria tel-fere Lour. | [5,97]|
| 221 | Rossicaside B                           | Boschniakia rosica            | [98]  |
| 222 | Rossicaside A                           | Boschniakia rosica            | [98]  |
| 223 | 2-O-Acetylrossicaside A                 | Orthocarpus densifolius var. gracilis | [99]  |
| 224 | β-D-glucopyranosyl-(1→4)-α-L-rhamnopyranosyl-(1→3)-4-O-coumaroyl-β-D-glucopyranoside | Boschniakia rosica            | [98]  |
| 225 | Lavandulifolioside                      | Leonurus glaucescens          | [83]  |
| 226 | β-(3′,4′-Dihydroxyphenyl)-ethyl-0-α-L-arabinopyranosyl-(1→2)-α-L-rhamnopyranosyl-(1→3)-4-O-coumaroyl-β-D-glucopyranoside or leonosides A | Leonurus glaucescens          | [83]  |
Table 3. Cont.

| No. | Name                                                                 | Source              | Refs. |
|-----|----------------------------------------------------------------------|---------------------|-------|
| 227 | β-(3-Hydroxy-4-methoxyphenyl)-ethyl-O-α-L-arabinopyranosyl(1→2)-α-L-rhamnopyranosyl(1→3)-4-O-feruloyl-β-D-glucopyranoside or leoniside B | Leonurus glaucescens | [83]  |
| 228 | 2R-Galactosyl-acteoside or lamalloside                                | Lamium album        |       |
| 229 | 3,4-Dihydroxy-β-phenylethoxy-O-β-D-glucopyranosyl(1→2)-α-L-rhamnopyranosyl(1→3)-4-O-caffeoyl-β-D-glucopyranoside or phlinoside D | Phlomis linearis    | [84]  |
| 230 | 3,4-Dihydroxy-β-phenylethoxy-O-α-L-lyxo-pyranosyl(1→2)-α-L-rhamnopyranosyl(1→3)-4-O-caffeoyl-β-D-glucopyranoside or tricusiose tedrus | Teucrium chamaedrys | [101] |
| 231 | 3,4-Dihydroxy-β-phenylethoxy-O-β-D-xlyo-pyranosyl(1→2)-α-L-rhamnopyranosyl(1→3)-4-O-caffeoyl-β-D-glucopyranoside or phlinoside F | Phlomis linearis    | [84]  |
| 232 | 3,4-Dihydroxy-β-phenylethoxy-O-β-D-xlyo-pyranosyl(1→2)-α-L-rhamnopyranosyl(1→3)-4-O-feruloyl-β-D-glucopyranoside or phlinoside D | Phlomis linearis    | [102] |
| 233 | 2-(4-Hydroxyphenyl)-ethyl-[3-O-α-L-rhamno-pyranosyl(1→4)-α-L-rhamnopyranosyl][6-O-p-coumaroyl]-O-β-D-glucopyranoside or ligupuruside C | Ligustrum purpurascens |       |
| 234 | 2-(4-Hydroxyphenyl)-ethyl-[3-O-α-L-rhamno-pyranosyl(1→4)-α-L-rhamnopyranosyl][6-O-(E)-caffeoyl]-O-β-D-glucopyranoside or ligupuruside D | Ligustrum purpurascens |       |
| 235 | 3-O-[α-L-Rhamnopyranosyl(1→4)-α-L-rhamno-pyranosyl][4-O-(E)-caffeoyl]-D-glucopyranose or ligupuruside F | Ligustrum purpurascens |       |
| 236 | Ligupuruside B                                                        | Ligustrum purpurascens |       |
| 237 | Ligurobustosides N                                                    | Ligustrum purpurascens |       |
| 238 | Ligupuruside A                                                        | Ligustrum purpurascens |       |
| 239 | 3,4-Dihydroxy-β-phenylethoxy-O-α-L-rhamno-pyranosyl(1→2)-α-L-rhamnopyranosyl(1→3)-4-O-caffeoyl-β-D-glucopyranoside or phlinoside C | Phlomis linearis    | [84]  |
| 240 | 3,4-Dihydroxy-β-phenylethoxy-O-α-L-rhamno-pyranosyl(1→2)-α-L-rhamnopyranosyl(1→3)-4-O-feruloyl-β-D-glucopyranoside or phlinoside E | Phlomis linearis    | [102] |
| 241 | Myricoside                                                            | Clerodendrum serratum | [103] |
| 242 | 3-Hydroxy-4-methoxy-β-phenethyl-O-β-D-apio-furanosyl(1→3)-α-L-rhamno-pyranosyl(1→5)-4-O-feruloyl-β-D-glucopyranoside or serratunoside A | Clerodendrum serratum | [103] |
| 243 | Aragoside                                                             | Arenga cundinancaricis |       |
| 244 | Persicoside                                                           | Arenga cundinancaricis |       |
| 245 | 1′-(3-O-β-D-(4′-Hydroxy-4-methoxy-β-phenyl)-ethyl)-4′-O-feruloyl-β-D-glucopyranosyl(1→3)-α-L-rhamnosyl(1→6)-D-glucopyranoside or arthesoloside B | Pediculatis artesleri | [66]  |
| 246 | 3,4-Dihydroxy-β-phenylethyl-O-α-L-rhamno-pyranosyl(1→2)-O-β-D-glucopyranosyl(1→6)-3-O-caffeoyl-β-D-glucopyranoside or magnuloside B | Magnolia obovata Thunb | [62]  |
| 247 | α-L-Xylopyranosyl(4′→2′)-O-β-D-glucopyranosyl]-1′-O-E-caffeoyl-β-D-glucopyranoside | Coassaena hydrangeifolia | [21]  |
| 248 | 2-(3,4-Dihydroxyphenyl)-8,2-ethoxyethyl-O-β-D-glucopyranosyl(1→4)-α-L-rhamno-pyranosyl(1→3)-4-O-trans-caffeoyl]-β-D-glucopyranoside or rossicaside F | Bocchiania rosica | [97]  |
| 249 | 4-Cinnamoyl desxylosylmussatioside                                     | Musatia             |       |
Table 3. Cont.

| No. | Name                                      | Source                  | Refs. |
|-----|-------------------------------------------|-------------------------|-------|
| 250 | 4-p-Coumaryloylmussatioside                | Mussatia                | [88]  |
| 251 | 4-cis-p-Coumaryloylmussatioside           | Mussatia bipincitina    | [104] |
| 252 | 4-p-Methoxycinnamoylmussatioside or ormulatioside III | Mussatia | [88]  |
| 253 | 4-Feruloylmussatioside                    | Mussatia                | [88]  |
| 254 | 4-Dimethylcaffeoylmussatioside or ormulatioside II | Mussatia | [88]  |
| 255 | 3-O-[E]-Sinapoyl-[β-D-fructofuranosyl-(2→1)]-[β-D-gluco-pyranosyl-(1→4)]-[β-D-gluco-pyranosyl-(1→2)]-[6-O-[E]-sinapoyl]-α-D-gluco-pyranoside or tricornose G | Polygala tricornis | [37]  |
| 256 | 3-O-[E]-Sinapoyl-[4-O-[E]-p-coumaryloyl]-[β-D-fructofuranosyl-(2→1)]-[β-D-gluco-pyranosyl-(1→4)]-[β-D-gluco-pyranosyl-(1→2)]-[6-O-[E]-sinapoyl]-α-D-gluco-pyranoside or tricornose L | Polygala tricornis | [37]  |
| 257 | 3-O-[E]-Sinapoyl-[4-O-[E]-feruloyl]-[β-D-fructofuranosyl-(2→1)]-[β-D-gluco-pyranosyl-(1→4)]-[β-D-gluco-pyranosyl-(1→2)]-[6-O-[E]-sinapoyl]-α-D-gluco-pyranoside or tricornose K | Polygala tricornis | [37]  |
| 258 | 3-O-[E]-sinapoyl-[4-O-[E]-sinapoyl]-[β-D-fructofuranosyl-(2→1)]-[β-D-gluco-pyranosyl-(1→4)]-[β-D-gluco-pyranosyl-(1→2)]-[6-O-[E]-sinapoyl]-α-D-gluco-pyranoside or tricornose H | Polygala tricornis | [37]  |
| 259 | 3-O-[E]-3,4,5-Trime-thoxycinnamoyl-[4-O-[E]-feruloyl]-[β-D-fructofuranosyl-(2→1)]-[β-D-gluco-pyranosyl-(1→4)]-[β-D-gluco-pyranosyl-(1→2)]-[6-O-[E]-sinapoyl]-α-D-gluco-pyranoside or tricornose J | Polygala tricornis | [37]  |
| 260 | 3-O-[E]-3,4,5-Trime-thoxycinnamoyl-[4-O-[E]-sinapoyl]-[β-D-fructofuranosyl-(2→1)]-[β-D-gluco-pyranosyl-(1→4)]-[β-D-gluco-pyranosyl-(1→2)]-[6-O-[E]-sinapoyl]-α-D-gluco-pyranoside or tricornose I | Polygala tricornis | [37]  |
| 261 | Senegose I                                 | Polygala senega var. latifolia Torr. Et Gray | [105] |
| 262 | 1-O-[E]-p-Coumaryl-[3-O-benzoyl]-[β-D-fructofuranosyl-(2→1)]-[β-D-gluco-pyranosyl-(1→2)]-[6-O-acetyl]-[β-D-gluco-pyranosyl-(1→3)]-[4-O-[E]-feruloyl]-[6-O-acetyl]-α-D-gluco-pyranoside or glomeratose F | Polygala glomerata | [38]  |
| 263 | 1-O-[E]-p-Coumaryl-[3-O-benzoyl]-[β-D-fructofuranosyl-(2→1)]-[β-D-gluco-pyranoside-(1→3)]-[4-O-[E]-β-D-gluco-pyranosyl-(1→2)]-[6-O-acetyl]-[α-D-gluco-pyranosyl] or glomeratose G | Polygala glomerata | [38]  |
| 264 | 1-O-p-coumaryl-[3-O-benzoyl]-[β-D-fructofuranosyl-(2→1)]-[β-D-gluco-pyranosyl-(1→2)]-[6-O-acetyl]-[β-D-gluco-pyranoside-(1→3)]-[4-O-p-coumaryl]-α-D-gluco-pyranoside or fallaxose C | Polygala fallax | [92]  |
| 265 | Reiniuse G                                 | Polygala glomerata; Polygala reinii Fr. et Sav | [38,46] |
| 266 | Dalmaisse H                                | Polygala dalmasiasea | [93]  |
| 267 | 1-O-[E]-p-Coumaryl-[3-O-benzoyl]-[β-D-fructofuranosyl-(2→1)]-[β-D-gluco-pyranosyl-(1→2)]-[6-O-acetyl]-[β-D-gluco-pyranoside-(1→3)]-[4-O-fueruloyl]-α-D-gluco-pyranoside or fallaxose D | Polygala fallax | [92]  |
| 268 | Dalmaisse J                                | Polygala dalmasiasea | [93]  |
| 269 | Dalmaisse L                                | Polygala dalmasiasea | [93]  |
| 270 | Dalmaisse M                                | Polygala dalmasiasea | [93]  |
| 271 | Reiniuse H                                 | Polygala reinii Fr. et Sav | [46]  |
| 272 | Senegose G                                 | Polygala fallax; Polygala senega var. latifolia Torr. Et Gray | [92,105] |
| 273 | Senegose H                                 | Polygala senega var. latifolia Torr. Et Gray | [105] |
| 274 | Senegose F                                 | Polygala reinii Fr. et Sav; Polygala senega var. latifolia Torr. Et Gray | [46,105] |
| No. | Name                                                                 | Source                                           | Refs. |
|-----|----------------------------------------------------------------------|--------------------------------------------------|-------|
| 275 | 3-O-β-D-Glucopyranosylpresegenin 28-O-β-D-xylopyranosyl-(1→4)-α-L-rhamnopyranosyl-(1→2)-4-O-[(E)-3,4-dimethoxycinnamoyl]-β-D-fructofuranosyl ester or Polygalasaponin XLII | Polygala glomerata Lour                          | [106] |
| 276 | 3,4-Dihydroxy-β-phenylethyl-O-α-L-rhamnopyranosyl-(1→2)-O-[O-β-D-glucopyranosyl-(1→4)-β-D-glucopyranosyl-(1→6)]-3-O-cafeoyl-β-D-allopyranoside or magnoloside C | Magnolia obovata Thunb                          | [62]  |
| 278 | 3-O-[4-O-[β-D-Glucopyranosyl-(1→3)-2-O-acetyl]-α-L-rhamnopyranosyl]-feruloyl]-β-D-fructo-furanosyl-(2→1)-4,6-di-O-benzoyl]-α-D-gluco-pyranoside or fallaxose B | Polygala fallax                                 | [92]  |
| 279 | 2-(3,4-Dihydroxyphenyl)ethyl-O-β-apio-furanosyl-(1→6)-O-[O-β-apiofuranosyl-(1→4)-α-L-rhamnopyranosyl-(1→3)-6-O-caffeoyl]-β-D-glucopyranoside or lunariifolioside | Phlomis lunariifolia                           | [106] |
| 280 | Tenuifoliose K                                                       | Polygala tenuifolia Wild                         | [11]  |
| 281 | Tenuifoliose J                                                       | Polygala tenuifolia Wild                         | [11]  |
| 282 | Tenuifoliose I                                                       | Polygala tenuifolia Wild                         | [11]  |
| 283 | Tenuifoliose H                                                       | Polygala tenuifolia Wild                         | [11]  |
| 284 | Tenuifoliose C                                                       | Polygala tenuifolia Wild, Polygala fallax       | [12,92]| |
| 285 | Tenuifoliose B                                                       | Polygala tenuifolia Wild                         | [12]  |
| 286 | Tenuifoliose D                                                       | Polygala tenuifolia Wild, Polygala reinii Fr. et Sav | [12,46]| |
| 287 | Tenuifoliose E                                                       | Polygala tenuifolia Wild                         | [12]  |
| 288 | Tenuifoliose A                                                       | Polygala tenuifolia Wild                         | [11,12]| |
| 289 | Tenuifoliose P                                                       | Polygala tenuifolia Wild                         | [11]  |
| 290 | Tenuifoliose O                                                       | Polygala tenuifolia Wild                         | [11]  |
| 291 | Reinirose I                                                          | Polygala reinii Fr. et Sav                       | [46]  |
| 292 | Tenuifoliose N                                                       | Polygala tenuifolia Wild                         | [11]  |
| 293 | Reinirose J                                                          | Polygala reinii Fr. et Sav                       | [46]  |
| 294 | 1-O-Feruloyl-(3-O-benzoyl)-β-D-fructofuranosyl-(2→1)]-[β-D-glucopyranosyl-(1→2)-[β-D-glucopyranosyl-(1→3)-6-O-acetyl]-β-D-glucopyranosyl-(1→3)-6-O-feruloyl]-α-D-glucopyranoside or fallaxose E | Polygala fallax                                 | [92]  |
| 295 | Senegose K                                                           | Polygala senega L.                               | [107] |
| 296 | Senegose J                                                           | Polygala senega L.                               | [107] |
| 297 | Senegose N                                                           | Polygala senega L.                               | [107] |
| 298 | Senegose O                                                           | Polygala senega L.                               | [107] |
| 299 | Senegose M                                                           | Polygala senega L.                               | [107] |
| 300 | Senegose L                                                           | Polygala senega L.                               | [107] |
| 301 | Senegose D                                                           | Polygala senega var. latifolia Torr. Et Gray    | [108] |
| 302 | Senegose C                                                           | Polygala senega var. latifolia Torr. Et Gray    | [108] |
| No. | Name               | Source                                      | Refs. |
|-----|--------------------|---------------------------------------------|-------|
| 303 | Senegose B         | *Polygala senega* var. *latifolia* Torr. Et Gray | [108] |
| 304 | Senegose A         | *Polygala senega* var. *latifolia* Torr. Et Gray | [108] |
| 305 | Senegose E         | *Polygala senega* var. *latifolia* Torr. Et Gray | [108] |
| 306 | Dalmaisiose D      | *Polygala dalmaisiana*                      | [93]  |
| 307 | Dalmaisiose B      | *Polygala dalmaisiana*                      | [93]  |
| 308 | Dalmaisiose E      | *Polygala dalmaisiana*                      | [93]  |
| 309 | Dalmaisiose I      | *Polygala dalmaisiana*                      | [93]  |
| 310 | Dalmaisiose N      | *Polygala dalmaisiana*                      | [93]  |
| 311 | Dalmaisiose F      | *Polygala dalmaisiana*                      | [93]  |
| 312 | Dalmaisiose P      | *Polygala dalmaisiana*                      | [93]  |
| 313 | Dalmaisiose G      | *Polygala dalmaisiana*                      | [93]  |
| 314 | Dalmaisiose C      | *Polygala dalmaisiana*                      | [93]  |
| 315 | Dalmaisiose K      | *Polygala dalmaisiana*                      | [93]  |
| 316 | Dalmaisiose O      | *Polygala dalmaisiana*                      | [93]  |
| 317 | E-Senegasaponin b  | *Polygala senega* L var. *latifolia* Torrey et Gray | [109] |
| 318 | Z-Senegasaponin b  | *Polygala senega* L var. *latifolia* Torrey et Gray | [109] |
| 319 | Senegin II         | *Polygala glomerata* Lour                   | [106] |
| 320 | (Z)-Senegin II     | *Polygala glomerata* Lour                   | [106] |
| 321 | Tenuifoliose M     | *Polygala tenuifolia* Wilkd                 | [11]  |
| 322 | Tenuifoliose L     | *Polygala tenuifolia* Wilkd                 | [11]  |
| 323 | Tenuifoliose F     | *Polygala tenuifolia* Wilkd                 | [11]  |
| 324 | Tenuifoliose F     | *Polygala tenuifolia* Wilkd                 | [11]  |
| 325 | 3-O-β-D-Glucopyranosyl [presenegenin 28-O-β-D-galactopyranosyl-(1→4)-β-D-xylo-pyranosyl-(1→4)-α-L-rhamnopyranosyl-(1→2)[β-D-glucopyranosyl-(1→3)](4-O-{[(E)-3,4-dimethoxycinnamoyl]}-β-O-fucopyranosyl ester or polygalasaponin XLI] | *Polygala glomerata* Lour | [106] |
| 326 | 3-O-β-D-Glucopyranosyl [presenegenin 28-O-β-D-galactopyranosyl-(1→4)-β-D-xylopyranosyl-(1→4)-α-L-rhamnopyranosyl-(1→2){6-O-acetyl-β-D-glucopyranosyl-(1→3)](4-O-{[(E)-3,4-dimethoxycinnamoyl]}-β-O-fucopyranosyl ester or polygalasaponin XLV] | *Polygala glomerata* Lour | [106] |
| 327 | 3-O-β-D-Glucopyranosyl [presenegenin 28-O-β-D-galactopyranosyl-(1→4)-β-D-xylopyranosyl-(1→4)-α-L-rhamnopyranosyl-(1→2){6-O-acetyl-β-D-glucopyranosyl-(1→3)](4-O-{[(Z)-3,4-dimethoxycinnamoyl]}-β-O-fucopyranosyl ester or polygalasaponin XLI] | *Polygala glomerata* Lour | [106] |
Table 3. Cont.

| No. | Name                                                                 | Source                      | Refs. |
|-----|-----------------------------------------------------------------------|-----------------------------|-------|
| 328 | 3-β-D-Glucopyranosylpresenegenin, 28-α-L-rhamnopyranosyl(1→4)-β-D-xylopyranosyl | Polygala japonica Houtt.    | [56]  |
|     | (1→4)-α-L-rhamnopyranosyl(1→2)-[4-O-p-methoxycinnamoyl]-| β-D-glucopyranosyl (1→3)]-β-D-fucopyranosyl ester or polygalasaponin XXXX |       |
| 329 | 3-β-D-Glucopyranosylpresenegenin 28-α-L-rhamnopyranosyl(1→4)-β-D-xylopyranosyl(1→4)-β-L-rhamnopyranosyl(1→2)-α-L-arabinopyranosyl(1→3)]-[4-O-(E)-p-methoxycinnamoyl]-β-D-fucopyranosyl ester or polygalasaponin XLIII | Polygala glomerata Lour   | [106] |
| 330 | 3-β-D-Glucopyranosylpresenegenin 28-α-L-arabinopyranosyl(1→4)-β-D-xylopyranosyl(1→4)-[β-D-apiofuranosyl(1→3)]-α-L-rhamnopyranosyl(1→2)-[4-O-3,4,5-trimethoxy-cinnamoyl]-β-D-fucopyranosyl ester or polygalasaponin XXXII | Polygala japonica Houtt.   | [56]  |
| 331 | E-Senegasaponin a                                                   | Polygala senega L.var. latifolia Torrey et Gray | [109] |
| 332 | Z-Senegasaponin a                                                   | Polygala senega L.var. latifolia Torrey et Gray | [109] |
| 333 | 1-O-(E)-p-Coumaroyl-[3-O-benzoyl]-β-D-fructo-furanosyl(2→1)-[6-O-(E)-feruloyl]-β-D-glucopyranosyl(1→2)-[6-O-acetyl-β-D-glucopyranosyl(1→3)]-[4-O-4-acetyl-β-D-glucopyranosyl(1→3)]-[4-O-4-acetyl-β-D-rhamnopyranosyl(1→3)]-β-D-glucopyranoside or polygalajaponicose I | Polygala japonica          | [110] |
| 334 | 3-β-D-Glucopyranosylpresenegenin 28-α-L-arabinopyranosyl(1→4)-β-D-xylopyranosyl(1→4)-[β-D-apiofuranosyl(1→3)]-α-L-rhamnopyranosyl(1→2)-[4-O-p-methoxycinnamoyl]-α-L-rhamnopyranosyl(1→3)]-β-D-fucopyranosyl ester or polygalasaponin XXXII | Polygala japonica Houtt.   | [56]  |
2.1. Monosaccharide Esters

The 27 monosaccharide esters [16,18,20–35] exist as anomic mixtures in solution and the phenylacrylic group is often attached at the C-6 position of the glycosyl moiety. Coincidentally, compounds 11–15 possess the same p-methoxy-cinnamoyl group attached to the rhamnose unit though an ester bond in the monosaccharide ester. Compounds 2, 4 and 20 are phenylpropanol esters linked with glucose as the important part. Compounds 1 and 3 contain two different phenylpropanols attached to one glucose molecule. Ningposide D (14) [16] is also an anomeric mixture of rhamnose esters and the anomeric ratio α/β is 3:1, here it was drawn as the α-L-rhamnose ester. Isolated from the underground parts of Globularia orientali, globularitrol (21) has a carbohydrate chain moiety, formed by a glucitol group. It has the ability to efficiently scavenge free radicals [32]. Grayanin (22) has a mandelonitrile unit connected at the C-1 position in the glucose. This compound is a unique cyanogenic glycoside among CASEDs [20]. The benzeneacetonitrile group of grayanin may be originated from phenylalanine from the biosynthetic pathway viewpoint. Up to now, paederol A (27) and B (26), are the only two reported CASEDs with acyclic sugars. By the way, paederol A and B did not exhibit obviously cytotoxicity in the Lu1 (lung cancer), LNCaP (prostate cancer) and MCF-7 (breast cancer) [34]. Kaempferol 3-0-β-D-(6-O-p-coumaroyl)-glucopyranoside (27) is the only flavonoid of CASEDs, which possess inhibitory activity towards a drug-metabolizing enzyme, CYP3A4 [35].

![Figure 2. Structures of compounds 1–10.](image1)

![Figure 3. Structures of compounds 11–15.](image2)
2.2. Disaccharide Esters

Disaccharide esters 28–162 (Figures 6–16) [4,5,10,13,15,17,19,24,25,29,36–91] constitute the largest group among CASEDs. Their glycosyl parts include glycosyl groups, with glucopyranosyl, rhamnopyranosyl, fructofuranosyl, and arabinopyranosyl ones being the most important and sucrose units as found in compounds 28–120, 162 are more rare. Among them, the glycosyl unit in 28–120 has the anomeric carbon on α-D-glucose linked to a β-D-fructose. The ester bond is often formed at the C-6 position of α-D-glucose and C-3 position of β-D-fructose. The compounds 122–140 are composed of α-L-rhamnose and β-D-glucose, with a connection between the C-1 location of α-L-rhamnose and C-3 position of β-D-glucose. The cinnamic acid unit is mainly connected to the C-4 position of β-D-glucose,

| Cpd | R1 | R2 | R3 | R4 | R5 |
|-----|----|----|----|----|----|
| 16  | H  | H  | H  | H  | E  |
| 17  | H  | H  | H  | H  | G  |
| 18  | H  | H  | H  | H  | K  |
| 19  | H  | H  | H  | E  | H  |
| 20  | H  | H  | G' | H  | G  |

![Figure 4. Structures of compounds 16–20.](image)

![Figure 5. Structures of compounds 21–27.](image)
and less often in the C-6 location. The glycosyl moieties of compounds 145–147 are similar to those of 122–140, and the configuration of the hydroxyl attached to the anomeric carbon of glucose could not be determined. The aglycone part of compounds 150–155 is two \( \beta \)-d-glucoses joined by C-1 and C-6, and the functional group is attached to the C-2 position of the parent nucleus.

![Figure 6. Structures of compounds 28–120.](image-url)
Figure 7. Structure of compound 121.

Figure 8. Structures of compounds 122–140.

Figure 9. Structure of compound 141.

Figure 10. Structures of compounds 142–143.
Figure 10. Structures of compounds 140–141.

Figure 11. Structure of compound 142.

Figure 12. Structures of compounds 143–144.

Figure 13. Structure of compound 145.

Figure 14. Structure of compound 146.

Figure 15. Structures of compounds 147–148.

Figure 16. Structures of compounds 149–150.

Figure 17. Structures of compounds 151–152.

Figure 18. Structures of compounds 153–154.

Figure 19. Structures of compounds 155–156.
Sibiricose A5 (28), tenuifoliside A (51) and DISS (73) from the root of Polygala sibirica (Yuanzhi) [13], have the same core sucrose unit and the ester is always connected at the C-6 position of α-D-glucose and C-3 position of β-D-fructose. These compounds have anti-depression properties. In 1968, verbascoside (=acteoside 131) was the first CASED isolated from the medical plant Syringa vulgaris (Oleaceae) [3]. So far, it has been reported in nine families. Magnoloside A (121) from medicinal plants of the Magnoliaceae family is unique among the phenylpropanoids in rarely occurring alone as the core glycosyl [62]. In addition, crenatoside (157) has a novel annular framework which attaches the C-1 and C-2 of the glucose to a hexatomic oxygen ring [91]. Glomeratose E (162) possesses a (E,E)-β,β′-bis-sinapoyl group between the α-D-glucose and β-D-fructose [38].

2.3. Trisaccharide Esters

Ninety three compounds 163–254 [5,19,21,24,37,46,51,55,63–67,75,78–86,93–104] represent the trisaccharide ester category. They are mainly obtained from the Scrophulariaceae plant family. The most common glycosyl moieties are sucrose, with glucose as core unit (compounds 163–174, 175, Figures 17–20 and Figure 21), di-apiose combined with glucose (176–178, Figures 22 and 23), glucose as the kernel glycosyl (179–246, 247–248, Figures 24–52 and Figure 53), and rhamnose as the central part with its terminal carbon combined with glucose and the C-3 connected with xylose (249–254, Figure 54). The phenylpropanoid groups usually esterify the C-3 and C-4 positions of fructose, C-3, C-4 and C-6 of glucose and C-4 of rhamnose. Tricornoses E (165) and F (166) from the Polygalaceae family possess two different phenylpropanoids attached to one fructose molecule [37]. Lilongiside (173), reiniose D (174) and hydrangeifolin II (253) differ from other trisaccharide esters in that their three sugar cores are not combined as a whole chain [21,46,55]. The aglycone groups of lilongiside and reiniose D are sucrose with glucose, rhamnose. Hydrangeifolin II is composed of
caffeoyl glycoside with a diglycosyl unit esterified with an ester linkage. This compound has a weak DPPH free radical scavenging activity. Teucrioside (229) from the Labiatae family is the only CASED that has a lyxose moiety, rarely occurring in higher plants [101]. The anomeric carbon configuration of glucose unit in ligupurpuroside F (234) is not determined [24]. Rossicaside F (254) exists as epimers at the β-C of the phenethyl alcohol moiety (R,S-β-OEt) [98].

![Figure 17. Structures of compounds 163–166.](image)

| Cpd. | R₁ | R₂ | R₃ | Cpd. | R₁ | R₂ | R₃ |
|------|----|----|----|------|----|----|----|
| 163  | K  | H  | K  | 165  | M  | I  | K  |
| 164  | M  | H  | K  | 166  | M  | K  | K  |

![Figure 18. Structures of compounds 167–168.](image)

| Cpd. | R₁ | R₂ | R₃ | R₄ | R₅ | R₆ | R₇ |
|------|----|----|----|----|----|----|----|
| 167  | H  | H  | I  | H  | H  | H  | K  |
| 168  | H  | H  | K  | H  | H  | H  | K  |

![Figure 19. Structures of compounds 169–172.](image)

| Cpd. | R₁ | R₂ | Cpd. | R₁ | R₂ |
|------|----|----|------|----|----|
| 169  | I  | H  | 171  | H  | I  |
| 170  | K  | H  | 172  | H  | K  |

![Figure 20. Structures of compounds 173–174.](image)

| Cpd. | R₁ | R₂ | R₃ | R₄ | R₅ | R₆ | R₇ | R₈ |
|------|----|----|----|----|----|----|----|----|
| 173  | H  | H  | H  | O  | H  | H  | A  | I  |
| 174  | H  | H  | P  | B  | H  | H  | H  | B  |
Figure 21. Structure of compound 175.

Cpd.  R_1  R_2  R_3
175  E   A   D

Figure 22. Structures of compounds 176–177.

Cpd.  R_1  R_2  R_3  R_4
176  S   H   H   G
177  S   H   G   H

Figure 23. Structure of compound 178.

Cpd.  R_1  R_2
178  S   G

Figure 24. Structures of compounds 179–182.

Cpd.  R_1  R_2
179  S   G
180  S   I
181  T   I
182  U   I
Figure 25. Structures of compounds 183–187.

| Cpd. | R₁ | R₂ | R₃ |
|------|----|----|----|
| 183  | S  | H  | G  |
| 184  | S  | G  | H  |
| 185  | S  | G  | A  |
| 186  | S  | I  | H  |
| 187  | T  | I  | H  |

Figure 26. Structures of compounds 188–192.

| Cpd. | R₁ | R₂ | R₃ |
|------|----|----|----|
| 188  | S  | G  | H  |
| 189  | S  | G  | A  |
| 190  | S  | H  | G  |
| 191  | S  | H  | I  |
| 192  | T  | H  | I  |

Figure 27. Structure of compound 193.

| Cpd. | R₁ | R₂ | R₃ |
|------|----|----|----|
| 193  | S  | G  | A  |

Figure 28. Structures of compounds 194–195.

| Cpd. | R₁ | R₂ | R₃ |
|------|----|----|----|
| 194  | S  | G  | H  |
| 195  | S  | I  | H  |
Figure 29. Structure of compound 196.

| Cpd. | R₁ | R₂ | R₃ |
|------|----|----|----|
| 196  | U  | H  | I  |

Figure 30. Structures of compounds 197–201.

| Cpd. | R₁ | R₂ | R₃ |
|------|----|----|----|
| 197  | S  | H  | G  |
| 198  | S  | H  | I  |
| 199  | S  | H  | I' |
| 200  | S  | H  | I  |
| 201  | T  | H  | I  |

Figure 31. Structures of compounds 202–205.

| Cpd. | R₁ | R₂ | R₃ |
|------|----|----|----|
| 202  | S  | H  | G  |
| 203  | U  | H  | G  |
| 204  | U  | H  | I  |
| 205  | U  | H  | I' |

Figure 32. Structures of compounds 206–207.

| Cpd. | R₁ | R₂ | R₃ |
|------|----|----|----|
| 206  | S  | H  | G  |
| 207  | S  | H  | I  |
| Cpd. | R₁ | R₂ | R₃ |
|------|----|----|----|
| 208  | S  | H  | E  |
| 209  | S  | H  | G  |
| 210  | S  | H  | I  |
| 211  | S  | H  | I' |
| 212  | U  | H  | I  |
| 213  | U  | H  | I' |

Figure 33. Structures of compounds 208–213.

| Cpd. | R₁ | R₂ | R₃ |
|------|----|----|----|
| 214  | S  | H  | G  |
| 215  | U  | H  | G  |
| 216  | U  | H  | I  |

Figure 34. Structures of compounds 214–216.

| Cpd. | R₁ | R₂ | R₃ |
|------|----|----|----|
| 217  | S  | H  | G  |
| 218  | S  | A  | G  |

Figure 35. Structures of compounds 217–218.

| Cpd. | R₁ | R₂ | R₃ |
|------|----|----|----|
| 219  | S  | H  | G  |

Figure 36. Structure of compound 219.
### Structures of compounds

| Cpd. | R1 | R2 | R3 | R4 |
|------|----|----|----|----|
| 220  | S  | H  | G  | H  |

Figure 37. Structure of compound 220.

| Cpd. | R1 | R2 | R3 | R4 |
|------|----|----|----|----|
| 221  | E  | H  | I  | H  |
| 222  | S  | H  | G  | H  |
| 223  | S  | A  | G  | H  |

Figure 38. Structures of compounds 221–223.

| Cpd. | R1 | R2 | R3 | R4 |
|------|----|----|----|----|
| 224  | H  | H  | I  | H  |

Figure 39. Structure of compound 224.

| Cpd. | R1 | R2 | R3 | R4 |
|------|----|----|----|----|
| 225  | S  | H  | G  | H  |
| 226  | S  | H  | I  | H  |
| 227  | T  | H  | I  | H  |

Figure 40. Structures of compounds 225–227.

| Cpd. | R1 | R2 | R3 | R4 |
|------|----|----|----|----|
| 228  | S  | H  | G  | H  |

Figure 41. Structure of compound 228.
Figure 42. Structure of compound 229.

Figure 43. Structure of compound 230.

Figure 44. Structures of compounds 231–232.

Figure 45. Structures of compounds 233–234.

Figure 46. Structures of compounds 235–238.
Table 1. Structures of compounds 239–240.

| Cpd. | R₁ | R₂ | R₃ | R₄ |
|------|----|----|----|----|
| 239  | S  | H  | G  | H  |
| 240  | S  | H  | I  | H  |

Figure 47. Structures of compounds 239–240.

Table 2. Structures of compounds 241–242.

| Cpd. | R₁ | R₂ | R₃ | R₄ |
|------|----|----|----|----|
| 241  | S  | H  | G  | H  |
| 242  | T  | H  | I  | H  |

Figure 48. Structures of compounds 241–242.

Figure 49. Structure of compound 243.

Table 3. Structure of compound 243.

| Cpd. | R₁ | R₂ | R₃ |
|------|----|----|----|
| 243  | S  | G  | H  |

Figure 50. Structure of compound 244.

Table 4. Structure of compound 244.

| Cpd. | R₁ | R₂ | R₃ |
|------|----|----|----|
| 244  | S  | G  | H  |

Figure 51. Structure of compound 245.
2.4. Tetrasaccharide Esters

Of all the tetrasaccharide esters 255–279 (Figures 55–60) [37,38,46,62,92,93,105–107], 23 are found in Polygalaceae plants. Most of the phenylacrylic moieties are coumaroyl, feruloyl, and sinapoyl groups. According to the core glycosyl type, these compounds can be classified into four groups, including the combination of fructose with three glucoses (255–274, Figures 55–57), rhamnose, fructose with two glucoses (277–278, Figure 60), the other tetrasaccharide esters (275, 276, 279, Figures 58–60). Senegoses F–I (261, 272–274) [105], whose absolute configurations were established by spectroscopic and chemical means, were purified from Polygala senega var. latifolia Torr. et Gra (Polygalaceae). Polygalasaponin XLII (275) which was obtained from the roots of Polygalaglomerata Lour belongs to the oleanane-type saponins, [107]. Its fucose C-4 position attaches to a 3,4-dimethoxycinnamoyl by an ester bond. The structures of fallaxose A (277) and fallaxose B (278), found in the roots of Polygala fallax, are similar, except for the acetyl group and the glucose location. Both are esterified with ferulic acid [92].
Found in the roots of *Fructose with two glucoses* (255 groups). According to the core glycosyl type, these compounds can be classified into four groups, found in *Polygalacaceae*. Most of the phenylacrylic moieties are coumaroyl, feruloyl and sinapoyl. In *Cpd. R 1 R2 R3 R4 R5 Cpd. R 1 R2 R3 R4 R5* 2016, 21, 1402 29 of 43, k-fucose C-4 position attaches (107).

| Cpd. | R₁ | R₂ | R₃ | R₄ | R₅ | Cpd. | R₁ | R₂ | R₃ | R₄ | R₅ | R₆ |
|------|----|----|----|----|----|------|----|----|----|----|----|----|
| 255  | K  | H  | H  | K  | 258 | K  | K  | H  | K  |
| 256  | K  | E  | H  | K  | 259 | M  | I  | H  | K  |
| 257  | K  | I  | H  | K  | 260 | M  | K  | H  | K  |

**Figure 55.** Structures of compounds 255–260.

| Cpd. | R₁ | R₂ | R₃ | R₄ | R₅ | R₆ |
|------|----|----|----|----|----|----|
| 261  | I  | B  | H  | I  | A  | A  |

**Figure 56.** Structure of compound 261.

| Cpd. | R₁ | R₂ | R₃ | R₄ | R₅ | R₆ |
|------|----|----|----|----|----|----|
| 262  | E  | B  | I  | A  | A  | 269 | E  | B  | I  | H  | I  |
| 263  | E  | B  | H  | E  | A  | 270 | E  | B  | I  | A  | I  |
| 264  | E  | B  | E  | H  | A  | 271 | I  | B  | E  | A  | A  |
| 265  | E  | B  | E  | A  | A  | 272 | I  | B  | I  | H  | A  |
| 266  | E  | B  | E  | A  | E  | 273 | I  | B  | I  | A  | H  |
| 267  | E  | B  | I  | H  | A  | 274 | I  | B  | I  | A  | A  |
| 268  | E  | B  | I  | H  | E  |  |  |  |  |  |  |

**Figure 57.** Structures of compounds 262–274.
To our knowledge, pentasaccharide esters 280–320 (Figures 61–64) [11,12,46,92,93,107–110], hexasaccharide esters 321–333 (Figures 65–71) [11,12,56,107,109,110], heptasaccharide esters 334 (Figure 72) [56] were all found in the Polygalaceae family and most of them form a series of similar type compounds. That is to say, CASEDs with higher carbon numbers are rarely found in plants outside the Polygalaceae. The phenylacrylic groups usually locate at C-1 of fructose, C-4 of glucose, as well as C-4 of fucose. Most glycosyl moieties of pentasaccharide esters are four glucoses and a fructose with different locations and sequence. Tenuifolioses A and B (285, 288), obtained from Polygala tenuifolia Willd, showed neuroprotective activity. Tenuifolioses A and B have the same glycosyl core, with β-D-glucoses connected at the C-1 and C-4 position and the first glucose combined with another glucose at C-2 and β-D-fructose at C-1 [12]. Compounds 280–294 with this same sugar core
serve to remind researchers of the need for more studies on these compounds to find more precursor compounds of anti-depression drugs. The tenuifoliolose A–E (284–288), senegose A–E (301–305), J–O (295–300) type of oligosaccharide multi-esters are esterified with coumaric and ferulic acids [108,111]. Compounds 306–307, 311 [93] are pentasaccharide esters having the same glycosyl connection sequence as that of reiniose G (265) and have a p-coumaroyl residue at C-6 of glucose [38]. Compounds 308–310, 312–316 are also pentasaccharide esters, but with a feruloyl residue at C-6 of glucose. Compounds 319–320 and 325–330 are CASEDs belonging to the oleanane-type saponins and found in the root parts of Polygala glomerata Lour [107], which have the same parent nuclei as polygalasaponin XLII (275). To our knowledge, only one heptasaccharide ester (polygalasaponin XXXII, 334) was reported, and it is also an oleanane-type saponin, with hippocampus-dependent learning and memory enhancing activity. Polygalasaponin XXXII [56], as the representative of oleanane-type saponins in CASEDs, has also captured attention of researchers to do more investigation on the other compounds of the class (317–320, 325–332) in order to identify compounds with the same activity or with more sugars that might improve the hippocampus-dependent learning and memory enhancing activity of polygalasaponin XXXII.

![Figure 61. Structures of compounds 280–294.](image)

| Cpd. | R₁ | R₂ | R₃ | R₄ | R₅ | R₆ |
|------|----|----|----|----|----|----|
| 280  | E  | B  | E  | H  | H  | A  |
| 281  | E  | B  | E  | H  | A  | A  |
| 282  | E  | B  | E  | A  | H  | A  |
| 283  | E  | B  | E  | A  | A  | A  |
| 284  | E  | B  | I  | H  | H  | A  |
| 285  | E  | B  | I  | H  | A  | A  |
| 286  | E  | B  | I  | A  | H  | A  |
| 287  | E  | B  | I  | A  | H  | H  |

| Cpd. | R₁ | R₂ | R₃ | R₄ | R₅ |
|------|----|----|----|----|----|
| 295  | E  | B  | I  | A  | H  |
| 296  | E  | B  | I  | A  | A  |
| 297  | E  | B  | I' | A  | A  |
| 298  | E' | B  | I  | A  | A  |
| 299  | I  | B  | E  | A  | H  |
| 300  | I  | B  | E  | A  | A  |

| Cpd. | R₁ | R₂ | R₃ | R₄ | R₅ |
|------|----|----|----|----|----|
| 301  | I  | B  | I  | H  | H  |
| 302  | I  | B  | I  | H  | A  |
| 303  | I  | B  | I  | A  | H  |
| 304  | I  | B  | I  | A  | A  |
| 305  | I  | B  | I' | A  | A  |

![Figure 62. Structures of compounds 295–305.](image)
Figure 63. Structures of compounds 306–316.

| Cpd. | R₁  | R₂  | R₃  | R₄  | R₅  |
|------|-----|-----|-----|-----|-----|
| 306  | E   | B   | N   | A   | H   |
| 307  | E   | B   | N   | A   | A   |
| 308  | E   | B   | P   | A   | H   |
| 309  | E   | B   | P   | A   | E   |
| 310  | E   | B   | P   | A   | I   |
| 311  | I   | B   | N   | A   | H   |
| 312  | I   | B   | P   | H   | I   |
| 313  | I   | B   | P   | A   | H   |
| 314  | I   | B   | P   | A   | A   |
| 315  | I   | B   | P   | A   | E   |
| 316  | I   | B   | P   | A   | I   |

Figure 64. Structures of compounds 317–320.

| Cpd. | R₁  | R₂  | R₃  |
|------|-----|-----|-----|
| 317  | F   | H   | H   |
| 318  | F'  | H   | H   |
| 319  | J   | H   | H   |
| 320  | J'  | H   | H   |

Figure 65. Structures of compounds 321–322.

| Cpd. | R₁  | R₂  | R₃  | R₄  | R₅  |
|------|-----|-----|-----|-----|-----|
| 321  | E   | B   | A   | H   | A   |
| 322  | E   | B   | A   | A   | A   |
Figure 66. Structures of compounds 323–324.

| Cpd. | R₁ | R₂ | R₃ | R₄ | R₅ |
|------|----|----|----|----|----|
| 323  | E  | B  | A  | H  | A  |
| 324  | E  | B  | A  | A  | A  |

Figure 67. Structures of compounds 325–328.

| Cpd. | R₁ | R₂ | R₃ | R₄ |
|------|----|----|----|----|
| 325  | J  | H  | H  | H  |
| 326  | J  | A  | H  | H  |
| 327  | J' | A  | H  | H  |
| 328  | F  | H  | H  | H  |

Figure 68. Structure of compound 329.
Cpd. | R₁ | R₂ | R₃
---|---|---|---
330 | M | H | H

Figure 69. Structure of compound 330.

Cpd. | R₁ | R₂
---|---|---
331 | F | H
332 | F' | H

Figure 70. Structures of compounds 331–332.

Cpd. | R₁ | R₂ | R₃ | R₄ | R₅
---|---|---|---|---|---
333 | E | B | A | A | A

Figure 71. Structure of compound 333.
3. Biological Activities

To date, approximately 334 CASEDs have been isolated from various medicinal plants and their structures characterized. However, the biological activities, mechanism of action and structure-activity-relationships (SAR) of many CASEDs have rarely been explored up to now. Hence, an overview of the pharmacological activities of the CASED may serve as valuable indication to further probe into their full therapeutic potentials.

3.1. Anti-Depression Activity and Neuroprotective Activity

Depression, one of the major mental disorders, is accompanied by symptoms such as emotional slump, reduced physical activities, feelings of helplessness and pessimism and even suicide attempts. At present there are three main points of view regarding the pathogenesis of depression, including the biogenic amine theory, the nerve nutrition theory and the cytokines theory.

Sibiricose A5 (28), tenuifoliside A (51), 3’/β-disinapoylsucrose (DISS, 73), tenuifoliside B (52), buergerisides A₁ (13), B₁ (12), B₂ (15) and C₁ (11), tenuifolioses A (285) and B (288) show obvious antidepressant activity [10,12,13,18]. Sibiricose A5 (28) and tenuifoliside A (51), extracted from Chinese herbal medicine *Polygala tenuifolia* Willd, were found to dramatically protect PC12 cells damaged by glutamate [9]. Tenuifolioses A (285) and B (288) showed neuroprotective activity against glutamate and serum deficiency at a concentration of 1 × 10⁻⁵ mol·L⁻¹ [12]. Liu et al. [1] discovered that DISS and tenuifoliside A (TEA, 51), isolated from *Radix Polygalae*, showed protective effects on SH-SY5Y against Cort-induced injury. A study by Ikeya et al. [112] showed that tenuifoliside B (52) improved the scopolamine-induced impairment of passive avoidance response by promoting the cholinergic system. Buergerisides A₁ (13), B₁ (12), B₂ (15) and C₁ (11) from the roots of *Scrophularia buergeriana* exhibit protective activity on primary cultures of rat cortical cells after exposure to excitotoxin, glutamate according to an investigation by Kim et al. [18].

Further findings demonstrate that a possible mechanism of the antidepressant action of DISS maybe be related with hippocampal neuroplasticity and neuroproliferation. DISS possesses potent and rapid antidepressant activity, which are mediated via brain MAO-A and MAO-B activity and upregulated serum cortisol levels induced by CMS [113]. In neuronal cells, DISS-mediated regulation of BDNF gene expression is associated with CREB-mediated transcription of BDNF upstream activation of ERK1/2 and CaMKII to cause neuroprotective and antidepressant effects [114]. Dong et al. [8] discovered that the neurotrophic mechanism of TEA (b24) in C6 cells correlates with TrkB/BDNF/ERK and TrkB/BDNF/PI3K.
3.2. Anticancer Activity

Belonging to the family of serine/threonine protein kinases that are activated by Ca\(^{2+}\), Protein Kinase C (PKC) is involved in signal transduction, and cellular proliferation and differentiation. It also plays an important role in cell cycle control, tumor genesis, antitumor drug resistance and apoptosis. PKC has been proved to be related with the activation of HIV-1 gene expression, tumor promotion, and the inhibition of apoptosis in leukemia cells. Therefore, it makes a lot of sense to find chemical compounds from natural plants to inhibit the activity of PKC [50,54].

Takasaki et al. found that vanicoside A (102) and vanicoside B (67) from Polygonum pensylvanirum inhibited PKC activity with IC\(_{50}\) values of 44 µg/mL and 31 µg/mL, respectively [54]. After this preliminary work, LaVerne et al. [50] continued the isolation work on this plant in order to obtain possible homologues via HPLC-MS and isolated vanicosides C-F (104, 57, 113, 91). Regrettably, LaVeme did not do much research on the pharmacological activity of the vanicosides. Notably, acteoside (=verbascoside, 131) from Lantana camara also shows PKC inhibitory activity in the rat brain with an IC\(_{50}\) of 25 µM [29]. With the widest distribution in the plant kingdom, acteoside has been widely applied to treat diseases such as cancer, inflammation, or immune disorders.

In the virus family, the Epstein-Barr virus (EBV) is a type of herpes virus causing cancer. EBV has been considered one of the causes of many kinds of malignant tumors such as nasopharyngeal carcinoma. EBV infection mainly occurs human oropharyngeal epithelial cells and B lymphocytes. Lapathoside A (63), lapathoside D (31), vanicoside B (67) and hydropiperoside (37) exhibit remarkable inhibitory effects on the EBV, which is early antigen induced by tumor-promoters, so it makes sense to focus on these four compounds as worthy anti-tumor-promoters for cancer chemoprevention [2,39].

Meanwhile, Takasaki et al. [39] reported that lapathoside A (63) and vanicoside B (67) inhibited two-stage carcinogenesis induced by 12-O-tetradecanoylphorbol-13-acetate (TPA). Moreover, vanicoside B exhibits remarkable inhibitory effects, which are initiated with a NO (nitric oxide) donor and NOR-1(±)-(E)-methyl-2-[((E)-hydroxyimino]-5-nitro-6-methoxy-3-hexenamide).

Smilaside D (40), smilaside E (47) and smilaside F (99) displayed cytotoxicity against human colon tumor (DLD-1) cells (ED\(_{50}\) = 2.7, 4.5, 5.0 µg/mL), and smilaside A (79) showed weak cytotoxicity against DLD-1 cells (ED\(_{50}\) = 11.6 µg/mL). Furthermore, smilaside A (79), smilaside B (107), smilaside D, smilaside E and smilaside F displayed weak cytotoxicity (ED\(_{50}\) = 5.1–13.0 µg/mL) on three to six human tumor cell lines, consisting of human cervical carcinoma (Hela), human oral epithelium carcinoma (KB), DLD-1, human medulloblastoma (Med) cells, human lung carcinoma (A-549) and human breast adenocarcinoma (MCF-7) [14].

3.3. Antioxidant Activity

 Plenty of CASEDs were found to possess antioxidant activities, mainly related to their substituted acid groups. The antioxidant properties of these compounds were tested by 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assays. Probably thanks to the presence of the 3,4-dihydroxy (catechol) moiety in the structure, compound 2 showed significant antioxidant activities, compared to caffeic acid [21]. Compound 21 from Globularia orientalis also exhibited antioxidant potential, indicating that it could efficiently scavenge free radicals [32].

Zhang et al. [15] found that smilasides G-L (38, 106, 46, 41, 105, 42) showed moderate scavenging activities against DPPH radicals and the causes J-L (41, 105, 42) exhibited stronger antioxidant activity, which was quite similar to that in positive control ((±)-α-tocopherol). These results support the idea that the substituted feruloyl group plays a key role in the antioxidant activity of phenylpropanoid sugar esters. Heterosmilasides (95), helonioside B (45) and compound 98 showed strong antioxidant DPPH radical scavenging activity with IC\(_{50}\) values of 12.7, 9.1 and 8.7 µg/mL, respectively [46]. Compounds 28, 32 and 44 exhibited higher activity on scavenging the DPPH radical, compared to L-cysteine at the concentration of 0.02 mM, and the antioxidant activity of compound 32 was almost as same as that of α-tocopherol [36]. Compound 62 and verbascoside showed antioxidant potential pointing out their ability to efficiently scavenge free radicals. 6-O-Sinapoyl sucrose (75) showed weak activity in the DPPH test, but in the superoxide scavenging test, its antioxidative
activity increased slightly, hence, a sucrose moiety esterified by sinapic acid seems to regulate the antioxidative activity [115]. Lapathoside D (31) showed DPPH radical scavenging activity with an IC\textsubscript{50} of 0.088 mM [3]. Kiem et al. [53] found that vanicoside A (102), hydroperoside B (103) and vanicoside E (113) exhibited significant DPPH radical scavenging properties, with IC\textsubscript{50} values of 23.4, 26.7 and 49.0 µg/mL, respectively. However, compounds 66, 67 and 113 were inactive, probably due to the non-existence of acetyl groups in their molecules compared with 102, 103 and 113. Wang et al. discovered that diboside A (58) and lapathoside A (63) only showed low activities in the DPPH test [51].

Ehrenoside (183), verpectoside A (185), B (193) and C (194) were isolated from the aerial parts of Veronica pectinata var. glandulosa. They revealed potent radical scavenging activity against DPPH radical. Ehrenoside and verpectoside B were more active than 3-tert-butyl-4-hydroxyanisole (BHA) and had comparable activity to all DL-α-tocopherol [104]. Hamerski et al. reported that the antioxidant activity of compound 2 (IC\textsubscript{50} values 15.0 µM) was comparable to that of the positive control caffeic acid, while compound 253 possessed only weak activity [21].

In the study of Wang et al. [116], compound 59 possessed modest activity, with an IC\textsubscript{50} of 20.1 µM in the DPPH radical scavenging test and in the metmyoglobin assay it had antioxidative activity comparable with Trolox (3.70 Trolox equivalents). Quiquesetinerviusides A-E (86, 87, 115, 85 and 114) exhibited low DPPH scavenging activity, but considerable OH radical scavenging activity (IC\textsubscript{50} 8.4 ± 1.1, 6.8 ± 1.0, 7.4 ± 1.0, 5.5 ± 0.9, 3.6 ± 0.8 µM, respectively) [4]. Hosoya et al. [89] used ESR to evaluate the effect on superoxide anion radicals (O\textsuperscript{2−}) of compounds 154, 150, 155, 153 and they exhibited IC\textsubscript{50} values of 28.5, 84.5, 8.4, 17.1 µM, respectively, using ascorbic acid (IC\textsubscript{50} value 140 µM) as a positive control.

### 3.4. Antiinflammatory Activity

Antiinflammatory activity refers to the removal of inflammation or swelling. Acteoside (131), angoroside A (196) and angoroside C (200) revealed a considerable effect in the TXB2-release assay. Angoroside A (196), angoroside D (199), acteoside (131) and isacteoside (128) significantly inhibited LPS-induced PGE\textsubscript{2}, NO and TNF-α in a concentration-dependent manner. In LPS-stimulated macrophages, angoroside C (200) only had activity on NO [63,70]. Acteoside (131) had strong in vitro and in vivo anti-inflammatory effects, whilst isacteoside (128) was found to have modest activity. Pretreatment with 1–50 µM CASED (compounds 131, 157, 220) concentration-dependently diminished phorbol-12-myristate-13-acetate (PMA) and N-formyl-methionyl-leucyl-phenylalanine (fMLP)-induced reactive oxygen species (ROS) production with IC\textsubscript{50} values of approximately 6.8–23.9 and 3.0–8.8 µM, respectively [117]. The anti-inflammatory activities of quiquesetinerviusides D (85) and E (114) were evaluated in RAW 264.7 cells. Both of them exhibited strong activities against LPS-stimulated NO production. And the outcome showed inhibition of quiquesetinerviuside D and E (IC\textsubscript{50} 9.5, 9.2 µM) compared with a positive control, quercetin (IC\textsubscript{50} 34.5 µM). In vitro cyclooxygenase (COX) catalyzed prostaglandin biosynthesis inhibition assay, compounds 131,205, 218 and these compounds exhibited stronger inhibitory potencies on Cox-2 than Cox-1 (131,205, 218 IC\textsubscript{50} on Cox-2 at 0.69, 0.49 and 0.61 mM, respectively).

### 3.5. Antiviral Activity

Niruriside (109) has particular inhibitory activity with an IC\textsubscript{50} value of 3.3 µM, against the binding of regulation of virion expression (REV) protein to responsive element (RRE) RNA [60]. Kernan et al. [69] reported that verbacteoside (131), isoverbascoside (128), luteoside A (188) and luteoside B (189) exhibited antiviral activity (EC\textsubscript{50}) in an in vitro assay against respiratory syncytial virus (RSV), which was resembled or better than that of ribavirin, a drug used to cure RSV contamination in humans. Furthermore, these compounds also showed better activity against RSV than ribavirin. Verbascoside (131) exhibited antiviral activity against vesicular stomatitis virus (VSV), but was inactive against herpes simplex type I (HSV-1). The non-toxic confining cellular viability concentration for the activity was 53.6% at 500 µg/mL [118].
3.6. Other Activities

Compounds 138, 131, 159, 158 isolated from Paulownia tomentosa stems were tested for in vitro cytotoxicity against Streptococcus pyogenes (A308 and A77), Staphylococcus aureus (SG511, 285 and 503), Streptococcus faecium MD8b, etc. All the compounds exhibited remarkable antibacterial activity. Compound 159 showed a minimal inhibitory concentration (MIC) value of 150 µg/mL against Staphylococcus and Streptococcus species [76]. A mixture of poliumoside (216) and lamalboside (227) revealed moderate antibacterial activity. Compounds 130, 205 and 218 also possess antimicrobial activity [119]. Vanicoside A (102) and B (67) showed β-glucosidase inhibitory activity, with IC₅₀ values of 59.8 and 48.3 µg/mL (59.9 and 50.5 µM), respectively [120]. The activity of forsythoside B (205) and alyssonoside (206) against free radical-induced impairment of endothelium-dependent relaxation in isolated rat aorta was investigated. Both provided partial protection at 10⁻⁴ M concentration against the electrolysis-induced inhibition acetylcholine response [121]. Senegin II (319) was tested for hypoglycemic activity in normal and KK-Ay mice. Under similar conditions, senegin II not only reduced the level of blood glucose in normal mice 4 h after intraperitoneal administration, but also significantly lowered the blood glucose level of KK-Ay mice [122]. Tenuifolioses B (288), and C (284) potentiated basal synaptic transmission in the dentate gyrus of anesthetized rats [12]. The only septsaccharide ester, polygalasaponin XXXII (334), could improve hippocampus-dependent learning and memory. The result suggests that it may be through the enhancement of synaptic transmission, activation of the MAP kinase cascade and improvement of BDNF level [56].

The rhizome extracts of Smilax glabra Rox B., which is called tufuling in Traditional Chinese Medicine, show many kinds of pharmacological activities like hypoglycaemic, immuno- modulatory, free-radical scavenging and antioxidant enzyme fortifying activities. Compounds 32, 90, 100, 101, 108, 111, 112 were purified from the S. glabra which should impulse scientists to perform more research on these compounds [40].

4. Conclusions

Because of the wide range of distribution, diverse structures and significant pharmacological activities of the CASEDs, more natural product researchers are paying great attention to these compounds. However, most studies on the CASED since 1977 are still isolated and report simple pharmacological activities. More in-depth research on the pharmacological mechanisms of action should be performed. Full exploitation on the broad array of biological activities of CASEDs awaits more researchers to devote themselves to this field.

Acknowledgments: The authors gratefully acknowledge the financial support of the National Natural Science Foundation of China grant No. 81573692), National Natural Science Foundation of China grant No. 8157140862), the Beijing Nova Program (grant No. 2011070), the Self-selected Topic of Beijing University of Chinese Medicine (grant No. 2015-JYB-JSMS024), the Beijing Nova Program (No. Z121102002512045).

Author Contributions: Y.T. and W.L. drafted and revised the manuscript; Y.L., Y.W., Y.Z., X.C., S.B., T.H., F.L., Y.S. and Y.G. made suggestions and played an important role in preparing this paper, and G.S approved the final version.

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

References

1. Liu, P.; Hu, Y.; Guo, D.H.; Wang, D.X.; Tu, H.H.; Ma, L.; Xie, T.T.; Kong, L.Y. Potential antidepressant properties of Radix polygalae (Yuan Zhi). Phytomedicine 2010, 17, 794–799. [CrossRef] [PubMed]
2. Takasaki, M.; Konoshima, T.; Kuroki, S.; Tokuda, H.; Nishino, H. Cancer chemopreventive activity of phenylpropanoid esters of sucrose, vanicoside B and lapathoside A, from Polygonum lapathifolium. Cancer Lett. 2001, 173, 133–138. [CrossRef]
3. Fan, P.; Terrier, L.; Hay, A.E.; Marston, A.; Hostettmann, K. Antioxidant and enzyme inhibition activities and chemical profiles of Polygonum sachalinensis F. Schmidt ex Maxim (Polygonaceae). Fitoterapia 2010, 81, 124–131. [CrossRef] [PubMed]
24. She, G.M.; Wang, D.; Zeng, S.F.; Yang, C.R.; Zhang, Y.J. New Phenylethanoid Glycosides and Sugar Esters
20. Shimomura, H.; Sashida, Y.; Adachi, T. Phenylpropanoidglucose esters from
19. Sasaki, H.; Nishimura, H.; Mitsuhashi, H. Hydroxycinnamic acid esters of phenethylalcohol glycosides from
17. Chen, B.; Wang, N.L.; Huang, J.H.; Yao, X. Iridoid and phenylpropanoid glycosides from
10. Ikeya, Y.; Sugama, K.; Okada, M.; Mitsuhashi, H. Four new phenolic glycosides from
4. Chang, C.L.; Zhang, L.J.; Chen, R.Y.; Kuo, L.M.Y.; Huang, J.P.; Huang, H.C.; Lee, K.H.; Wu, Y.C.;
25. Nicoletti, M.; Galeffi, C.; Messana, I.; Marini-Bettolo, G.B.; Garbarino, J.A.; Gambaro, V. Phenylpropanoid
23. Xia, P.F.; Feng, Z.M.; Yang, Y.N.; Zhang, P.C. Two flavonoid glycosides and a phenylpropanoid glucose ester
18. Kim, S.R.; Kim, Y.C. Neuroprotective phenylpropanoid esters of rhamnose isolated from roots of
16. Nguyen, A.T.; Fontaine, J.; Malonne, H.; Claey, S.; Claey, M.; Luhmer, M.; Duez, P. A sugar ester and an iridoid
15. Zhang, L.; Liao, C.C.; Huang, H.C.; Shen, Y.C.; Yang, L.M.; Kuo, Y.H. Antioxidant phenylpropanoid
14. Kuo, Y.H.; Hsu, Y.W.; Liaw, C.C.; Lee, J.K.; Huang, H.; Kuo, L.M.Y. Cytotoxic Phenylpropanoid Glycosides
13. Miyase, T.; Noguchi, H.; Chen, X.M. Sucrose esters and xanthone C-glycosides from the roots of
12. Miyase, T.; Iwata, Y.; Ueno, A. Tenuifolioses A-F, Oligosaccharide Multi-Esters from the Roots of
11. Miyase, T.; Iwata, Y.; Ueno, A. Tenuifolioses G-P, Oligosaccharide Multi-Esters from the Roots of
9. Tu, H.H.; Liu, P.; Ma, L.; Liao, H.B.; Xie, T.T.; Mu, L.H.; Liu, Y.M. Study on antidepressant components of
8. Dong, X.Z.; Huang, C.L.; Yu, B.Y.; Hu, Y.; Mu, L.H.; Liu, P. Effect of Tenuifoliside A isolated from Polygala
7. Hu, Y.; Liao, H.B.; Guo, D.H.; Liu, P.; Rahman, K. Antidepressant-like effects of 3, 6′-disinapoyl
6. Birkhofer, L.; Kaiser, C.; Thomas, U. Sugar esters. IV. Acteose and neacteose sugar esters from
5. Kernan, M.R.; Amarquaye, A.; Chen, J.L.; Chan, J.; Sesin, D.F.; Parkinson, N.; Ye, Z.J.; Barrett, M.; Bales, C.;
98x137] 
98x124] 
98x98] 
98x124] 
98x137] 
98x124] 
98x86] 
98x137] 
98x779] 
98x779] 
98x779] 
98x779]
27. Hiroshi, W.; Yasufumi, S.; Nobutoshi, T.; Cambie, R.C.; Braggins, J.E. Chemical and chemotaxonomical studies of ferns. LXXXVII. Constituents of Trichomanes reniforme. Chem. Pharm. Bull. 1995, 43, 461–465.
28. Taoubi, K.; Fauvel, M.T.; Gleye, J.; Moulis, C.; Fouraste, I. Phenylpropanoid glycosides from Lantana camara and Lippia multiflora. Planta Med. 1997, 63, 192–193. [CrossRef] [PubMed]
29. Abdallah, O.M.; Kamel, M.S.; Mohamed, M.H. Phenylpropanoid glycosides of Prunus sici. Phytochemistry 1994, 37, 1689–1692. [CrossRef]
30. Lou, H.; Li, X.; Zhu, T.; Li, W. Sinapic acid esters and a phenolic glycoside from Cynanchum hanceckianum. Phytochemistry 1993, 32, 1283–1286. [CrossRef]
31. Hussein, S.A.M.; Ayoub, N.A.; Nawwar, M.A.M. Caffeoyl sugar esters and an ellagitannin from Rubus sanctus. Phytochemistry 2003, 63, 905–911. [CrossRef]
32. Calisa, I.; Kirmizibekmez, H.; Tasdemira, D.; Sticherb, O.; Irelandc, C.M. Sugar esters from Globularia orientalis. Z. Naturforsch. 2002, 57c, 591–596.
33. Kim, I.H.; Kaneko, N.; Uchiyama, N.; Lee, J.E.; Takeya, K.; Kawahara, N.; Goda, Y. Two phenylpropanoid glycosides from Neopicrorhiza scrofulariiflora. Chem. Pharm. Bull. 2006, 54, 275–277. [CrossRef] [PubMed]
34. Fukuyama, Y.; Sato, T.; Miura, I.; Asakawa, Y.; Takemoto, T. Hydropiperoside, a novel coumaryl glycoside from the root of Polygala arillata. J. Nat. Prod. 2000, 63, 1071. [CrossRef]
35. Wang, P.; Li, S.; Ownby, S.; Zhang, Z.; Yuan, W.; Zhang, W.; Scott Beasley, R. Ecdysteroids and a sucrose phenylpropanoid ester from Froelichia floridana. Phytochemistry 1985, 24, 1793–1797. [CrossRef]
36. Sun, X.; Zimmermann, M.L.; Campagne, J.M.; Sneden, A.T. New sucrose phenylpropanoid esters from Polygonum lapathifolium. Phytochemistry 1998, 47, 45–52. [CrossRef]
37. Liu, J.; Jiang, Y.; Tu, P.F. Tricornoses A-L, Oligosaccharide Multi-esters from the Roots of Polygala chamaebuxus. J. Nat. Prod. 2005, 68, 739–744. [CrossRef] [PubMed]
38. Wang, Y.; Gao, W.Y.; Zhang, T.J.; Guo, Y.Q. A novel phenylpropanoid glycosides and a new derivation of phenolic glycoside from Paris Polyphylla var. yunnanensis. Chin. Chem. Lett. 2007, 18, 548–550. [CrossRef]
39. Hamburger, M.; Hostettmann, K. Hydroxycinnamic acid esters from Polygala glomerata. Phytochemistry 1978, 17, 825–829. [CrossRef] [PubMed]
40. Saitoh, H.; Miyase, T.; Ueno, A. Reinioses A-J, oligosaccharide multi-esters from the roots of Polygala reinii. Helv. Chim. Acta 2000, 83, 1373–1377. [CrossRef] [PubMed]
41. Chang, H.T.; Tu, P.F. New Oligosaccharide Esters and Xanthone C-Glucosides from Polygala telephioides. Helv. Chim. Acta 2007, 90, 944–950. [CrossRef]
42. Sun, X.; Zimmermann, M.L.; Campagne, J.M.; Sneden, A.T. New sucrose phenylpropanoid esters from Polygonum perfoliatum. J. Nat. Prod. 2000, 63, 1094–1097. [CrossRef] [PubMed]
43. Li, J.; Jiang, Y.; Tu, P.F. Tricornoses A-L, Oligosaccharide Multi-esters from the Roots of Polygala lapathifolium and their antioxidant activity. Arch. Pharm. Res. 2009, 32, 1373–1377. [CrossRef] [PubMed]
44. Saitoh, H.; Miyase, T.; Ueno, A. Reinioses A-J, Oligosaccharide Multi-esters from the Roots of Polygala reinii. Fr. et Sav. Chem. Pharm. Bull. 1994, 42, 1879–1885. [CrossRef] [PubMed]
45. Chang, H.T.; Tu, P.F. New Oligosaccharide Esters and Xanthone C-Glucosides from Polygala telephioides. Helv. Chim. Acta 2007, 90, 944–950. [CrossRef]
46. Lepore, L.; Malafronte, N.; Cordero, F.B.; Gualtieri, M.J.; Abdó, S.; Piaz, F.D.; De Tommasi, N. Isolation and structural characterization of glycosides from an anti-angiogenic extract of Monnina obtusifolia H.B.K. Fitoterapia 2011, 82, 178–183. [CrossRef] [PubMed]
47. Brown, L.V.L.; Larson, S.R.; Sneden, A.T. Vanicosides C-F, new phenylpropanoid glycosides from Polygonum pensylvanicum. J. Nat. Prod. 1998, 61, 762–766. [CrossRef] [PubMed]
48. Wang, K.J.; Zhang, Y.J.; Yang, C.R. Antioxidant phenolic constituents from Fagopyrum dibotrys. J. Ethnopharmacol. 2005, 99, 259–264. [CrossRef] [PubMed]
49. Kobayashi, W.; Miyase, T.; Suzuki, S.; Noguchi, H.; Chen, X.M. Oligosaccharide Esters from the Roots of Polygala arillata. J. Nat. Prod. 2000, 63, 1066–1069. [CrossRef] [PubMed]
52. Van Kiem, P.; Nhiem, N.X.; Cuong, N.X.; Hoa, T.Q.; Huong, H.T.; van Minh, C.; Kim, Y.H. New phenylpropanoid esters of sucrose from *Polygonum hydropiper* and their antioxidant activity. *Arch. Pharm. Res.* 2008, 31, 1477–1482. [CrossRef] [PubMed]

53. Zimmermann, M.L.; Sneden, A.T. Vanicosides A and B, protein kinase C inhibitors from *Polygonum pensylvanicum*. *J. Nat. Prod.* 1994, 57, 236–242. [CrossRef] [PubMed]

54. Shimomura, H.; Sashida, Y.; Mimaki, Y. Bitter phenylpropanoid glycosides from *Lilium longiflorum*. *Phytochemistry* 1987, 26, 2965–2968. [CrossRef]

55. Shoyama, Y.; Hatano, K.; Nishioka, I.; Yamagishi, T. Phenolic glycosides from *Lilium speciosum* var. *rubrum*. *Chem. Pharm. Bull.* 1993, 41, 415–417. [PubMed]

56. Zhang, D.; Miyase, T.; Kuroyanagi, M.; Umehara, K.; Ueno, A. Five new triterpene saponins, polygalasaponins XXVIII-XXXII from the root of *Polygala japonica* Houtt. *Chem. Pharm. Bull.* 1996, 44, 810–815. [CrossRef] [PubMed]

57. Bashir, A.; Hamburger, M.; Msonthi, J.D.; Hostettmann, K. Sinapoic acid esters from *Scrophularia scorodonia*. *Phytochemistry* 1997, 42, 741–745. [CrossRef]

58. Yoshinari, K.; Sashida, Y.; Mimaki, Y.; Shimomura, H. New polyacylated sucrose derivatives from the bark of *Prunus padus*. *Chem. Pharm. Bull.* 1990, 38, 415–417. [CrossRef]

59. Bashir, A.; Hamburger, M.; Msonthi, J.D.; Hostettmann, K. Sinapoic acid esters from *Polygala virgata*. *Phytochemistry* 1993, 32, 741–745. [CrossRef]

60. Qian-Cutrone, J.; Huang, S.; Trimble, J.; Li, H.; Lin, P.F.; Alam, M.; Klohr, S.E.; Kadow, K.F. Niruriside, a new HIV REV/RRE binding inhibitor from *Phyllanthus niruri*. *J. Nat. Prod.* 1993, 56, 134–137. [CrossRef] [PubMed]

61. Yan, L.; Gao, W.; Zhang, Y.; Wang, Y. A new phenylpropanoid glycosides from *Paris polyphylla* var. *yunanensis*. *Fitoterapia* 2008, 79, 306–307. [CrossRef] [PubMed]

62. Kobayashi, H.; Karasawa, H.; Miyase, T.; Fukushima, S. Studies on the constituents of *Cistanchis Herba*. IV. Isolation and structures of two new phenylpropanoid glycosides, cistanosides C and D. *Chem. Pharm. Bull.* 1996, 44, 1245–1248. [CrossRef]

63. Miyase, T.; Mimatsu, A. Acylated Iridoid and Phenylethanoid Glycosides from the Aerial Parts of *Scrophularia nodosa*. *J. Nat. Prod.* 1999, 62, 1079–1084. [CrossRef] [PubMed]

64. Takashi, H.; Yoshiyasu, F.; Toshiihide, Y.; Kazuyuki, N. Structures of magnolosides B and C, novel phenylpropanoid glycosides with allopentose as core the sugar unit. *Chem. Pharm. Bull.* 1988, 36, 1245–1248. [CrossRef]

65. Benkrief, R.; Ranarivelo, Y.; Skalsibounis, A.L.; Tillequin, F.; Koch, M.; Pusset, J.; Sévenet, T. Monoterpene alkaloids, iridoids and phenylpropanoid glycosides from *Osmanthus austrocaledonica*. *Phytochemistry* 1998, 47, 825–832. [CrossRef]

66. Su, B.N.; Ma, L.P.; Jia, Z.J. Iridoid and Phenylpropanoid Glycosides from *Pedicularis artselaeri*. *J. Planta Med.* 1998, 64, 720–723. [CrossRef] [PubMed]

67. Liu, Z.M.; Jia, Z.G. Phenylpropanoid and iridoid glycosides from *Pedicularis striata*. *Phytochemistry* 1991, 30, 1341–1344. [PubMed]

68. Kanchanapoom, T.; Kasai, R.; Yamasaki, K. Phenolic glycosides from *Markhamia stipulata*. *Phytochemistry* 2002, 59, 557–563. [CrossRef]

69. Kanchanapoom, T.; Kasai, R.; Yamasaki, K. Lignan and phenylpropanoid glycosides from *Fernosoa adenophylla*. *Phytochemistry* 2001, 57, 1245–1248. [CrossRef]

70. De Santos Galindez, J.; Diaz-Lanza, A.M.; Fernández Matellano, L.; Rumbero Sánchez, A. A new phenylpropanoid glycoside isolated from *Scrophularia scorodonia* L. *Magn. Reson. Chem.* 2000, 38, 688–691. [CrossRef]

71. Skrzypek, Z.; Wysokinska, H.; Swiątek, L.; Wróblewski, A.E. Phenylpropanoid Glycids from *Penstemon serrulatus*. *J. Nat. Prod.* 1999, 62, 127–129. [CrossRef] [PubMed]

72. Ho, J.C.; Chen, C.M.; Li, Z.Q.; Row, L.C. Phenylpropanoid glycosides from the parasitic plant, *Aeginetia indica*. *J. Chin. Chem. Soc.* 2004, 51, 1073–1076. [CrossRef]

73. Jia, Z.J.; Liu, Z.M.; Wang, C.Z. Phenylpropanoid and iridoid glycosides from *Pedicularis lasiophrys*. *Phytochemistry* 1992, 31, 263–266. [PubMed]

74. Nonaka, G.; Nishioha, I. Bitter phenylpropanoid glycosides from *Conandron ramoidioides*. *Phytochemistry* 1977, 16, 1265–1267. [CrossRef]
99. Boros, C.A.; Marshall, D.R.; Caterino, C.R.; Stermitz, F.R. Iridoid and phenylpropanoid glycosides from Orthocarpus spp. Alkaloid content as a consequence of parasitism on Lupinus. J. Nat. Prod. 1991, 54, 506–513. [CrossRef]

100. Budzianowski, J.; Skrzypczak, L. Phenylpropanoid esters from Lamium album flowers. Phytochemistry 1995, 38, 997–1001. [CrossRef]

101. Gross, G.A.; Lahloub, M.F.; Anklin, C.; Schulten, H.R.; Sticher, O. Teucr不到位o, a phenylpropanoid glycoside from Teucrium chamaedrys. Phytochemistry 1988, 27, 1459–1463. [CrossRef]

102. Çalış, İ.; Başaran, A.A.; Saracoğlu, İ.; Sticher, O. Phlomisides D and E, phenylpropanoid glycosides, and iridoids from Phlomis linearis. Phytochemistry 1991, 30, 3073–3075. [CrossRef]

103. Yang, H.; Hou, A.J.; Mei, S.X.; Peng, L.Y.; Sun, H.D. A new phenylpropanoid glycoside: Serratumoside A from Clerodendrum serratum. Chin. Chem. Lett. 2000, 11, 323–326.

104. Jiménez, C.; Villaverde, M.C.; Riguera, R.; Castedo, L.; Stermitz, F. Phenylpropanoid glycosides from Bermejo, P.; Abad, M.J.; Díaz, A.M.; Fernández, L.; De Santos, J.; Sanchez, S.; Villaescusa, L.; Carrasco, L.; Wang, M.; Shao, Y.; Li, J.; Zhu, N.; Rangarajan, M.; LaVoie, E.J.; Ho, C.T. Antioxidative phenolic glycosides from Clausena latifolia var. latifolia. Chem. Pharm. Bull. 2004, 52, 408–410. [CrossRef]

105. Ikeya, Y.; Takeda, S.; Tunakawa, M.; Karakida, H.; Tada, K.; Yamaguchi, T.; Aburada, M. Cognitive Improving Effect of 3,6′-disinapoyl sucrose from Polygala japonica Willd. J. Pharm. Pharmacol. 2011, 63, 869–874. [CrossRef]

106. Çalis, İ.; Kırmızıbekmez, H. Glycosides from Phlomis lunariifolia. Phytochemistry 2006, 65, 2619–2625. [CrossRef]

107. Saitoh, H.; Miyase, T.; Ueno, A. Senegoses J-O, Oligosaccharide Multi-Esters from the Roots of Polygala senega var. latifolia Torr. Et Gray. Chem. Pharm. Bull. 1993, 41, 2125–2128. [CrossRef] [PubMed]

108. Çalis, İ.; Başaran, A.A.; Saracoğlu, İ.; Sticher, O. Phlomisides A–E, phenylpropanoid glycosides, and iridoids from Phlomis linearis. Phytochemistry 1991, 30, 3073–3075. [CrossRef] [PubMed]

109. Yoshikawa, M.; Murakami, T.; Ueno, T.; Kadoya, M.; Matsuda, H.; Yamahara, J.; Murakami, N. Bioactive sterols and triterpenoids from the roots of Phlomis japonica. J. Mol. Neurosci. 2004, 21, 2115–2122. [CrossRef] [PubMed]

110. Yoshikawa, M.; Murakami, T.; Ueno, T.; Kadoya, M.; Matsuda, H.; Yamahara, J.; Murakami, N. Bioactive sterols and triterpenoids from the roots of Phlomis japonica. J. Mol. Neurosci. 2004, 21, 2115–2122. [CrossRef] [PubMed]

111. Zhang, D.; Miyase, T.; Kuroyanagi, M.; Umehara, K.; Noguchi, H. Polygalasaponins XLII–XLVI from roots of Polygala japonica. J. Nat. Prod. 2000, 63, 408–410. [CrossRef] [PubMed]

112. Zhang, D.; Miyase, T.; Kuroyanagi, M.; Umehara, K.; Noguchi, H. Polygalasaponins XLII–XLVI from roots of Polygala japonica. J. Nat. Prod. 2000, 63, 408–410. [CrossRef] [PubMed]

113. Hu, Y.; Liu, M.; Liu, P.; Gao, D.H.; Wei, R.B.; Rahman, K. Possible mechanism of the antidepressant effect of 3,6′-disinapoyl sucrose from Polygala tenuifolia. J. Pharm. Pharmacol. 2004, 56, 1081–1085. [CrossRef] [PubMed]

114. Hu, Y.; Liu, M.; Liu, P.; Gao, D.H.; Wei, R.B.; Rahman, K. Possible mechanism of the antidepressant effect of 3,6′-disinapoyl sucrose from Polygala tenuifolia. J. Pharm. Pharmacol. 2004, 56, 1081–1085. [CrossRef] [PubMed]

115. Fabre, N.; Urizzi, P.; Souchard, J.P.; Fréchard, A.; Claparols, C.; Fourasté, I.; Moulis, C. An antioxidant sinapic acid ester isolated from Polygala glomerata L. Planta Med. 1999, 65, 421–424. [CrossRef] [PubMed]

116. Fabre, N.; Urizzi, P.; Souchard, J.P.; Fréchard, A.; Claparols, C.; Fourasté, I.; Moulis, C. An antioxidant sinapic acid ester isolated from Polygala glomerata L. Planta Med. 1999, 65, 421–424. [CrossRef] [PubMed]

117. Lin, L.C.; Wang, Y.W.; Hou, Y.C.; Chang, S.; Liou, K.T.; Chou, Y.C.; Wang, W.Y.; Shen, Y.C. The inhibitory effect of phenylpropanoid glycosides and iridoid glucosides on free radical production and β2 integrin expression in human leucocytes. J. Pharm. Pharmacol. 2006, 58, 129–135. [CrossRef] [PubMed]

118. Bermejo, P.; Abad, M.J.; Díaz, A.M.; Fernández, L.; De Santos, J.; Sanchez, S.; Villaescusa, L.; Carraos, L.; Irurzun, A. Antiviral Activity of Seven Iridoids, Three Saikosaponins and One Phenylpropanoid Glycoside Extracted from Bupleurum rigidum and Scrophularia scorodonia. Planta Med. 2002, 68, 106–110. [CrossRef] [PubMed]

119. Sahpaz, S.; Garbacki, N.; Tits, M.; Bailleul, F. Isolation and pharmacological activity of phenylpropanoid esters from Marrubium vulgare. J. Ethnopharmacol. 2002, 79, 389–392. [CrossRef]
120. Kawai, Y.; Kumagai, H.; Kurihara, H.; Yamazaki, K.; Sawano, R.; Inoue, N. β-Glucosidase inhibitory activities of phenylpropanoid glycosides, vanicoside A and B from Polygonum sachalinense rhizome. *Fitoterapia* 2006, 77, 456–459. [CrossRef] [PubMed]

121. Ismailoğlu, U.B.; Saracoğlu, I.; Harput, U.S.; Sahin-Erdemli, I. Effects of phenylpropanoid and iridoid glycosides on free radical-induced impairment of endothelium-dependent relaxation in rat aortic rings. *J. Ethnopharmacol.* 2002, 79, 193–197. [CrossRef]

122. Kako, M.; Miura, T.; Nishiyama, Y.; Ichimaru, M.; Moriyasu, M.; Kato, A. Hypoglycemic activity of some triterpenoid glycosides. *J. Nat. Prod.* 1997, 60, 604–605. [CrossRef] [PubMed]

**Sample Availability:** Samples of the compounds not available are available from the authors.