REVIEW

Advances in Research on Chemical Constituents and Their Biological Activities of the Genus *Actinidia*

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Abstract

Kiwi, a fruit from plants of the genus *Actinidia*, is one of the famous fruits with thousand years of edible history. In the past twenty years, a great deal of research has been done on the chemical constituents of the *Actinidia* species. A large number of secondary metabolites including triterpenoids, flavonoids, phenols, etc. have been identified from different parts of *Actinidia* plants, which exhibited significant in vitro and in vivo pharmacological activities including anticancer, anti-inflammatory, neuroprotective, anti-oxidative, anti-bacterial, and anti-diabetic activities. In order to fully understand the chemical components and biological activities of *Actinidia* plants, and to improve their further research, development and utilization, this review summarizes the compounds extracted from different parts of *Actinidia* plants since 1959 to 2020, classifies the types of constituents, reports on the pharmacological activities of relative compounds and medicinal potentials.

Keywords *Actinidia* chemical constituents · Isolation · Biological activities

1 Introduction

With the development of natural product research, a huge number of chemical constituents have been identified from natural resources. There is no doubt that the research on the chemical composition of fruits, including trace elements, has greatly improved the application prospects of these fruits. With no exception, it is the same to kiwifruit, one of the most prestigious fruits with a long history of eating [1, 2]. Kiwi belongs to plants of the genus *Actinidia* comprising more than 70 species around the world [3]. Some of these plants are proven to have a wide range of medicinal activities. For example, *A. valvata*, whose root is known as “Mao-Ren-Shen” in traditional Chinese medicine, exhibits antitumor and anti-inflammatory activities and has been used for the treatment of hepatoma, lung carcinoma

and myeloma for a long time [4, 5]. The roots of *A. chinensis* Planch, called “Teng-Li-Gen” usually, were used as a traditional Chinese medicine for the treatment of various cancers, such as esophagus cancer, liver cancer, and gastric cancer [6]. In the past two decades, great research had been accomplished about exploring the chemical composition of *Actinidia* plants. These studies have greatly promoted the understanding of the chemical components and functions of the *Actinidia* plant. According to literature survey, 12 *Actinidia* species including *A. valvata*, *A. chinensis*, *A. arguta*, *A. polygama*, *A. kolomikta*, *A. eriantha*, *A. macrosperma*, *A. deliciosa*, *A. chrysantha*, *A. rufa*, *A. indochinensis*, and *A. valvata* were reported for their natural products. This review systematically summarizes the chemical components and their biological activities from different parts of 12 *Actinidia* species from 1959 to 2020. According to structure types, a total of 325 molecules have been collected including terpenoids, phenols, and other small groups (Fig. 1). Names and isolation information were listed in the tables, while the biological activities of the extracts or compounds were discussed in the text.

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Fig. 1 Constituents proportion of 12 *Actinidia* plants

2 Chemical Constituents

2.1 Terpenoids

In recent years, a large number of terpenoids were isolated from many *Actinidia* species. Among them, triterpenes account for the vast majority that are mainly composed by several normal frameworks including ursane-type, oleanane-type, and lupane-type. Of the total 325 compounds in this review, 104 are triterpenoids. From the literature review, ursolic acids and their saponins are undoubtedly the most abundant in *Actinidia* species.

2.1.1 Ursane Triterpenoids

Ursane-type triterpenes are characterized of ursolic acid and its saponins, possessing a 6/6/6/6/6-fused carbon skeleton. A total of 76 ursane-type triterpenoids (**1–76**) have been identified from plants of the genus *Actinidia* (Fig. 2, Table 1). Ursolic acid (3β -Hydroxyurs-12-en-28-oic acid **1**) [7], is one of the most frequently obtained compound in many kinds of kiwifruit plants with unique flavor. Great attention had been paid on biological activities about ursolic acid, attracting much interest in recent years. Ursolic acid exhibits different pharmacological activities, including anti-cancer, amylolytic enzyme inhibitors, cytotoxicity, downregulating thymic stromal lymphopoietin and others [7–11].

Compounds **2–7** are ursane triterpenoids featuring with two hydroxyl groups. Compound **3** (2α -Hydroxyursolic acid) was tested for its antiproliferative activity and cytotoxicity in MDA-MB-231 human breast cancer cells through the methylene blue assay. It significantly

down-regulated expressions of TRAF2, PCNA, cyclin D1, and CDK4 and up-regulated the expressions of p-ASK1, p-p38, p-p53, and p-21. Furthermore, it induced apoptosis in MDA-MB-231 cell by significantly increasing the Bax/Bcl-2 ratio and inducing the cleaved caspase-3 [12]. Compound **4** exhibited inhibitory activity on pancreatic lipase with an IC_{50} value of $20.42 \pm 0.95 \mu\text{M}$ [13]. It also showed cytotoxicity to human lung adenocarcinoma (A549), ovarian cancer (SK-OV-3), skin melanoma (SK-MEL-2), and colon cancer (HCT-15) cell lines with IC_{50} values ranging from 11.96 to 14.11 μM [14–17].

Compounds **7–14** are trihydroxy-ursolic acid derivatives. In early 1992, Sashida et al. reported the isolation of **8–10**. Compounds **8** and **9** were evaluated for their cytotoxicity against A549 cells, LOVO cells, and HepG2 cells with IC_{50} values of 32.9, 31.6, 35.7 $\mu\text{g/mL}$ respectively for **8** and 34.6, 13.9, 34.5 $\mu\text{g/mL}$ respectively for **9** [18, 19]. Compounds **17–26** are ursolic acids with four or five hydroxy groups. Xu et al. reported **17** from roots of *A. valvata*, this compound exhibited weak cytotoxicity against A549, LOVO and HepG2 cell lines with IC_{50} values of above 100 $\mu\text{g/mL}$ [20]. $2\alpha,3\alpha,19\alpha,24$ -Tetrahydroxyurs-12-en-28-oic acid **20** was separated from the leaves of *A. valvata* which showed cytotoxicity against PLC, Hep3B, HepG2, HeLa, SW480, MCF-7 and Bel7402 in vitro [21]. A new polyoxygenated triterpenoid ($2\beta,3\alpha,6\alpha$)-2,3,6,20,23,30-hexahydroxyurs-12-en-28-oic acid **26** was obtained from the roots of *A. valvata* DUNN, it exhibited moderate cytotoxic activity against BEL-7402 and SMMC-7721 tumor cell lines in vitro [22].

Compound **30** (3β -O-acetylursolic acid) was isolated from the fruit galls of *A. polygama* and the structure was elucidated on the basis of chemical and spectral evidence. It was reported to be a mixed-type protein tyrosine phosphatase 1B (PTP1B) inhibitor with an IC_{50} value of $4.8 \pm 0.5 \mu\text{M}$ [23, 24]. Isolation of the antiviral active ingredient of *A. chinensis* root bark gave fupenzic acid **40**, which showed moderate inactivity under the concentration of 100 $\mu\text{g/mL}$ [25]. Callus tissue from the stems of *A. arguta* (Actinidiaceae) produced three ursane-type triterpenes including ursolaldehyde **41**, α -amyrin **42**, and uvaol **43** [26]. Of them, compound **43** showed anti-inflammatory, anticancer, and wound healing activities [27–29]. Anti-inflammatory properties of **43** on DSS-induced colitis and LPS-stimulated macrophages have been explored detailly and completely. It showed excellent potential of NO production inhibition. It could attenuate disease activity index (DAI), colon shortening, colon injury, and colonic myeloperoxidase activity in DSS-induced colitis mice. What's more, studies on LPS challenged murine macrophage

Fig. 2 Structures of ursane triterpenoids 1–76 from *Actinidia* plants

Fig. 2 (continued)

Fig. 2 (continued)

Fig. 2 (continued)

RAW246.7 cells also revealed that uvaol reduces mRNA expression and production of pro-inflammatory cytokines and mediators. These results indicating that uvaol is a prospective anti-inflammatory agent for colonic inflammation [27]. Guided by the hepatoprotective activity, the phytochemical study on the roots of *A. chinensis* led to the isolation of two new compounds $2\alpha,3\beta$ -dihydroxyurs-12-en-28,30-olide **46**, $2\alpha,3\beta,24$ -trihydroxyurs-12-en-28,30-olide **47** and 3β -hydroxyurs-12,18-dien-28-oic acid **50** [30]. Compounds **52–54** showed antifungal activity against *C. musae* at 3 $\mu\text{g/mL}$ [31]. A new compound $2\alpha,3\alpha,23,24$ -tetrahydroxyurs-12,20(30)-dien-28-oic acid **55** was isolated from the roots of *A. chinensis* Planch. It exhibited moderate antitumor activities against five human cancer cell lines (HepG2, A549, MCF-7, SK-OV-3, and HeLa) with IC_{50} values of 19.62 ± 0.81 , 18.86 ± 1.56 , 45.94 ± 3.62 , 62.41 ± 2.29 , and 28.74 ± 1.07 μM , respectively [32].

Compounds **59–63** are actinidic acid derivatives with a phenylpropanoid unit that were identified as 3-O-*trans*-*p*-coumaroylasiatic acid **59**, 23-O-*trans*-*p*-coumaroylasiatic acid **60**, actiniargupene E **61**, actiniargupene F **62**, and actiniargupene G **63** from the leaves of *A. arguta*. All the compounds showed inhibitory effects on α -glucosidase activity. Among them compound **59** showed most potentially inhibitory activity on α -glucosidase with an IC_{50} of

81.3 ± 2.7 μM , equal to that of the positive control (acarbose, 72.8 ± 3.1 μM) [33]. The structure–activity relationship suggested that triterpenoids with a phenylpropanoid moiety exhibited more potent effects than those without such a unit [34]. Compound **71** showed potent cytotoxic activity against human SKVO3 and TPC-1 cancer cell lines with IC_{50} values of 10.99 and 14.34 μM , respectively [19, 35]. Compound **74** exhibited moderate cytotoxic activity against BEL-7402 and SMMC-7721 tumor cell lines [22]. Compounds **75** and **76** were isolated from roots of *A. valvata* Dunn. They exhibited moderate cytotoxic activity in vitro against BEL-7402 and SMMC-7721 tumor cell line [36].

2.1.2 Oleanane Triterpenoids

Oleanane-type triterpenoids also possessed a 6/6/6/6/6 pentacyclic carbon skeleton. Unlike ursane triterpenes, oleanane-type triterpenoids have two methyl groups at the C-20 position instead of each one at the C-19 and C-20, respectively. So far, a total of 24 oleanane-type triterpenoids have been identified from *Actinidia* plants (**77–100**, Fig. 3, Table 2). The most representative compound is oleanolic acid **77**. It was found from callus tissue from the stems of *A. arguta*, together with $2\alpha,3\beta$ -dihydroxyolean-12-en-28-oic

Table 1 Information of ursane triterpenoids from *Actinidia* plants

No.	Compound name	Species Refs.	Part	Bioactivity Refs.
1	3 β -Hydroxyurs-12-en-28-oic acid	<i>A. eriantha</i> [7]	Roots	Anticancer (in vitro) [8] Inhibiting amylolytic enzyme (in vitro) [9] Antidepressant and neuroprotective (in vitro) [10] Downregulating thymic stromal lymphopoi- etin (in vitro) [11]
2	3 β ,24-Dihydroxyurs-12-en-28-oic acid	<i>A. arguta</i> [37] <i>A. polygama</i> [23]	Leaves Fruit galls	
3	2 α ,3 β -Dihydroxyurs-12-en-28-oic acid	<i>A. polygama</i> [23] <i>A. arguta</i> [13]	Fruit galls Roots	Anti-metastation (In vitro) [38] Anticancer (In vitro) [12]
4	23-Hydroxyursolic acid	<i>A. arguta</i> [13]	Roots	Anti-pancreatic lipase (In vitro) [13] Anticancer(In vitro) [14–16] Anti-inflammatory (in vitro) [17]
5	2 β ,3 β -Dihydroxyursolic acid	<i>A. sp</i> [39]		
6	2 α ,3 α -Dihydroxyurs-12-en-28-oic acid	<i>A. chinensis</i> [30]	Roots	
7	2 α ,3 α ,24-Trihydroxyurs-12-en-28-oic acid	<i>A. eriantha</i> [40]	Roots	
8	2 α ,3 β ,24-Trihydroxy-urs-12-en-28-oic acid	<i>A. eriantha</i> Benth [41] <i>A. polygama</i> [18]	Fruit galls	Against A549, LOVO, and HepG2 cell lines (in vitro) [19]
9	2 α ,3 β ,23-Trihydroxyurs-12-en-28-oic acid	<i>A. polygama</i> [18] <i>A. chrysanthia</i> [42]	Fruit galls Roots	Against A549, LOVO, and HepG2 cell lines (in vitro) [19]
10	2 α ,3 α ,23-Trihydroxyurs-12-en-28-oic acid	<i>A. polygama</i> [18]	Fruit galls	
11	2 β ,3 α ,24-Trihydroxy-urs-12-en-28-oic acid	<i>A. rufa</i> [43]	Roots	
12	2 β ,3 β ,10-Trihydroxy ursolic acid	<i>A. sp</i> [39]		
13	2 α ,3 β ,14 β -Trihydroxy ursolic acid	<i>A. sp</i> [39]		
14	2 α ,3 α ,19-Trihydroxyurs-12-en-28-oic acid	<i>A. chinensis</i> [44]	Roots	Inhibiting tumor angiogenesis (in vitro) [45]
15	2 β ,3 β ,23-Trihydroxyurs-12-en-28-oic acid	<i>A. eriantha</i> [7]	Roots	Against HepG2, A549, MCF-7, SK-OV-3, and HeLa cell lines (in vitro) [32]
16	2 β ,3 α ,23-Trihydroxyurs-12-en-28-oic acid	<i>A. chinensis</i> Planch [32]	Roots	Against HepG2, A549, MCF-7, SK-OV-3, and HeLa cell lines (in vitro) [32]
17	2 α ,3 α ,23,24-Tetrahydroxyurs-12-en-28-oic acid	<i>A. polygama</i> [18]	Fruit galls	Against A549, LOVO and HepG2 cell lines (in vitro) [20]
18	2 α , 3 β , 19 α , 23-Tetrahydroxyurs-12-en- 28-oic acid	<i>A. chinensis</i> Planch [32]	Roots	
19	2 α ,3 β ,19 α ,24-Tetrahydroxyurs-12-en-28-oic acid	<i>A. indochinensis</i> Merr. Var [46]	Roots	
20	2 α ,3 α ,19 α ,24-Tetrahydroxyurs-12-en-28-oic acid	<i>A. valvata</i> [21]	Leaves	Anti-tumor (in vitro) [21]
21	2 α ,3 β ,23,24-Tetrahydroxyurs-12-en-28-oic acid	<i>A. chinensis</i> Planch [32]	Roots	
22	2 α ,3 β ,6 β ,23-Tetrahydroxyurs-12-en-28-oic acid	<i>A. valvata</i> Dunn [47]	Roots	
23	2 α ,3 β ,23,27-Tetrahydroxy-12-en-28-ursolic acid	<i>A. deliciosa</i> [48]	Roots	
24	2 α ,3 α ,19 α ,23,24-Pentahydroxy-urs-12-en- 28-oic acid	<i>A. chinensis</i> Planch [19]	Roots	
25	2 α ,3 β ,19 α ,23,24-Pentahydroxyurs-12-en- 28-oic acid	<i>A. rufa</i> Planch ex miq [43]	Roots	
26	(2 β ,3 α ,6 α)-2,3,6,20,23,30-Hexahydroxyurs- 12-en-28-oic acid	<i>A. valvata</i> Dunn [22]	Roots	Against BEL-7402 and SMMC-7721 cells lines (in vitro) [22]
27	2 β ,3 β -Dihydroxy-23-oxours-12-en-28-oic acid	<i>A. eriantha</i> Benth [49]	Roots	

Table 1 (continued)

No.	Compound name	Species Refs.	Part	Bioactivity Refs.
28	2 α ,3 α -Dihydroxyurs-12-ene-24-al-28-oic acid	<i>A. polygama</i> [18]	Fruit galls	
29	2 α ,3 α ,24-Trihydroxyurs-12-ene-23,28-dioic acid	<i>A. polygama</i> [18]	Fruit galls	
30	3 β -O-Acetylursolic acid	<i>A. polygama</i> [23]	Fruit galls	Inhibiting PTP1B (in vitro) [24]
31	24-Acetyloxy-2 α ,3 α -dihydroxyurs-12-en-28-oic acid	<i>A. eriantha</i> [7]	Roots	
32	2 α ,3 β ,19 α -Trihydroxyurs-12-en-23,28-dioic,acid-23-methylester	<i>A. chinensis</i> Radix [50]	Roots	
33	3 β -Hydroxy-13,28-epoxyurs-11-en-3-ol	<i>A. kolomikta</i> [51]	Rhizomes	
34	28-Norurs-12-en-3 β ,17 β -diol	<i>A. kolomikta</i> [51]	Rhizomes	
35	Triptohypol E	<i>A. kolomikta</i> [51]	Rhizomes	
36	Neoilexonol	<i>A. kolomikta</i> [51]	Rhizomes	
37	11 α -Methoxyurs-12-ene-3 β ,12-diol	<i>A. arguta</i> [34]	Leaves	
38	Ilelatifol A	<i>A. arguta</i> [34]	Leaves	
39	(2 α ,3 β)-2,3,23-Trihydroxyurs-13(18)-en-28-oic acid	<i>A. chinensis</i> Planch [52]	Roots	
40	Fupenzic acid	<i>A. chinensis</i> [25]	Root bark	Antiviral (in vitro) [25]
41	Nrsolaldehyde	<i>A. arguta</i> [26]	Stems	
42	α -Amyrin	<i>A. arguta</i> [26]	Stems	
43	Uvaol	<i>A. arguta</i> [26]	Stems	Anti-inflammatory (in vivo) [27] Anticancer (in vitro) [28] Wound healing (in vivo) [29]
44	Pseudotaraxasterol	<i>A. chinensis</i> Planch [19]	Roots	
45	2 α ,3 α ,24-Trihydroxyurs-11-en-13,28-olide	<i>A. polygama</i> [23]	Fruit galls	
46	2 α ,3 β -Dihydroxyurs-12-en-28,30-olide	<i>A. chinensis</i> [30]	Roots	
47	2 α ,3 β ,24-Trihydroxyurs-12-en-28,30-olide	<i>A. chinensis</i> [30]	Roots	
48	Ehretiolide	<i>A. kolomikta</i> [51]	Rhizomes	
49	3 β -Acetoxys-11-en-28-oic 13(28)-lactone	<i>A. kolomikta</i> [51]	Rhizomes	
50	3 β -Hydroxyurs-12,18-dien-28-oic acid	<i>A. chinensis</i> [30]	Roots	
51	(2 α ,3 β ,4 α)-2,3-Dihydroxy-24-norursa-12,18-dien-28-oic acid	<i>A. valvata</i> Dunn [47]	Roots	
52	2 α ,3 α ,23-Trihydroxy-12,20(30)-ursadien-28-oic acid	<i>A. polygama</i> [18] <i>A. deliciosa</i> [31]	Fruit galls Peels	Antifungal (in vitro) [31]
53	2 α ,3 β ,23-Trihydroxy-12,20(30)-ursadien-28-oic acid	<i>A. deliciosa</i> [31]	Peels	Antifungal (in vitro) [31]
54	2 α ,3 α ,24-Trihydroxy-12,20(30)-ursadien-28-oic acid	<i>A. deliciosa</i> [31]	Peels	Antifungal (in vitro) [31]
55	2 α ,3 α ,23,24-Tetrahydroxyursa-12,20(30)-dien-28-oic acid	<i>A. chinensis</i> Planch [32]	Roots	Anti-tumor (in vitro) [32]
56	3 β - <i>Trans-p</i> -coumaroyloxy-2 α ,24-dihydroxyurs-12-en-28-oic acid	<i>A. polygama</i> [23]	Fruit galls	
57	3-O- <i>Trans-p</i> -coumaroyl tormentic acid	<i>A. chinensis</i> Radix [50]	Roots	
58	3-O- <i>Cis-p</i> -coumaroyl tormentic acid	<i>A. chinensis</i> Radix [50]	Roots	
59	3-O- <i>Trans-p</i> -coumaroylasiatic acid	<i>A. polygama</i> [18]	Fruit galls	
60	23-O- <i>Trans-p</i> -coumaroylasiatic acid	<i>A. arguta</i> [34]	Leaves	Inhibiting α -glucosidase (in vitro) [34]
61	Actiniargupene E	<i>A. arguta</i> [34]	Leaves	Inhibiting α -glucosidase (in vitro) [34]
62	Actiniargupene F	<i>A. arguta</i> [34]	Leaves	Inhibiting α -glucosidase (in vitro) [34]
63	Actiniargupene G	<i>A. arguta</i> [34]	Leaves	Inhibiting α -glucosidase (in vitro) [34]
64	3-O- <i>Trans-p</i> -coumaroyl actinidic acid	<i>A. arguta</i> [13] <i>A. arguta</i> [34]	Roots Leaves	

Table 1 (continued)

No.	Compound name	Species Refs.	Part	Bioactivity Refs.
65	3-O- <i>Cis-p</i> -coumaroylactinidic acid	<i>A. arguta</i> [34]	Leaves	Inhibiting α -glucosidase (in vitro) [34]
66	Actiniargupene A	<i>A. arguta</i> [34]	Leaves	Inhibiting α -glucosidase (in vitro) [34]
67	Actiniargupene B	<i>A. arguta</i> [34]	Leaves	Inhibiting α -glucosidase (in vitro) [34]
68	Actiniargupene C	<i>A. arguta</i> [34]	Leaves	Inhibiting α -glucosidase (in vitro) [34]
69	(+)-Tormentoside	<i>A. arguta</i> [53]	Roots	
70	(+)-Euscaphic acid-28-O- β -D-glucopyranoside	<i>A. arguta</i> [53]	Roots	
71	2 α ,3 α ,19 α ,24-Tetrahydroxyurs-12-en-28-oic acid 28-O- β -D-glucopyranoside	<i>A. chinensis</i> Planch [19]	Roots	Inhibiting SKVO3 and TPC-1 cancer cells lines (in vitro) [42]
72	2 α ,3 β ,19 α ,23-Tetrahydroxyurs-12-en-28-oic acid 28-O- β -D-glucopyranoside	<i>A. chinensis</i> Radix [50]	Roots	
73	2 α ,3 β ,19 α ,23,24-Pentahydroxyurs-12-en-28-oic acid-28-O- β -D-glucopyranoside	<i>A. rufa</i> [35]	Roots	
74	(2 β ,3 α)-2,3,20,23,24,30-Hexahydroxyurs-12-en-28-oic acid O- β -D-glucopyranosyl ester	<i>A. valvata</i> Dunn [22]	Roots	Against BEL-7402 and SMMC-7721 tumor cells lines (in vitro) [22]
75	2 α ,3 β ,23,30-Tetrahydroxyurs-12,18-diene-28-oic acid O- β -D-glucopyranosyl ester	<i>A. valvata</i> Dunn [36]	Roots	Against BEL-7402 and SMMC-7721 tumor cells lines (in vitro) [36]
76	30-O- β -D-Glucopyranosyloxy-2 α ,3 α ,24-trihydroxyurs-12,18-diene-28-oic acid O- β -D-glucopyranosyl ester	<i>A. valvata</i> Dunn [36]	Roots	Against BEL-7402 and SMMC-7721 tumor cells lines (in vitro) [36]

acid **78** [26]. Oleanolic acid **77** is abundant in nature and exhibits a wide range of biological activities including anti-inflammatory [54], anti-hypertension [55], anti-tumor [56, 57], neuroprotection [58], and anti-cholesterol activities [59]. Oleanolic acid was performed to test the effect on apoptosis and autophagy of SMMC-7721 Hepatoma cells. It can significantly inhibit the growth of liver cancer SMMC-7721 cells and induce autophagy and apoptosis [57]. Compound **78** also showed anti-tumor and anti-inflammatory activities [60, 61]. Lim et al. have demonstrated that **78** showed very strong anti-tumor-promoting activity with an IC_{50} of 0.1 mg/mL [60].

Bioassay- and 1H NMR-guided fractionation of the methanol extract afforded two oleanolic acids of 2 α ,3 β ,23-trihydroxyolean-12-en-28-oic acid **80** and 2 α ,3 α ,24-trihydroxyolean-12-en-28-oic acid **81**, showing antifungal activity against *C. musae* at 3 μ g/mL [31]. The EtOAc extract of the roots of *A. eriantha* Benth exhibited potent growth inhibitory activity against SGC7901 cells, CNE2 cells and HUVECs cells. From which, compound **87** (3 β ,23,24-trihydroxyl-12-oleanen-28-oic acid) was identified [62]. Compound **88** was extracted from the roots bark of *A. chinensis*, which showed anti-viral activity [25]. A new triterpenoid 12 α -chloro-2 α ,3 β ,13 β ,23-tetrahydroxyolean-28-oic acid-13-lactone **89** was extracted from the roots

of *A. chinensis* Planch (Actinidiaceae). It was tested for cytochrome P450 (CYPs) enzyme inhibitory activity in later years, which could significantly inhibit the catalytic activities of CYP3A4 to < 10% of its control activities [19, 52].

3 β -(2-Carboxybenzoyloxy) oleanolic acid **93** and spathodic acid-28-O- β -D-glucopyranoside **94** were extracted from the root bark of *A. chinensis*. The anti-phytoviral activity test indicated that **94** showed potent activity on TMV, and CMV with inactivation effect of 46.67 ± 1.05 , and 45.79 ± 2.23 (100 mg/L), compared to ningnanmycin with inactivation effect of 30.15 ± 1.16 and 27.18 ± 1.02 (100 mg/L) respectively [25]. 3 β ,23-Dihydroxy-30-norolean-12,20(29)-dien-28-oic acid **98**, 3 β ,23-dihydroxy-1-oxo-30-norolean-12,20(29)-dien-28-oic acid **99**, and 2 α ,3 α ,23,24-tetrahydroxy-30-norolean-12,20(29)-dien-28-oic acid **100** are three one-carbon-degraded oleanane triterpenoids that were identified from *A. chinensis* Radix for the first time [50].

2.1.3 Lupane Triterpenoids

Lupane triterpenoids possess a 6/6/6/5-fused carbon skeleton. Compared with ursane and oleanane triterpenoids, the number of lupane triterpenoids in the *Actinidia*

Fig. 3 Structures of oleanane triterpenoids **77–100** from *Actinidia* plants

Table 2 Information of oleanane triterpenoids from *Actinidia* plants

No.	Compound name	Species Refs.	Part	Bioactivity Refs.
77	Oleanolic acid	<i>A. arguta</i> [26]	Stems	Anti-inflammatory (in vitro) [54] Anti-hypertension (in vivo) [55] Anti-tumor (in vitro) [56, 57] Neuroprotection(in vitro) [58] Anti-cholesterol(in vitro) [59]
78	2 α ,3 β -Dihydroxyolean-12-en-28-oic acid	<i>A. arguta</i> [26]	Stems	
79	2 α ,3 α -Dihydroxyolean-12-en-28-oic acid	<i>A. chinensis</i> Planch [63]	Fruits	
80	2 α ,3 β ,23-Trihydroxyolean-12-en-28-oic acid	<i>A. deliciosa</i> [31]	Peels	Antifungal (in vitro) [31]
81	2 α ,3 α ,24-Trihydroxyolean-12-en-28-oic acid	<i>A. deliciosa</i> [31]	Peels	Antifungal (in vitro) [31]
82	3 β -O-Acetyloleanolic acid	<i>A. arguta</i> [64] <i>A. chinensis</i> [45]	Stems Roots	Anti-angiogenesis (in vitro) [45]
83	2 α ,3 β ,19-Trihydroxyolean-12-en-28-oic acid	<i>A. chinensis</i> [45]	Roots	Anti-angiogenesis (in vitro) [45]
84	(3 β ,4 α ,16 α)-3,16,23-Trihydroxyolean-12-en-28-oic acid	<i>A. valvata</i> Dunn [47]	Roots	
85	(2 β , 3 β , 4 α , 16 α)-2, 3, 16, 23-Tetrahydroxyolean-12-en-28-oic acid	<i>A. valvata</i> Dunn [47]	Roots	
86	2 α ,3 β ,19 α ,23-Tetrahydroxyoleanolic acid	<i>A. deliciosa</i> [65]	Roots	
87	3 β ,23,24-Trihydroxyl-12-oleanen-28-oic acid	<i>A. eriantha</i> Benth [62]	Roots	Anti-angiogenesis (in vitro) [62]
88	9(11),12-Diene-30-oic acid	<i>A. chinensis</i> [25]	Roots bark	Anti-viral (in vitro) [25]
89	12 α -Chloro-2 α ,3 β ,13 β ,23-tetrahydroxyolean-28-oic acid-13-lactone	<i>A. chinensis</i> Planch [19]	Roots	Anti-catalysis (in vitro) [43]
90	β -Amyrin	<i>A. arguta</i> [26]	Stems	
91	Erythrodilol	<i>A. kolomikta</i> [51]	Dried rhizomes	
92	12-Oleanene 2 α ,3 α ,24-triol	<i>A. macrosperma</i> [66]	Roots	
93	3 β -(2-Carboxybenzoyloxy) oleanolic acid	<i>A. chinensis</i> [25]	Root bark	Anti-phytoviral (in vitro) [25]
94	Spathodic acid-28-O- β -D-glucopyranoside	<i>A. chinensis</i> [25]	Root bark	Anti-phytoviral (in vitro) [25]
95	Oleanolic acid-23-O- β -D-glucopyranoside	<i>A. eriantha</i> Benth [62]	Roots	Anti-angiogenesis (in vitro) [62]
96	2 α ,3 β ,19 α ,23,24-Pentahydroxy-12-oleanen 28-oic acid 28- β -D-glucopyranosyl	<i>A. chinensis</i> Radix [50]	Roots	
97	3-O- β -D-Glucopyranosyl-2 α ,3 β ,6 β ,19 α ,21 β ,23-hexahydroxylolean-12-en-28-oic acid	<i>A. kolomikta</i> [67]	Leaves	
98	3 β ,23-Dihydroxy-30-norolean-12,20(29)-dien-28-oic acid	<i>A. chinensis</i> Radix [50]	Roots	
99	3 β ,23-Dihydroxy-1-oxo-30-norolean-12,20(29)-dien-28-oic acid	<i>A. chinensis</i> Radix [50]	Roots	
100	2 α ,3 α ,23,24-Tetrahydroxy-30-norolean-12,20(29)-dien-28-oic acid	<i>A. chinensis</i> Radix [50]	Roots	

plants is much smaller, only four related compounds have been identified (**101–104**, Fig. 4, Table 3). Three of them (**101–103**) were identified from the rhizomes of *A. kolomikta* [51]. Betulinic acid **101** is one of the most representative compound of lupane triterpenes, it has been extensively studied in recent years based on the wide biological activities including anti-inflammatory, antitumor, anti-HIV, anti-diabetic and antimalarial activities [68–73].

Much attention as a molecular target about protein tyrosine phosphatase 1B had been paid to the treatment of insulin resistance diseases because of its critical roles in negatively regulating insulin- and leptin-signaling cascades. Betulinic acid showed significant PTP1B inhibitory activity, with IC₅₀ values of 3.5 μ M [24].

Fig. 4 Structures of lupane triterpenoids **101–104** from *Actinidia* plants

2.1.4 Other Terpenoids

A total of 19 other terpenoids including iridoids, diterpenoids, and their glycosides have been found from *Actinidia* plants (**105–123**, Fig. 5, Table 4). None of these compounds have good biological activities, only compound **120** showed certain anti-angiogenesis activity [77].

2.2 Steroids

β -Sitosterol **124** is a very normal phytosterol almost distributed in all plants. Eight phytosterols have been obtained from the *Actinidia* plants (**124–131**, Fig. 6, Table 5). Pharmacological studies on these steroids have demonstrated that β -sitosterol showed various bioactivities including anti-inflammatory, anti-cancer, antimicrobial and anti-diabetic properties [81–88]. A study suggested that β -sitosterol may serve as a potential therapeutic in the treatment of acute organ damages [82].

In addition to phytosterols, seven normal ergosterols (**132–137**, Fig. 6, Table 5) were obtained from peel or

rhizomes of kiwifruit plants. It is well known that ergosterols should be fungal products. Compounds **132–137** may be produced by fungal infected kiwifruit plants.

2.3 Phenols

2.3.1 Catechins and Epicatechins

A total of 16 related compounds (**139–154**) have been obtained from kiwifruit plants (Fig. 7, Table 6). Compounds **148** and **149** possessed a novel structure featuring with a pyrrolidin-2-one substituent at C-6 and C-8, respectively. Compounds **152** and **153** were two sulfur-containing catechins that was rare in nature. Pharmacological studies have revealed that (+)-catechin **139** and (–)-epi-catechin **140** showed nitric oxide inhibitory activity in LPS stimulated RAW 264.7 cell with IC_{50} values of 26.61 and 25.30 μ g/mL, respectively [53, 91]. Compound **147** showed moderate radical scavenging and antioxidant capabilities by measuring their capacity to scavenge DPPH and anion superoxide radical and to reduce a Mo(VI) salt [89]. Two new flavan-3-ols, 6-(2-pyrrolidinone-5-yl)-(–)-epicatechin **148** and 8-(2-pyrrolidinone-5-yl)-(–)-epicatechin **149**, as well as proanthocyanidin B-4 **150**, were isolated from an EtOAc-soluble extract of the roots of *A. arguta*. The isolates were tested in vitro for their inhibitory activity on the formation of advanced glycation end products (AGEs). All of them exhibited significant inhibitory activity against AGEs formation with IC_{50} values ranging from 10.1 to 125.2 μ M [92].

2.3.2 Flavones, Isoflavones, and Flavonols

A total of 48 flavone derivatives have been identified from kiwifruit plants, most of which are glycosides (**155–202**, Fig. 8, Table 7). Pharmacological studies indicated that these compounds, particularly kaempferol and its derivative, had a wide range of biological activities including antiproliferation, antioxidation, anti-inflammation, anticancer, anti-free radical, and neuroprotection activities [96–99]. Kaempferol **157** was found to prevent neurotoxicity by several ways

Table 3 Information of lupane triterpenoids from *Actinidia* Plants

No.	Compound name	Species Refs.	Part	Bioactivity Refs.
101	Betulinic acid	<i>A. kolomikta</i> [51]	Rhizomes	Anti-inflammatory (in vitro) [68] Antitumor(in vitro) [69] Anti-HIV(in vitro) [72] Anti-diabetic(in vivo) [73]
102	Betulin	<i>A. kolomikta</i> [51]	Rhizomes	Anti-tumor(in vitro) [74–76]
103	Diospyrolide	<i>A. kolomikta</i> [51]	Rhizomes	
104	Lupa-12,20(30)-diene-2 β ,3 β ,28-triol	<i>A. deliciosa</i> [48]	Roots

Fig. 5 Structures of other terpenoids **105**–**123** from *Actinidia* plants

Table 4 Information of other triterpenoids from *Actinidia* plants

No.	Compound name	Species Refs.	Part	Bioactivity Refs.
105	Dihydroepinepetalactone	<i>A. polygama</i> [78]	Fresh fruits	
106	Isodihydroepinepetalactone	<i>A. polygama</i> [78]	Fresh fruits	
107	Isoepiiridomyrmecin	<i>A. polygama</i> [78]	Fresh fruits	
108	Isononepetalactone	<i>A. polygama</i> [78]	Fresh fruits	
109	Dehydroiridomyrmecin	<i>A. polygama</i> [78]	Fresh fruits	
110	Isodehydroiridomyrmecin	<i>A. polygama</i> [78]	Fresh fruits	
111	Actinidialactone	<i>A. polygama</i> [78]	Fresh fruits	
112	Isoactinidialactone	<i>A. polygama</i> [78]	Fresh fruits	
113	Neonepetalactone	<i>A. polygama</i> [78]	Fresh fruits	
114	Dihydronepetalactone	<i>A. polygama</i> [78]	Fresh fruits	
115	Isodihydronepetalactone	<i>A. polygama</i> [78]	Fresh fruits	
116	Iridomyrmecin	<i>A. polygama</i> [78]	Fresh fruits	
117	Isoiridomyrmecin	<i>A. polygama</i> [78]	Fresh fruits	
118	Matatabiether	<i>A. polygama</i> [79]	Leaves and galls	
119	(<i>R</i>)-1,2,6,7,8,9-Hexahydro-10-hydroxy-1,6,6-trimethylphenanthro[1,2- <i>b</i>]furan-5,11-dione	<i>A. valvata</i> Dunn [47]	Roots	
120	(6 <i>R</i> ,7 <i>E</i> ,9 <i>S</i>)-6,9-Hydroxy-megastigman-4,7-dien-3-one-9- <i>O</i> - β -glucopyranoside	<i>A. eriantha</i> Benth [62]	Roots	Anti-angiogenesis (in vitro) [62]
121	Kiwiinoside	<i>A. chinensis</i> [80]	Fresh leaves	
122	Iridodialo- β -D-gentiobioside	<i>A. polygama</i> [77]	Leaves	
123	Dehydroiridodialo- β -D-gentiobioside	<i>A. polygama</i> [77]	Leaves

Fig. 6 Structures of steroids **124**–**138** from *Actinidia* plants

which was able to completely block *N*-methyl-D-aspartate (NMDA)-induced neuronal toxicity and potently inhibited MAO (monoamine oxidase) with the IC_{50} of 0.8 μ M [99]. Two novel flavonoids **171** and **172** were separated from the leaves of *A. valvata* Dunn. They exhibited dose-dependent activity in scavenging 1,1-diphenyl-2-picrylhydrazyl (DPPH)

free radicals, superoxide anion radicals, and hydroxyl radicals, and inhibited lipid peroxidation of mouse liver homogenate in vitro [100]. Compounds **178** [101] and **179** [102] were two new compounds obtained from the leaves of *A. kolomikta*. The latter was screened for its protective effect on human erythrocytes against AAPH-induced hemolysis,

Table 5 Information of steroids from *Actinidia* plants

No.	Compound name	Species Refs.	Part	Bioactivity Refs.
124	β -Sitosterol	<i>A. eriantha</i> [7]	Roots	Anti-inflammatory (In vivo) [84] Anticancer (in vitro) [85] Anti-microbial (in vitro) [86] Anti-diabetic (In vivo) [88]
125	Stigmast-3,6-dione	<i>A. chrysantha</i> [42]	Roots	
126	Masterol	<i>A. deliciosa</i> [89]	Peels	
127	Stigmast-7-en-3 β -ol	<i>A. deliciosa</i> [89]	Peels	
128	3 β -Hydroxystigmast-5-en-7-one	<i>A. chinensis</i> Planch [52]	Roots	
129	Sitostanetriol	<i>A. kolomikta</i> [51]	Dried rhizomes	
130	(24 <i>R</i>)-Stigmast-4-en-3-one	<i>A. kolomikta</i> [51]	Dried rhizomes	
131	Stigmasterol	<i>A. arguta</i> [26]	Stems	Anti-inflammatory (in vitro) [90]
132	Daucosterol	<i>A. eriantha</i> [40] <i>A. chinensis</i> [44]	Roots Roots	
133	Campesterol	<i>A. deliciosa</i> [89]	Peels	
134	Ergosterol	<i>A. deliciosa</i> [89]	Peels	
135	Ergost-22-en-3-ol	<i>A. deliciosa</i> [89]	Peels	
136	5,7,14,22-Ergostatetraen-3 β -ol	<i>A. deliciosa</i> [89]	Peels	
137	5,8-Epidioxyergosta-6,22-dien-3 β -ol	<i>A. kolomikta</i> [51]	Dried rhizomes	
138	24-Methylene-pollinastanol	<i>A. kolomikta</i> [51]	Dried rhizomes	

which could slow the hemolysis induced by AAPH [102]. Eerduna et al. evaluated the effects of compound **182** on acute myocardial infarction in rats, the groups treated with **182** showed a dose-dependent reduction in myocardial infarct size model, markedly inhibited the elevation of the activity of creatine kinase, troponin T level, and the content of malondialdehyde induced by AMI [103]. Compound **182** also showed a capacity to increase the activities of superoxide dismutase, catalase, and endothelial nitric oxide synthase [104]. Lim et al. tested the DPPH radical scavenging activity and nitric oxide production inhibitory activity in IFN- γ , LPS stimulated RAW 264.7 cell of quercetin **185**, quercetin-3-O- β -D-glucoside **186**, and quercetin 3-O- β -D-galactoside **193** with IC₅₀ value of 20.41, 18.23, and 30.46 μ g/mL, respectively [91].

2.3.3 Xanthenes

Three xanthenes were isolated from n-butyl alcohol fraction of *A. arguta* (Sieb. & Zucc) Planch. ex Miq and identified as 2- β -D-glu-1,3,7-trihydrogen xanthone **203**, 7-O- $[\beta$ -D-xylose-(1 $\rightarrow$ 6)- β -D-glucopyranoside]-1,8-dihydroxy-3-methoxy xanthone **204**, and

1-O- $[\beta$ -D-xylose-(1 $\rightarrow$ 6)- β -D-glucopyranside]-8-hydroxy-3,7-dimethoxy xanthone **205** (Fig. 9, Table 8). They were isolated from this plant for the first time [108]. Compound **203** showed extensive biological activities, including inhibiting α -Glycosidase, NO production inhibition and NF- κ B inhibition and PPAR activation [116, 117]. It has been demonstrated the inhibitory effects on NF- κ B transcriptional activation in HepG2 cells stimulated with TNF α with an IC₅₀ value of 0.85 ± 0.07 μ M, which was more potent than the positive control of sulfasalazine (IC₅₀=0.9 μ M) [118].

2.3.4 Anthocyanins

Five anthocyanins were obtained from the flesh of larger fruit of *A. deliciosa* and *A. chinensis* and identified as delphinidin 3-galactoside **206**, cyanidin 3-galactoside **207**, cyanidin 3-glucoside **208**, delphinidin 3-[2-(xylosyl)galactoside] **209**, and cyanidin 3-[2-(xylosyl)galactoside] **210**, respectively (Fig. 9, Table 8) [119]. Cyanidin 3-glucoside **208** exhibited a wide range of pharmacological activities including anti-inflammatory, neuroprotective, anti-cancer, and antioxidant activities [120–124].

Fig. 7 Structures of catechins and epicatechins 139–154 from *Actinidia* plants

Table 6 Information of catechins and epicatechins from *Actinidia* plants

No.	Compound name	Species Refs.	Part	Bioactivity Refs.
139	(+)-Catechin	<i>A. arguta</i> [41]	Roots	Anti-DPPH radical and inhibiting nitric oxide (in vitro) [57] Anti-bacteria (in vitro) [93]
140	(-)-Epi-catechin	<i>A. arguta</i> [41]	Roots	Anti-DPPH radical and inhibiting nitric oxide (in vitro) [57]
141	(+)-Afzelechin	<i>A. chinensis</i> Planch [94]	Roots	
142	(-)-Epi-afzelechin	<i>A. chinensis</i> Planch [94]	Roots	
143	(+)-Catechin(4 α →8)(+)-catechin	<i>A. chinensis</i> Planch [94]	Roots	
144	(-)-Epi-catechin(4 β →8)(-)-epi-catechin	<i>A. chinensis</i> Planch [94]	Roots	
145	(+)-Afzelechin(4 α →8)(+)-afzelechin	<i>A. chinensis</i> Planch [94]	Roots	
146	(-)-Epi-afzelechin(4 β →8)(-)-epi-afzelechin	<i>A. chinensis</i> Planch [94]	Roots	
147	Gallocatechin	<i>A. deliciosa</i> [89]	Peels	Radical scavenging and antioxidant (in vitro) [89]
148	6-(2-Pyrrolidinone-5-yl)-(-)-epicatechin	<i>A. arguta</i> [92]	Roots	Against advanced glycation-end (in vitro) [92]
149	8-(2-Pyrrolidinone-5-yl)-(-)-epicatechin	<i>A. arguta</i> [92]	Roots	Against advanced glycation-end (in vitro) [92]
150	Proanthocyanidin B-4	<i>A. arguta</i> [92]	Roots	Against advanced glycation-end (in vitro) [92]
151	(-)-Epi-Catechin-5-O- β -D-glucopyranoside	<i>A. arguta</i> [92]	Roots	Against advanced glycation-end (in vitro) [92]
152	Benzylthio(-)-epicatechol	<i>A. chinensis</i> [95]	Vegetative parts	
153	4'-Benzylthioprocyanidol B2	<i>A. chinensis</i> [95]	Vegetative parts	
154	Procyanidol C1	<i>A. chinensis</i> [95]	Vegetative parts	

2.3.5 Emodins

A total of nine emodin derivatives were obtained (**211–219**, Fig. 9, Table 8). Three emodin constituents were isolated from EtOAc fraction of the roots of *A. deliciosa* for the first time, and their structures were identified to be aloe-emodin **211**, 11-O-acetyl-aloe-emodin **212**, and aloe-emodin 11-O- α -L-rhamno-pyranoside **213** [125]. Compound **211** exhibited intriguing biological activities including inflammatory, antifungal, and anticancer activity [126–128]. Lipoxygenases (LOXs) are potential treatment targets in a variety of inflammatory conditions, enzyme kinetics showed that aloe emodin inhibited lipoxygenase competitively with an IC_{50} of 29.49 μ M [126]. Compound **215** was reported to possess wide biological activities including anti-inflammatory, neuroprotection, anti-cardiovascular and α -glucosidase inhibitory activity [129–132]. It exhibited potent inhibition of α -glucosidase with an IC_{50} value of 19 ± 1 μ M and lower cytotoxicity to the Caco-2 cell line [132].

2.3.6 Phenylpropionic Acids

A total of 38 phenylpropionic acid derivatives have been identified from kiwifruit plants (**220–257**, Fig. 10, Table 9), while most of them were glycosides or quinic acid derivatives. Phytochemical examination of the fruits of *A. arguta* led to the isolation of two organic acids including caffeic acid **220** and caffeoyl- β -D-glucopyranoside **221**, which were tested for their nitric oxide production inhibitory activity in LPS-stimulated RAW 264.7 cells and DPPH radical scavenging activities. Compared with positive control (L-NMMA), they were potently reduced nitric oxide productions and showed anti-oxidative activities [135]. Nine succinic acid derivatives (**228–236**), eleven quinic acid (**245–255**) derivatives and two shikimic acid derivatives (**256** and **257**) were isolated from the fruits of *A. arguta*. The NF- κ B transcriptional inhibitory activity of the compounds was evaluated using RAW 264.7 macrophages cells induced by lipopolysaccharide. Among the groups of

Fig. 8 Structures of flavones, isoflavones, and flavonols **155–202** from *Actinidia* plants

Fig. 8 (continued)

Fig. 8 (continued)

Fig. 8 (continued)

Fig. 8 (continued)

different organic acid derivatives, the quinic acid derivatives inhibited NF- κ B transcriptional activity with an IC_{50} value of 4.0 μ M [136].

2.3.7 Coumarins

Coumarins are rarely identified from kiwifruit plants, and only eleven members have been reported (258–267, Fig. 11, Table 10). Umbelliferone 258 was obtained from the leaves of *A. polygama* (Sieb. et Zucc.) Miq [109]. A number of studies demonstrate the pharmacological properties of 258 including antitumor, anti-inflammatory, antioxidant, anti-diabetic, and immunomodulatory activities [143–149]. It showed cytotoxicity against MCF-7 and MDA-MB-231 cell lines with IC_{50} values of 15.56 and 10.31 μ M, respectively [148]. Phytochemical examination of the fruits of *A. arguta* led to the isolation of esculetin 259 [135]. Two coumarins were isolated from the roots of *A. deliciosa* and identified as fraxetin 260 and isoscopoletin 261 [150]. Compound 260 showed potent inhibition against lipopolysaccharide (LPS)-induced nitric oxide (NO) generation with an IC_{50} value of 10.11 ± 0.47 μ M [151]. Esculin 263 and fraxin 264 were characterized from the stems and fruits of *A. deliciosa*

(kiwifruit) and *A. chinensis* [152]. Compound 264 showed inhibitory activity towards HepG2 with an IC_{50} value of 14.71 μ M [153].

2.3.8 Lignans

Lignans also had a narrow distribution in kiwi plants, only six members have been identified from *Actinidia* plants (269–274, Fig. 12, Table 11). (+)-Pinoresinol 271, (+)-medioresinol 272, and (–)-syringaresinol 273 were partitioned from the fraction of the roots of *A. arguta* [53]. Compound 271 is a biologically active lignan and widely found in many dietary plants. It was reported to possess antifungal, anti-inflammatory, antioxidant, hypoglycemic, and antitumor activities [158–162]. A study on this compound suggested that 271 displayed significant inhibition of fMLP/CB-induced superoxide anion generation and elastase release, with an IC_{50} value of 1.3 ± 0.2 μ g/mL [159]. The 50% ethanol extract of *A. arguta* showed strong inhibitory effect on α -glucosidase (32.6%), while a bio-guided isolation on the extract gave a bioactive compound pinoresinol diglucoside 274 [138].

Table 7 Information of flavones, isoflavones, and flavonols from *Actinidia* plants

No.	Compound name	Species Refs.	Part	Bioactivity Refs.
155	7,4'-Dihydroxyflavone	<i>A. chinensis</i> Planch [105]	Roots	Anti-inflammatory (in vitro) [106]
156	Formononetin	<i>A. chinensis</i> Planch [105]	Roots	
157	Kaempferol	<i>A. deliciosa</i> [107]	Leaves	Antiproliferation human tumor cell (in vitro) [96] Antioxidant and anti-inflammatory (in vitro) [97] Anticancer (in vitro) [98] Neuroprotection (in vitro) [99]
158	6-C-Glucose-5,7,3',4'-tetrahydroxy flavone	<i>A. arguta</i> [108]	Roots	
159	6-C-Glucose-5,7,4'-trihydroxy flavone	<i>A. arguta</i> [108]	Roots	
160	6-C-Glycopyranosyl-8-C-xyloeyl apigenin	<i>A. polygama</i> [109]	Leaves	
161	Vicenin-I	<i>A. polygama</i> [110]	Aerial Parts	
162	Kaempferol 3-O-glucoside	<i>A. deliciosa</i> [107]	Leaves	
163	Kaempferol 3-O-rhamnoside	<i>A. deliciosa</i> [107]	Leaves	
164	Kaempferol 7-O-glucoside	<i>A. deliciosa</i> [107]	Leaves	
165	Kaempferol 3-O- β -D-galactopyranoside	<i>A. polygama</i> [109]	Leaves	
166	Kaempferol-7-O- β -L-rhamnoside	<i>A. kolomikta</i> [102]	Leaves	
167	Kaempferol-3-O- α -L-rhamnopyranosyl-(1 $\rightarrow$ 6)- β -D-galactopyranoside	<i>A. polygama</i> [109]	Leaves	
168	Kaempferol 3-O-rutinoside	<i>A. deliciosa</i> [107]	Leaves	
169	Kaempferol-7-O-(4"-O-acetyl-rhamnosyl)-3-O-rutinoside	<i>A. kolomikta</i> [111]	Leaves	
170	Kaempferol-3-O- α -L-rhamnopyranosyl-(1 $\rightarrow$ 3)- α -L-rhamnopyranosyl-(1 $\rightarrow$ 6)- β -D-galactopyranoside	<i>A. polygama</i> [109]	Leaves	
171	Kaempferol 3-O- α -L-rhamnopyranosyl-(1 $\rightarrow$ 3)-(2,4-di-O-acetyl- α -L-rhamnopyranosyl) (1 $\rightarrow$ 6)- β -D-galactopyranoside	<i>A. valvata</i> Dunn [100]	Leaves	Anti-free radical (in vitro) [100]
172	Kaempferol 3-O- α -L-rhamnopyranosyl (1 $\rightarrow$ 3)-(4-O-acetyl- α -L-rhamnopyranosyl) (1 $\rightarrow$ 6)- β -D-galactopyranoside	<i>A. valvata</i> Dunn [100]	Leaves	Anti-free radical (in vitro) [100]
173	Kaempferol 3-O- $[\alpha$ -L-rhamnopyranosyl-(1 $\rightarrow$ 3)-(4-O-acetyl)-O- α -L-rhamnopyranosyl-(1 $\rightarrow$ 6)-O-acetyl]-O- β -D-galactopyranoside]	<i>A. polygama</i> [110]	Aerial parts	
174	Kaempferol 3-O- $[\alpha$ -rhamnopyranosyl-(1 $\rightarrow$ 4)-rhamnopyranosyl-(1 $\rightarrow$ 6)- β -galactopyranoside]	<i>A. deliciosa</i> [112]	Leaves	
175	Kaempferol 3-O- $[\alpha$ -rhamnopyranosyl-(1 $\rightarrow$ 4)-rhamnopyranosyl-(1 $\rightarrow$ 6)- β -glucopyranoside]	<i>A. deliciosa</i> [112]	Leaves	
176	Kaempferol 3-O- $[\alpha$ -rhamnopyranosyl-(1 $\rightarrow$ 4)-3"-O-acetyl- α -rhamnopyranosyl-(1 $\rightarrow$ 6)- β -galactopyranoside]	<i>A. deliciosa</i> [112]	Leaves	
177	Kaempferol-7-O- α -L-rhamnosyl-3-O-rutinoside	<i>A. kolomikta</i> [102]	Leaves	
178	Kaempferide-7-O-rhamnoside	<i>A. kolomikta</i> [101]	Leaves	
179	Kaempferide-7-O-(4"-O-acetyl)- α -L-rhamnoside	<i>A. kolomikta</i> [102]	Leaves	Against AAPH-induced hemolysis (in vitro) [102]
180	Kaempferide-3-O-rutinoside	<i>A. kolomikta</i> [113]	Leaves	Anti-free radical (in vitro) [113]
181	Kaempferide-7-O-(4"-O-acetyl-rhamnosyl)-3-O-glucoside	<i>A. kolomikta</i> [113]	Leaves	Anti-free radical (in vitro) [113]

Table 7 (continued)

No.	Compound name	Species Refs.	Part	Bioactivity Refs.
182	Kaempferide-7-O-(4"-O-acetyl-rhamnosyl)-3-O-rutinoside	<i>A. kolomikta</i> [113]	Leaves	Anti-free radical (in vitro) [113] Reducing myocardial infarction (in vivo) [104]
183	Kaempferide-7-O-rhamnosyl-3-O-rutinoside	<i>A. kolomikta</i> [101]	Leaves	
184	Kaempferide-7-O-(3"-O-acetyl-rhamnosyl)-3-O-rutinoside	<i>A. kolomikta</i> [111]	Leaves	
185	Quercetin	<i>A. deliciosa</i> [107]	Leaves	
186	Quercetin-3-O- β -D-glucoside	<i>A. deliciosa</i> [107]	Leaves	
187	Quercetin 3-O-rhamnoside	<i>A. deliciosa</i> [107]	Leaves	
188	Quercetin 7-O-glucoside	<i>A. deliciosa</i> [107]	Leaves	
189	Quercetin 3-O-xyloside	<i>A. deliciosa</i> [107]	Leaves	
190	Quercetin 3-O-arabinoside	<i>A. deliciosa</i> [107]	Leaves	
191	Quercetin 3-O-rutinoside	<i>A. deliciosa</i> [107]	Leaves	
192	Quercetin 3-O-rhamnoside 7-O-glucoside	<i>A. deliciosa</i> [107]	Leaves	
193	Quercetin 3-O- β -D-galactoside	<i>A. polygama</i> [110]	Aerial parts	Anti-DPPH radical and nitric oxide production (in vitro) [110]
194	Quercetin 3-O- β -D-glucofuranoside (isoquercitrin)	<i>A. chinensis</i> Planch [114]		
195	Quercetin 3-O- α -L-rhamnopyranosyl-(1 $\rightarrow$ 6)- β -D-galactopyranoside	<i>A. arguta</i> [108]	Roots	
196	Isorhamnetin-3-O- β -D-glucoside	<i>A. kolomikta</i> [102]	Leaves	
197	Quercetin-3-O- $[\alpha$ -rhamnopyranosyl-(1 $\rightarrow$ 4)-rhamnopyranosyl-(1 $\rightarrow$ 6)- β -galactopyranoside]	<i>A. deliciosa</i> [112]	Leaves	
198	Quercetin 3-O- β -D-[2 ^G -O- β -D-xylopyranosyl-6 ^G -O- α -L-rhamnopyranosyl] glucopyranoside	<i>A. arguta</i> [115]	Leaves	
199	Quercetin 3-O- β -D-xylopyranosyl-(1 $\rightarrow$ 2)-O- β -D-glucopyranoside	<i>A. arguta</i> [115]	Leaves	
200	7-O- $[\beta$ -D-Pyranrhamnose-(1 $\rightarrow$ 6)- β -D-pyran glucose]-5,3'-dihydroxy-4'-methoxy two dihydrogen flavone	<i>A. arguta</i> [108]	Roots	
201	4'-Methoxyl-quercetin-7-(4"-O-acetyl-rhamnosyl)-3-O- β -D-glucopyranoside	<i>A. kolomikta</i> [111]	Leaves	
202	4'-Methoxyl-quercetin-7-(4"-O-acetyl-rhamnosyl)-3-O-rutinoside	<i>A. kolomikta</i> [111]	Leaves	

2.3.9 Simple Phenols

Simple benzene derivatives including glycosides and isoprenylated benzene products from *Actinidia* plants were collected (275–298, Fig. 13, Table 12). Phytochemical examination of the fruits of *A. arguta* led to the isolation of protocatechuic acid 279 [135]. It showed anti-inflammatory [163], antioxidant [163], neuroprotective [164], and anti-proliferative activities [165]. Protocatechuic acid exhibited significant ($p < 0.05$) anti-inflammatory (83% and 88% inhibition for egg-albumin induced and xylene induced oedema, respectively), analgesic (56% inhibition and 22 s of pain suppression for acetic acid-induced and hot plate-induced pain, respectively), and antioxidant effects (97% inhibition

and absorbance of 2.516 at 100 $\mu\text{g/mL}$ for DPPH and FRAP assay, respectively) in the models [166]. Extraction of leaf tissue from the golden-fleshed kiwifruit cultivar *A. chinensis* “Hort16A” expressing genotype-resistance against the fungus *Botrytis cinerea*, a new phenolic compound, 3,5-dihydroxy-2-(methoxycarbonylmethyl)phenyl 3,4-dihydroxybenzoate 278 was therefore obtained [167].

Four novel skeleton phenolic compounds planchols A–D (291–294) were isolated from the roots of *A. chinensis* Planch. Their structures were elucidated by spectroscopic analysis and chemical evidence. The structure of 291 was further confirmed by the single-crystal X-ray diffraction. Moreover, it was found that 291 and 292 showed remarkable cytotoxic activity against P-388 with IC_{50} of 2.50 and

Fig. 9 Structures of xanthenes, isoflavones, and flavonols **203–219** from *Actinidia* plants

Table 8 Information of xanthones, anthocyanins, and emodins from *Actinidia* plants

No.	Compound name	Species Refs.	Part	Bioactivity Refs.
203	2- β -D-Glu-1,3,7-trihydrogen xanthone	<i>A. arguta</i> [108]	Roots	Inhibiting α -Glycosidase (in vitro) [116] NO inhibitory (in vitro) [117] NF- κ B Inhibition and PPAR Activation (in vitro) [118]
204	7-O- $[\beta$ -D-Xylose-(1 $\rightarrow$ 6)- β -D-glucopyranoside]-1,8-dihydroxy-3-methoxy xanthone	<i>A. arguta</i> [108]	Roots	
205	1-O- $[\beta$ -D-Xylose-(1 $\rightarrow$ 6)- β -D-glucopyranoside]-8-hydroxy-3,7-dimethoxy xanthone	<i>A. arguta</i> [108]	Roots	
206	Delphinidin 3-galactoside	<i>A. deliciosa</i> [119]	Fruits	Antioxidation (in vitro) [135]
207	Cyanidin 3-galactoside	<i>A. deliciosa</i> [119]	Fruits	
208	Cyanidin 3-glucoside	<i>A. deliciosa</i> [119]	Fruits	Anti-inflammatory (in vitro) [120, 121] Neuroprotective (in vivo) [122] Anti-cancer (in vitro) [123] Antioxidation (in vivo) [124]
209	Delphinidin 3-[2-(xylosyl)galactoside]	<i>A. deliciosa</i> [119]	Fruits	
210	Cyanidin 3-[2-(xylosyl)galactoside]	<i>A. deliciosa</i> [119]	Fruits	
211	Aloe-emodin	<i>A. deliciosa</i> [125]	Roots	Anti-inflammatory (in vitro) [126] Antifungal (in vitro) [127] Anticancer (in vitro) [128]
212	11-O-Acetyl-aloe-emodin	<i>A. deliciosa</i> [125]	Roots	
213	Aloe-emodin 11-O- α -L-rhamnopyranoside	<i>A. deliciosa</i> [125]	Roots	
214	Physcion (emodin-6-Me ether)	<i>A. chinensis</i> Planch [133]	Roots	
215	Emodin (frangala-emodin)	<i>A. chinensis</i> Planch [133]	Roots	Anti-inflammatory (in vivo and in vitro) [129] Neuroprotection (in vitro) [130] Anti-cardiovascular (in vitro) [131] Inhibiting α -Glucosidase (in vitro) [132]
216	Questin (emodin-8-Me ether)	<i>A. chinensis</i> Planch [133]	Roots	Hepatoprotection (in vitro) [134]
217	Citreorosein (ω -hydroxyemodin)	<i>A. chinensis</i> Planch [133]	Roots	
218	Emodic acid	<i>A. chinensis</i> Planch [133]	Roots	
219	Emodin-8- β -D-glucoside	<i>A. chinensis</i> Planch [133]	Roots	

3.85 μ M, respectively, and against A-549 with IC₅₀ of 1.42 and 2.88 μ M, respectively [94].

2.4 Miscellaneous

Three alkaloids (299–301), eleven fatty acids and derivatives (302–312), and other thirteen small molecules (313–325) were obtained from *Actinidia* plants (Fig. 14, Table 13). Actinidine 299 and boschniakine 300 were isolated from the leaves and galls of *A. polygama* and also

isolated from *A. arguta* which might be converted from iridoids [174, 175]. A bioassay-guided fractionation of the fruits of *A. polygama* led to the separation and identification of a polyunsaturated fatty acid, α -linolenic acid (ALA) 305 [176]. This compound was found to possess a broad biological properties including anti-inflammatory [177], anti-tumor [178], anti-hyperlipidemic [179], anti-diabetic [180], and anti-fungal [181] activities. By a bio-guided fractionation, a ceramide namely actinidiamide 312 was identified as an

Fig. 10 Structures of phenylpropionic acids 220–257 from *Actinidia* plants

Table 9 Information of phenylpropionic acids from *Actinidia* plants

No.	Compound name	Species Refs.	Part	Bioactivity Refs.
220	Caffeic acid	<i>A. arguta</i> [135]	Fruits	Anti-oxidation (in vitro) [135]
221	Caffeoyl- β -D-glucopyranoside	<i>A. arguta</i> [135]	Fruits	Anti-oxidation (in vitro) [135]
222	<i>Trans</i> -ferulic acid	<i>A. polygama</i> [110]	Aerial parts	
223	Coumaric acid 4-O-glucoside	<i>A. polygama</i> [110]	Aerial parts	
224	<i>Trans</i> -phydroxycinnamic acid	<i>A. chinensis</i> [137]	Roots	
225	Caffeic 3-O- β -D-glucopyranoside acid	<i>A. deliciosa</i> [89]	Pulps	
226	Caffeic 4-O- β -D-glucopyranoside acid	<i>A. deliciosa</i> [89]	Pulps	
227	4,4'-Dihydroxyl-dihydrochalcone-2'-O- β -D-glucopyranoside	<i>A. chinensis</i> Plach [52]	Roots	
228	Argutinoside A	<i>A. arguta</i> [136]	Fruits	
229	Argutinoside B	<i>A. arguta</i> [136]	Fruits	
230	Argutinoside C	<i>A. arguta</i> [136]	Fruits	
231	Argutinoside D	<i>A. arguta</i> [136]	Fruits	
232	Argutinoside E	<i>A. arguta</i> [136]	Fruits	
233	Argutinoside F	<i>A. arguta</i> [136]	Fruits	
234	Argutinoside G	<i>A. arguta</i> [136]	Fruits	
235	Argutinoside H	<i>A. arguta</i> [136]	Fruits	
236	Argutinoside I	<i>A. arguta</i> [136]	Fruits	
237	Fertaric acid	<i>A. arguta</i> [138]	Fruits	
238	Cryptochlorogenic acid	<i>A. chinensis</i> [137]	Roots	
239	Neochlorogenic acid	<i>A. chinensis</i> [137]	Roots	Anti-inflammatory (in vitro) [139] Antibacteria and antioxidation (in vitro) [140]
240	3-O-Coumaroylquinic acid	<i>A. chinensis</i> [137]	Roots	
241	Chlorogenic acid	<i>A. deliciosa</i> [89]	Pulp	Antitumor (in vitro) [141] Anti-inflammatory (in vitro) [142]
242	5- <i>Trans</i> - <i>p</i> -coumaroylmalic acid	<i>A. chinensis</i> Radix [50]	Roots	
243	5- <i>Cis</i> - <i>p</i> -coumaroylquinic acid	<i>A. chinensis</i> Radix [50]	Roots	
244	4-O- <i>Cis</i> - <i>p</i> -coumaroylquinic acid	<i>A. chinensis</i> Radix [50]	Roots	
245	3-O- <i>Trans</i> - <i>p</i> -coumaroyl quinic acid methyl ester	<i>A. arguta</i> [136]	Fruits	Inhibiting NF- κ B transcription (in vitro) [136]
246	3-O- <i>Cis</i> - <i>p</i> -coumaroyl quinic acid methyl ester	<i>A. arguta</i> [136]	Fruits	
247	3-O- <i>Trans</i> - <i>p</i> -caffeoyl quinic acid methyl ester	<i>A. arguta</i> [136]	Fruits	
248	5-O- <i>Trans</i> - <i>p</i> -coumaroyl quinic acid methyl ester	<i>A. arguta</i> [136]	Fruits	
249	5-O- <i>Cis</i> - <i>p</i> -coumaroyl quinic acid methyl ester	<i>A. arguta</i> [136]	Fruits	
250	5-O- <i>Trans</i> - <i>p</i> -caffeoyl quinic acid methyl ester	<i>A. arguta</i> [136]	Fruits	
251	5-O- <i>Cis</i> - <i>p</i> -caffeoyl quinic acid methyl ester	<i>A. arguta</i> [136]	Fruits	
252	3-O- <i>Trans</i> - <i>p</i> -caffeoyl quinic acid butyl ester	<i>A. arguta</i> [136]	Fruits	
253	4-O- <i>Trans</i> - <i>p</i> -caffeoyl quinic acid butyl ester	<i>A. arguta</i> [136]	Fruits	
254	5-O- <i>Trans</i> - <i>p</i> -coumaroyl quinic acid butyl ester	<i>A. arguta</i> [136]	Fruits	
255	5-O- <i>Trans</i> - <i>p</i> -caffeoyl quinic acid butyl ester	<i>A. arguta</i> [136]	Fruits	
256	3-O- <i>Trans</i> - <i>p</i> -coumaroyl shikimic acid	<i>A. arguta</i> [136]	Fruits	
257	3-O- <i>Cis</i> - <i>p</i> -coumaroyl shikimic acid	<i>A. arguta</i> [136]	Fruits	

anti-inflammatory component from the EtOAc fraction of *A. polygama* Max. It potently inhibited nitric oxide production (30.6% inhibition at 1 μ g/mL) in lipopolysaccharide (LPS)-stimulated RAW264.7 cells and β -hexosaminidase release

(91.8% inhibition at 1 μ g/mL) in IgE-sensitized RBL-2H3 cells [182].

In summary, this review focused on the biological components and related pharmacological activities of various

Fig. 11 Structures of coumarins 258–268 from *Actinidia* plants

Table 10 Information of coumarins from *Actinidia* plants

No.	Compound name	Species Refs.	Part	Bioactivity Refs.
258	Umbelliferone	<i>A. polygama</i> [109]	Leaves	Anti-tumor (in vitro) [143] Anti-inflammatory (in vitro) [144] Antioxidant (in vitro) [149] Antidiabetic (in vitro and in vivo) [146] Immunomodulatory (in vitro) [148]
259	Esculetin	<i>A. arguta</i> [135]	Fruits	Anti-tumor (in vitro) [154] Anti-oxidant and anti-inflammatory (in vivo) [155]
260	Fraxetin	<i>A. deliciosa</i> [150]	Roots	Anti-inflammatory (in vitro) [151] Anti-tumor (in vitro) [156]
261	Isoscopoletin	<i>A. deliciosa</i> [150]	Roots	Anti-inflammatory [151]
262	Isofraxoside	<i>A. chinensis</i> [137]	Roots	
263	Esculin	<i>A. deliciosa</i> [152]	Stems	
264	Fraxin	<i>A. chinensis</i> [152]	Fruits	Anti-inflammatory (in vivo) [157] Antitumor (in vitro) [153]
265	5-Hydroxy-6-methoxy-7-O- β -D-glycopyranosylcoumarin	<i>A. chinensis</i> Radix [50]	Roots	
266	6'-Acetoxy-8- β -D-glucopyranosyloxy-7-hydroxy-6-methoxy-coumarin	<i>A. chinensis</i> Radix [50]	Roots	
267	6-Hydroxy-7-(β -D-glucopyranosyloxy) coumarin	<i>A. deliciosa</i> [89]	Peels	
268	6,8-Dimethoxy-7-(β -D-glucopyranosyloxy) coumarin	<i>A. deliciosa</i> [89]	Peels

Fig. 12 Structures of lignans **269–274** from *Actinidia* plants

Table 11 Information of of lignans from *Actinidia* plants

No.	Compound name	Species Refs.	Part	Cytotoxicity Refs.
269	Urolingoside	<i>A. polygama</i> [110]	Aerial parts	Roots
270	4'-O-β-Dxylopyranoside	<i>A. chinensis</i> Radix [50]		
271	(+)-Pinoresinol	<i>A. arguta</i> [53]	Roots	
				Antifungal (in vitro) [158]
				Anti-inflammatory (in vitro) [159]
				Antioxidation (in vitro) [160]
				Hypoglycemic (in vitro) [161]
				Anti-tumor (in vitro) [162]
272	(+)-Medioresinol	<i>A. arguta</i> [53]	Roots	
273	(-)-Syringaresinol	<i>A. arguta</i> [53]	Roots	
274	Pinoresinol diglucoside	<i>A. arguta</i> [138]	Leaves	Inhibiting α-glucosidase (in vitro) [138]

Fig. 13 Structures of simple phenols 275–298 from *Actinidia* plants

parts of *Actinidia* plants, including triterpenoids, steroids, flavonoids, catechins, coumarins, lignans, phenols, and other small organic molecules. A total of 325 molecules have been collected in this review. Most of the active molecules are derived from the roots of *Actinidia* plants, while triterpenes and flavonoids are the most important types regardless of the number of compounds and their biological activity significance. The stems, leaves, fruit galls, and other parts of kiwi are mainly rich in flavonoids, phenylpropionic acids, and

other small molecule compounds. Currently, these chemical components are not structurally novel. In addition, there are few in-depth researches on pharmacological activities of the bioactive compounds. Therefore, research on the chemical constituents of *Actinidia* plants is still promising. We hope that this review can provide positive information for the further exploration of the chemical components and their biological activities of *Actinidia* plants.

Table 12 Information of simple phenols from *Actinidia* plants

No.	Compound name	Species Refs.	Part	Bioactivity Refs.
275	Tyrosol	<i>A. arguta</i> [168]	Roots	Anti-inflammatory (in vitro) [151]
276	2,2-Dimethyl-6-chromancarboxylic acid	<i>A. deliciosa</i> [150]	Roots	
277	Monodictyphenone	<i>A. chinensis</i> Radix [50]	Roots	Inhibiting protein tyrosine phosphatase (in vitro) [169]
278	3,5-Dihydroxy-2-(methoxycarbonyl methyl) phenyl 3,4-dihydroxybenzoate	<i>A. chinensis</i> [167]	Leaves	
279	Protocatechuic acid	<i>A. arguta</i> [135]	Fruits	Anti-inflammatory and antioxidant (in vitro and in vivo) [163] Neuroprotective (in vitro) [164] Anti-proliferative (in vitro) [165]
280	4-Hydroxy benzoic acid	<i>A. arguta</i> [92]	Roots	
281	Vanillic acid	<i>A. deliciosa</i> [150]	Roots	
282	4-(β -D-Glucopyranosyloxy)-3-hydroxybenzoic acid	<i>A. chinensis</i> Radix [50]	Roots	
283	<i>p</i> -Hydroxybenzaldehyde	<i>A. chinensis</i> Radix [50]	Roots	
284	Tachioside	<i>A. deliciosa</i> [150]	Roots	
285	Syringaldehyde	<i>A. chinensis</i> Planch [105]	Roots	Anti-inflammatory (in vitro) [170]
286	Vanillic acid 4-O- β -D-glucopyranoside	<i>A. deliciosa</i> [150]	Roots	
287	Protocatechualdehyde	<i>A. chinensis</i> [171]	Roots	Antioxidant and anti-inflammatory (in vitro) [172]
288	4-Hydroxy-2-methoxyphenyl- β -D-glucopyranoside	<i>A. macrosperma</i> [66]	Roots	
289	Erythro-1,2-bis-(4-hydroxy-3-methoxyphenyl)-1,3-propanediol	<i>A. chinensis</i> [171]	Roots	
290	Threo-1,2-bis-(4-hydroxy-3-methoxyphenyl)-1,3-propanediol	<i>A. chinensis</i> [171]	Roots	
291	Planchols A	<i>A. chinensis</i> Planch [94]	Roots	Against P-388 and A-549 cell lines (in vitro) [94]
292	Planchols B	<i>A. chinensis</i> Planch [94]	Roots	Against P-388 and A-549 cell lines (in vitro) [94]
293	Planchols C	<i>A. chinensis</i> Planch [94]	Roots	Against P-388 and A-549 cell lines (in vitro) [94]
294	Planchols D	<i>A. chinensis</i> Planch [94]	Roots	Against P-388 and A-549 cell lines (in vitro) [94]
295	2,8-Dimethyl-2-(4,8,12-trimethyltridec-11-enyl) chroman-6-ol	<i>A. deliciosa</i> [89]	Peels	
296	α -Tocopherol	<i>A. deliciosa</i> [89]	Peels	
297	δ -Tocopherol	<i>A. deliciosa</i> [89]	Peels	
298	2,8-Dimethyl-2-(4,8,12-trimethyltridec-11-enyl) chroman-6-ol	<i>A. chinensis</i> [173]	Peels

Fig. 14 Structures of other molecules 299–325 from *Actinidia* plants

Table 13 Information other molecules from *Actinidia* plants

No.	Compound name	Species Refs.	Part	Bioactivity Refs.
299	Actinidine	<i>A. polygama</i> [174]	Leaves and galls	Anti-obesity (in vivo) [183]
300	Boschniakine	<i>A. arguta</i> [175]		
301	Indole-3-carboxylic acid	<i>A. chinensis</i> Planch [184]	Roots	
302	Undecanoic acid	<i>A. deliciosa</i> [185]	Roots	Anti-inflammatory (in vivo) [186]
303	n-Stearic acid	<i>A. deliciosa</i> [150]	Roots	
304	Tetracosanoic acid	<i>A. eriantha</i> Benth [41]	Roots	
305	α -Linolenic acid	<i>A. polygama</i> [176]	Fruits	Anti-inflammatory (in vivo) [177] Anti-tumor (in vivo) [178] Anti-hyperlipidemic (in vivo) [179] Anti-diabetic (in vivo) [180] Anti-fungal (in vitro) [181]
306	(9Z,11E)-13-Hydroxy-9,11-octadecadienoic acid	<i>A. chinensis</i> Radix [50]	Roots	
307	Ricinoleic acid	<i>A. chinensis</i> Radix [50]	Roots	
308	Lignoceric acid	<i>A. chinensis</i> Planch [187]	Roots	
309	Stearyl- β -D-glucopyranoside	<i>A. chinensis</i> Planch [187]	Roots	
310	Dotriacontanic acid	<i>A. chinensis</i> Planch [52]	Roots	
311	Sphingolipid	<i>A. chinensis</i> Planch [52]	Roots	
312	Actinidiamide	<i>A. polygama</i> [182]	Fruits	Anti-inflammatory (in vitro) [182]
313	n-Butyl-O- β -D-fructopyranoside	<i>A. deliciosa</i> [188]	Roots	
314	Sucrose	<i>A. chinensis</i> Planch [187]	Roots	
315	γ -Quinide	<i>A. chinensis</i> Planch [187]	Roots	
316	1-Methyl-5-ethyl citrate	<i>A. arguta</i> [136]	Fruits	
317	1,6-Dimethyl citrate	<i>A. arguta</i> [136]	Fruits	
318	1,5,6-Trimethyl citrate	<i>A. arguta</i> [136]	Fruits	
319	1,6-Dimethyl-5-ethyl citrate	<i>A. arguta</i> [136]	Fruits	
320	6-Butyl citrate	<i>A. arguta</i> [136]	Fruits	
321	1-Methyl-6-butyl citrate	<i>A. arguta</i> [136]	Fruits	
322	Succinic acid	<i>A. kolomikta</i> [189]	Leaves	
323	Meso-inositol	<i>A. kolomikta</i> [189]	Leaves	
324	Maltose	<i>A. kolomikta</i> [189]	Leaves	
325	α -Kolomiktriase	<i>A. kolomikta</i> [190]	Roots	

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