

Review

Actinidia arguta (Sieb. et Zucc.) Planch. ex Miq.: A Review of Phytochemistry and Pharmacology

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Abstract: *Actinidia arguta* (Siebold & Zucc.) Planch ex Miq. (*A. arguta*) is a highly valued vine plant belonging to the *Actinidia* lindl genus. It is extensively utilized for its edible and medicinal properties. The various parts of *A. arguta* serve diverse purposes. The fruit is rich in vitamins, amino acids, and vitamin C, making it a nutritious and flavorful raw material for producing jam, canned food, and wine. The flowers yield volatile oils suitable for essential oil extraction. The leaves contain phenolic compounds and can be used for tea production. Additionally, the roots, stems, and leaves of *A. arguta* possess significant medicinal value, as they contain a wide array of active ingredients that exert multiple pharmacological and therapeutic effects. These effects include quenching thirst, relieving heat, stopping bleeding, promoting blood circulation, reducing swelling, dispelling wind, and alleviating dampness. Comprehensive information on *A. arguta* was collected from scientific databases covering the period from 1970 to 2023. The databases used for this review included Web of Science, PubMed, ProQuest, and CNKI. The objective of this review was to provide a detailed explanation of *A. arguta* from multiple perspectives, such as phytochemistry and pharmacological effects. By doing so, it aimed to establish a solid foundation and propose new research ideas for further exploration of the plant's potential applications and industrial development. To date, a total of 539 compounds have been isolated and identified from *A. arguta*. These compounds include terpenoids, flavonoids, phenolics, phenylpropanoids, lignin, organic acids, volatile components, alkanes, coumarins, anthraquinones, alkaloids, polysaccharides, and inorganic elements. Flavonoids, phenolics, alkaloids, and polysaccharides are the key bioactive constituents of *A. arguta*. Moreover, phenolics and flavonoids in *A. arguta* exhibit remarkable antioxidant, anti-inflammatory, and anti-tumor properties. Additionally, they show promising potential in improving glucose metabolism, combating aging, reducing fatigue, and regulating the immune system. While some fundamental studies on *A. arguta* have been conducted, further research is necessary to enhance our understanding of its mechanism of action, quality evaluation, and compatibility mechanisms. A more comprehensive investigation is highly warranted to explore the mechanism of action and expand the range of drug resources associated with *A. arguta*. This will contribute to the current hot topics of anti-aging and anti-tumor drug research and development, thereby promoting its further development and utilization.

Keywords: *Actinidia arguta* (Sieb. et Zucc.) Planch. ex Miq.; secondary metabolites; flavonoids; phenolics; pharmacological effects



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1. Introduction

The *Actinidia* lindl genus belongs to the Actinidiaceae family and comprises more than 54 species, including deciduous, semi-deciduous, and evergreen vines. *Actinidia arguta* (Sieb. et Zucc.) Planch. ex Miq. (*A. arguta*), which is commonly known as kiwiberry (Figure 1), is a large deciduous vine found in China, Korea, Japan, and Russia. It thrives in

mixed forests and well-watered environments, particularly at altitudes ranging from 500 to 1500 m [1]. Another noteworthy plant within this genus is *Actinidia chinensis* Planch., which contributes to China's role as the world's leading kiwifruit producer [2]. These two species display distinct morphological characteristics, making them easily distinguishable. The primary difference lies in the size and appearance of the fruit. *A. arguta* produces relatively smaller, smooth, green-skinned fruit, while *Actinidia chinensis* bears larger, brown-skinned fruit covered in fuzz [3].

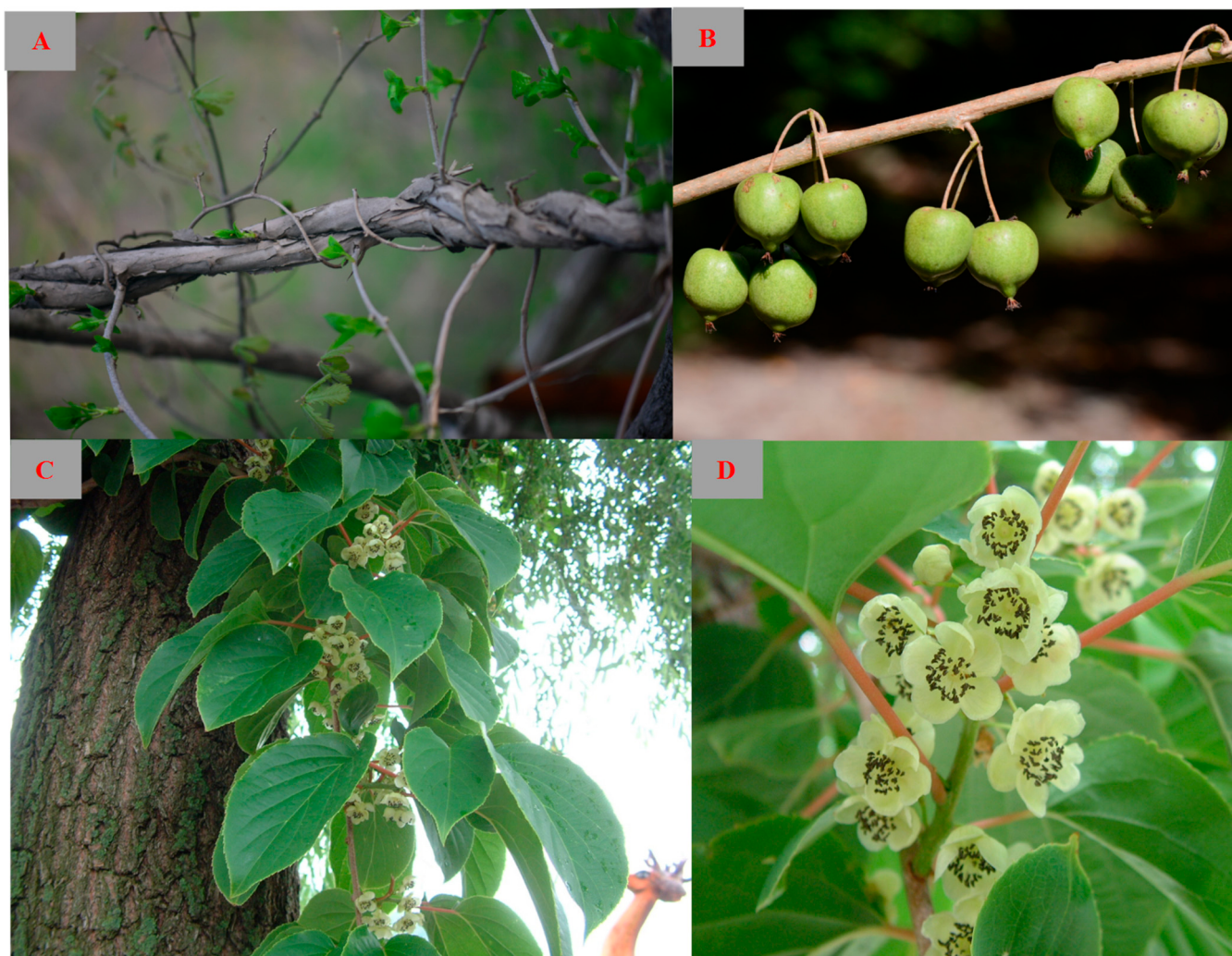


Figure 1. Stems (A), fruit (B), leaves (C), and flowers (D) of *Actinidia arguta*.

The roots of *A. arguta* possess significant medicinal properties [4]. Its benefits have been documented in the “Dietary Materia Medica” of the Tang Dynasty and the “Compendium of Materia Medica” of the Ming Dynasty. Traditionally, the roots have been used to quench thirst, relieve heat, stop bleeding, promote blood circulation, reduce swelling, dispel wind, and alleviate dampness. In modern clinical practice, it is employed in the treatment of ailments such as rheumatism, lymphoid tuberculosis, esophageal cancer, gastric cancer, and breast cancer. Additionally, *A. arguta* is valued both as an ornamental tree species and a fruit tree. Its leaves contain polyphenolic compounds suitable for tea preparation [5]. The fruit, which is known for its potent antipyretic and astringent effects, is also highly nutritious and widely consumed [6]. Its small size and seeds make it ideal for fresh consumption, as well as for making jam, canned food, and wine [7–9]. The flesh is tender and juicy, offering a delightful sweet and sour flavor. Abundant in amino acids, vitamins, and minerals,

particularly vitamin C, which surpasses other fruits by severalfold, the *A. arguta* fruit is a valuable ingredient for the development of functional health foods [10,11].

Extensive research identified and isolated over 500 compounds from *A. arguta*, spanning various categories, such as terpenoids, phenolics, flavonoids, phenylpropanoids, lignin, organic acids, volatile oils, steroids, anthraquinones, coumarins, alkaloids, and amino acids [12]. Notably, terpenoids, phenolics, and flavonoids have garnered significant attention due to their immense potential for development and utilization.

While studies summarizing the phytochemistry and pharmacological effects of *A. arguta* exist, certain information gaps and inadequacies need to be addressed. These include an incomplete listing of chemical components and insufficient details regarding their chemical structures. Additionally, the description of the pharmacological mechanism of *A. arguta* lacks thoroughness. A previous report discussed the chemical components and pharmacological effects of *A. arguta* [13]. However, this previous review only provided brief introductions to the names of over 60 chemical components, their total extracts, and a concise overview of the anti-tumor, antioxidant, and hypoglycemic effects. In contrast, our review encompasses a total of 539 components, complete with structural information for each compound. Furthermore, our review delves into distinct classifications of pharmacological research, providing an up-to-date and comprehensive observational perspective on *A. arguta*.

Therefore, we conducted a comprehensive literature review to address the aforementioned gaps by offering a comprehensive examination of the phytochemistry and pharmacological effects of *A. arguta*. We aimed to inspire future research on *A. arguta* while providing valuable references for the rational utilization of its resources and the efficient development of related products.

2. Materials and Methods

To ensure the reliability and integrity of the information gathered for this review, we meticulously collected data from numerous databases including Web of Science, PubMed, ProQuest, and the China National Knowledge Infrastructure (CNKI). Our literature search encompassed articles published in peer-reviewed journals, Ph.D. dissertations, master's theses, conference papers, and classic texts of Chinese herbal medicines. To maximize the breadth of our research, we employed specific keywords during the literature search, such as *Actinidia arguta*, phytochemistry, secondary metabolites, pharmacology, biological activity, safety, toxicology, medicinal uses, and other related terms. This enabled us to retrieve a comprehensive range of relevant studies published between 1970 and November 2023.

3. Phytochemistry

Given the successful isolation and identification of numerous bioactive compounds from the roots, stems, leaves, and fruit of *A. arguta*, there is a growing interest in utilizing the fruit of *A. arguta* as raw materials for health food and the roots, stems, and leaves of *A. arguta* as medicinal resources [2–11]. *A. arguta* contains a diverse range of compounds, with over 500 compounds isolated from the plant according to literature reports [12]. These compounds can be broadly categorized into eight types, including terpenoids, flavonoids, phenolics, phenylpropanoid and lignin compounds, organic acids, and volatile compounds. This emphasizes the abundant potential of *A. arguta* as a source of bioactive ingredients that can be further explored in drug development, functional food production, and nutritional applications [13].

3.1. Terpenoids

Terpenoids are primarily found in *A. arguta*, consisting mainly of triterpenoids and their glycosides, with a small amount of sesquiterpenoids. These terpenoids are primarily isolated from the roots and leaves of the plant. With 25 identified terpenoids (Table 1, Figure 2), primarily belonging to the ursane and oleanane types, ursolic acid and oleanolic acid were initially isolated from the leaves [14] and roots [15] of *A. arguta*. Shi et al. (1993) iso-

lated and identified three triterpenoids from the leaves of *A. arguta*: 3 β -hydroxyurs-12-en-28-oic acid (**1**), 3 β ,24-dihydroxyurs-12-en-28-oic acid (**2**) [16], and 2 α ,3 α ,24-trihydroxyurs-12-en-28-oic acid (**3**) [17]. Teng et al. (2019) employed high-performance liquid chromatography-mass spectrometry (HPLC-MS) analysis to identify two triterpenoid compounds, namely, 2 α ,3 β -dihydroxyurs-12-en-28,30-olide (**4**) and 12 α -chloro-2 α ,3 β ,23-tetrahydroxyolean-28-oic acid-13-lactone (**5**) [18]. Zhao et al. (1994) isolated and identified acetyl oleanolic acid from the stem of *A. arguta* [19]. Ahn et al. (2020) isolated eight known triterpenoids and seven new triterpenoids, including actiniargupenes A–F (**10–12**, **17–19**) and dehydroisoactinidic acid (**16**), from the leaves of *A. arguta*. All the compounds (100 μ M) demonstrated inhibitory effects on α -glucosidase activity. Among them, 3-O-*trans-p*-coumaroylasiatic acid (**20**) outperformed acarbose, while actiniargupene E (**18**) and actiniargupene A (**10**) exhibited comparable effects to acarbose [20]. Li et al. (2020) first isolated a new norsesquiterpene glycoside, namely, (2*R*,6*R*,9*R*)-trihydroxy-megastigmane-4,7*E*-dien-3-one-9-O- β -D-glucopyranoside (**24**), and a monoterpenoid, namely, (6*S*, 9*R*)-roseoside (**25**), from the fruit of *A. arguta* [21].

Table 1. Terpenoids isolated from *Actinidia arguta*.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
1	3 β -Hydroxyurs-12-en-28-oic acid	C ₃₀ H ₄₈ O ₃	456.3603	Leaves	EI-MS, ¹ H-NMR, ¹³ C-NMR	[16]
2	3 β ,24-Dihydroxyurs-12-en-28-oic acid	C ₃₀ H ₄₈ O ₄	472.3553	Leaves	IR, EI-MS, ¹ H-NMR, ¹³ C-NMR	[16]
3	2 α ,3 α ,24-Trihydroxyurs-12-en-28-oic acid	C ₃₀ H ₄₈ O ₅	488.3502	Leaves	IR, EI-MS, ¹ H-NMR	[17]
4	2 α ,3 β -Dihydroxyurs-12-en-28,30-olide	C ₃₀ H ₄₆ O ₄	470.3396	Roots	HPLC-DAD-ESI-MS	[18]
5	12 α -Chloro-2 α ,3 β ,23-tetrahydroxyolean-28-oic acid-13-lactone	C ₃₀ H ₄₇ O ₅ Cl	522.3112	Roots	HPLC-DAD-ESI-MS	[18]
6	Oleanolic acid	C ₃₀ H ₄₈ O ₃	456.3603	Roots	HPLC	[14,15]
7	Ursolic acid	C ₃₀ H ₄₈ O ₃	456.3603	Roots, stems	IR, MS, ¹³ C-NMR	[14,15,19]
8	Acetyl oleanolic acid	C ₃₂ H ₅₀ O ₄	498.3709	Stems	IR, MS, ¹ H-NMR, ¹³ C-NMR	[19]
9	Actinidic acid	C ₃₀ H ₄₆ O ₅	486.3345	Leaves	UV, IR, HR-ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HSQC, HMBC, NOESY	[20]
10	Actiniargupene A	C ₃₀ H ₄₆ O ₄	470.3396	Leaves	UV, IR, HR-ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HSQC, HMBC, NOESY	[20]

Table 1. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
11	Actiniargupene B	C ₃₉ H ₅₂ O ₇	632.3713	Leaves	UV, IR, HR-ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HSQC, HMBC, NOESY	[20]
12	Actiniargupene C	C ₃₉ H ₅₂ O ₇	632.3713	Leaves	UV, IR, HR-ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HSQC, HMBC, NOESY	[20]
13	3-O- <i>trans-p</i> -Coumaroyl actinidic acid	C ₃₉ H ₅₂ O ₇	632.3713	Leaves	IR, HR-ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HSQC, HMBC, NOESY	[20]
14	3-O- <i>cis-p</i> -Coumaroyl actinidic acid	C ₃₉ H ₅₂ O ₇	632.3713	Leaves	IR, HR-ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HSQC, HMBC, NOESY	[20]
15	2 α ,3 α ,23-Trihydroxyursa-12,20(30)-dien-28-oic acid	C ₃₉ H ₅₂ O ₇	632.3713	Leaves	IR, HR-ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HSQC, HMBC, NOESY	[20]
16	Dehydroisoactinidic acid	C ₃₀ H ₄₆ O ₅	486.3345	Leaves	UV, IR, HR-ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HSQC, HMBC, NOESY	[20]
17	Actiniargupene D	C ₃₉ H ₅₄ O ₇	634.3870	Leaves	UV, IR, HR-ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HSQC, HMBC, NOESY	[20]
18	Actiniargupene E	C ₃₉ H ₅₄ O ₈	650.3819	Leaves	UV, IR, HR-ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HSQC, HMBC, NOESY	[20]
19	Actiniargupene F	C ₃₉ H ₅₄ O ₇	634.3870	Leaves	UV, IR, HR-ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HSQC, HMBC, NOESY	[20]

Table 1. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
20	3-O- <i>trans-p</i> -Coumaroylasiatic acid	C ₃₉ H ₅₄ O ₇	634.3870	Leaves	UV, IR, HR-ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HSQC, HMBC, NOESY	[20]
21	23-O- <i>trans-p</i> -Coumaroylasiatic acid	C ₃₉ H ₅₄ O ₇	634.3870	Leaves	UV, IR, HR-ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HSQC, HMBC, NOESY	[20]
22	11 α -Methoxyurs-12-ene-3 β ,12-diol	C ₃₁ H ₅₂ O ₃	472.3916	Leaves	UV, IR, HR-ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HSQC, HMBC, NOESY	[20]
23	Ilelatifol A	C ₃₀ H ₄₈ O ₃	456.3603	Leaves	UV, IR, HR-ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HSQC, HMBC, NOESY	[20]
24	(2 <i>R</i> ,6 <i>R</i> ,9 <i>R</i>)-Trihydroxy-megastigmane-4,7 <i>E</i> -dien-3-one-9-O- β -D-glucopyranoside	C ₁₉ H ₃₀ O ₉	402.1890	Fruit	UV, ¹ H-NMR, ¹³ C-NMR, HRESI-TOF-MS, HMBC, NOESY, HPLC, ECD	[21]
25	(6 <i>S</i> ,9 <i>R</i>)-Roseoside	C ₁₉ H ₃₀ O ₈	386.0941	Fruit	ESI-MS, ¹ H-NMR, ¹³ C-NMR, ECD	[21]

UV: ultraviolet spectrophotometry; IR: infrared spectroscopy; ¹³C-NMR: carbon-13 nuclear magnetic resonance spectrometry; ¹H-NMR: hydrogen-1 nuclear magnetic resonance spectrometry; ESI-MS: electrospray ionization-mass spectrometry; MS: mass spectrometry; HMBC: ¹H-detected heteronuclear multiple bond correlation; NOESY: nuclear Overhauser effect spectroscopy; HPLC: high-performance liquid chromatography; ECD: electrical conductivity detector; HRESI-TOF-MS: high-resolution electrospray ionization-time of flight-mass spectrometry; HPLC-DAD-ESI-MS: high-performance liquid chromatography-diode array detection-electrospray ionization-mass spectrometry.

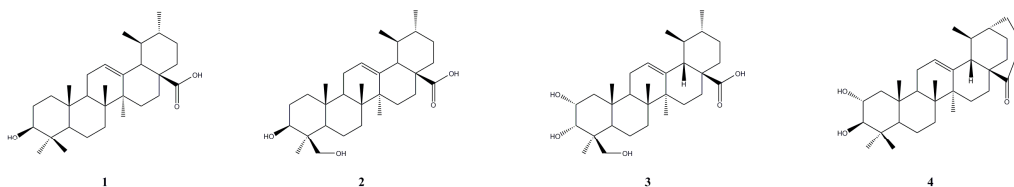


Figure 2. Cont.

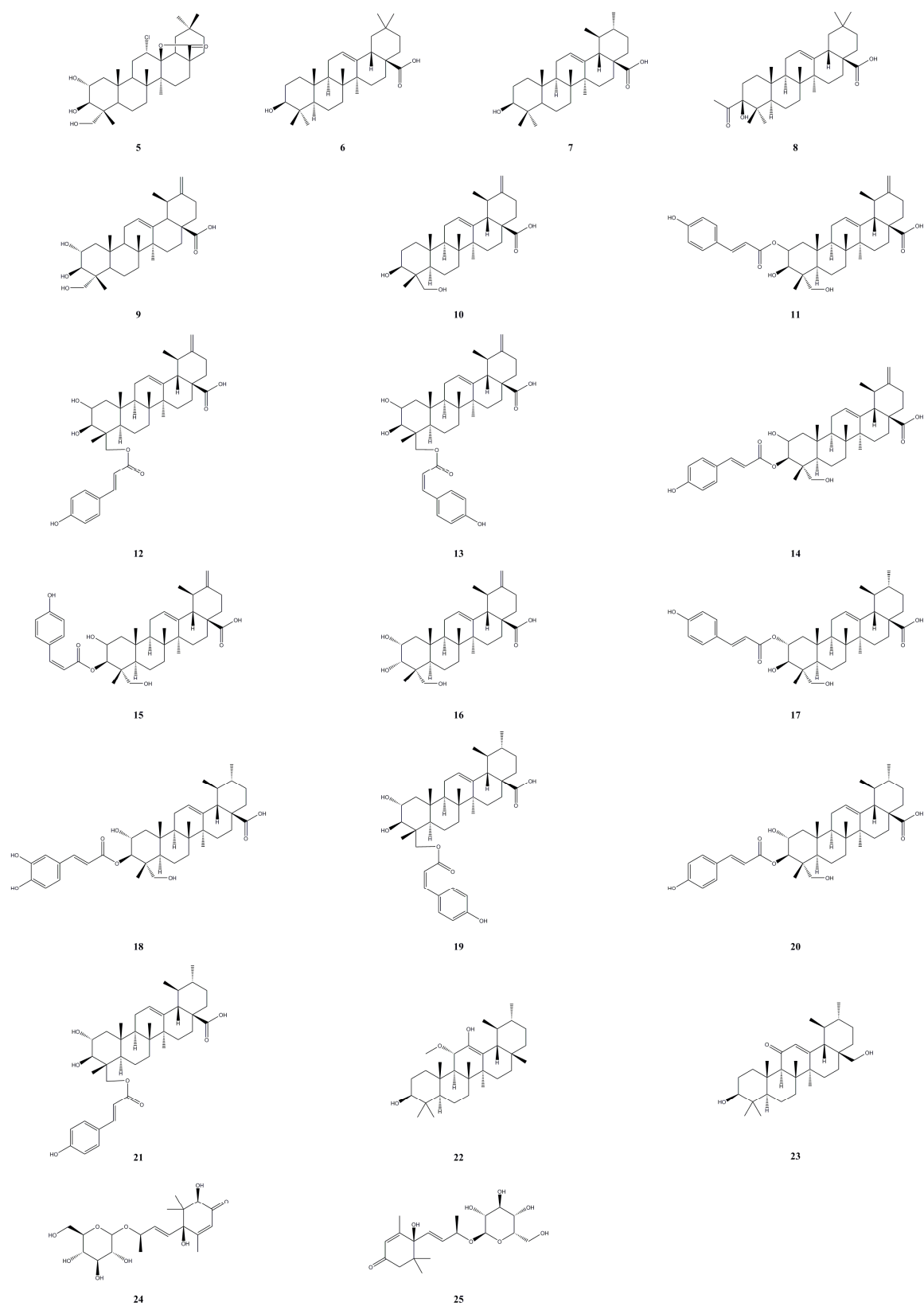


Figure 2. Chemical structures of terpenoids isolated from *Actinidia arguta*. Chemical structures were drawn using Chemdraw Professional 15.0 software.

3.2. Flavonoids

In recent years, 28 flavonoids were isolated and identified from the roots, fruit, and leaves of *A. arguta* (Table 2, Figure 3). One study reported the identification of rutin (26) and quercetin (27) using HPLC technology and comparing them with reference materials [22]. HPLC-MS analysis was also utilized to identify 15 flavonoids from *A. arguta*, including kaempferol-3-O-rutinoside (+) (40), kaempferol-3-O-rutinoside (−) (41), kaempferol-3-O-neohesperidoside (42), isorhamnetin-3-O-neohesperidoside (+) (43), isorhamnetin-3-O-neohesperidoside (−) (44), isorhamnetin-3-O-rutinoside (45), isorhamnetin-3-O-neohesperidoside (46), quercetin-3-O-rhamnoglucoside (47), and isorhamnetin-3-O- α -L-rhamnopyranosyl-(1-3)- α -L-rhamnopyranosyl-(1-6)- β -D-galactopyranoside (53) [23]. Other isolated flavonoids include proanthocyanidin B2 (30), proanthocyanidin C1 (31), (+)-gallocatechin (32), quercetin-3-O-galactoside (33), quercetin-3-O-rutinoside (34), and quercetin-3-O-glucoside (35); the presence of these compounds is the reason for strong antioxidant activity of *A. arguta*, as evidenced by peroxyl radical scavenging capacity and cellular antioxidant activity assays [24]. Additionally, Li et al. (2020) isolated two flavonoid monosaccharide glycosides from the fruit: quercetin-3-O- β -D-galactopyranoside (48) and astragalin (36) [21]. From the roots of *A. arguta*, five flavonoids were isolated and identified: (−)-*epi*-catechin (28), (+)-catechin (29), procyanidin B4 (37), 6-(2-pyrrolidinone-5-yl)-(−)-epicatechin (38), and 8-(2-pyrrolidinone-5-yl)-(−)-epicatechin (39). Among them, 37 and 29 exhibited the most potent inhibitory activity against advanced glycation end product formation, with half-maximal inhibitory concentration (IC₅₀) values of 10.1 μ M and 13.6 μ M, respectively. Flavonoids 38, 39, and 28 also demonstrated significant activities in the assay, with IC₅₀ values of 36.0, 47.8, and 125.2 μ M, respectively, suggesting their potential in the treatment of diabetes-related complications and diseases [25]. From the leaves of *A. arguta*, four flavonoids were sequentially isolated and identified: quercetin-3-O-[α -rhamnopyranosyl-(1-4)-rhamnopyranosyl-(1-6)- β -galactopyranoside (49), kaempferol-3-O-[α -rhamnopyranosyl-(1-4)-rhamnopyranosyl-(1-6)- β -galactopyranoside (50), quercetin 3-sambubioside (51), and quercetin 3-O- β -D-[2-O- β -D-xylopyranosyl-6-O- α -L-rhamnopyranosyl] glucopyranoside (52) [26,27].

Table 2. Flavonoids isolated from *Actinidia arguta*.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
26	Rutin	C ₂₇ H ₃₀ O ₁₆	610.1534	Skin and flesh of the ripe fruit	HPLC	[22]
27	Quercetin	C ₁₅ H ₁₀ O ₇	302.0427	Skin and flesh of the ripe fruit	HPLC	[22]
28	(−)- <i>epi</i> -Catechin	C ₁₅ H ₁₄ O ₆	290.0790	Roots	ESI-MS, ¹ H-NMR, ¹³ C-NMR	[25]
29	(+)-Catechin	C ₁₅ H ₁₄ O ₆	290.0790	Roots	ESI-MS, ¹ H-NMR, ¹³ C-NMR	[25]
30	Proanthocyanidin B2	C ₃₀ H ₂₆ O ₁₂	578.1424	Fruit	UV, HPLC-MS	[24]
31	Proanthocyanidin C1	C ₄₅ H ₃₈ O ₁₈	866.2058	Fruit	UV, HPLC-MS	[24]
32	(+)-Gallocatechin	C ₁₅ H ₁₄ O ₇	306.0740	Fruit	UV, HPLC-MS	[24]
33	Quercetin-3-O-galactoside	C ₂₁ H ₂₀ O ₁₂	464.0955	Fruit	UV, HPLC-MS	[24]
34	Quercetin-3-O-rutinoside	C ₂₇ H ₃₀ O ₁₆	610.1534	Fruit	UV, HPLC-MS	[24]
35	Quercetin-3-O-glucoside	C ₂₁ H ₂₀ O ₁₂	464.0955	Fruit	UV, HPLC-MS	[24]
36	Astragalin	C ₂₁ H ₂₀ O ₁₁	448.1006	Fruit	ESI-MS, ¹ H-NMR, ¹³ C-NMR	[21]
37	Procyanidin B4	C ₃₀ H ₂₆ O ₁₂	578.1424	Roots	ESI-MS, ¹ H-NMR, ¹³ C-NMR	[25]

Table 2. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
38	6-(2-Pyrrolidinone-5-yl)- (-)-epicatechin	C ₁₉ H ₁₉ NO ₇	373.1162	Roots	IR, ESI-MS, HR-ESI-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[25]
39	8-(2-Pyrrolidinone-5-yl)- (-)-epicatechin	C ₁₉ H ₁₉ NO ₇	373.1162	Roots	IR, FAB-MS, HR-FAB-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[25]
40	Kaempferol-3-O- rutinoside (+)	C ₂₇ H ₃₀ O ₁₅	594.1585	Fruit	LC-MS/MS	[23]
41	Kaempferol-3-O- rutinoside (-)	C ₂₇ H ₃₀ O ₁₅	594.1585	Fruit	LC-MS/MS	[23]
42	Kaempferol-3-O- neohesperidoside	C ₂₇ H ₃₀ O ₁₅	594.1585	Fruit	LC-MS/MS	[23]
43	Isorhamnetin-3-O- neohesperidoside (+)	C ₂₈ H ₃₂ O ₁₆	624.1690	Fruit	LC-MS/MS	[23]
44	Isorhamnetin-3-O- neohesperidoside (-)	C ₂₈ H ₃₂ O ₁₆	624.1690	Fruit	LC-MS/MS	[23]
45	Isorhamnetin-3-O- rutinoside	C ₂₈ H ₃₂ O ₁₆	624.1690	Fruit	LC-MS/MS	[23]
46	Isorhamnetin-3-O- neohesperidoside	C ₂₈ H ₃₂ O ₁₆	624.1690	Fruit	LC-MS/MS	[23]
47	Quercetin-3-O- rhamnoglucoside	C ₂₅ H ₂₈ O ₁₅	568.1428	Fruit	LC-MS/MS	[23]
48	Quercetin-3-O-β-D- galactopyranoside	C ₂₁ H ₂₀ O ₁₂	464.0955	Fruit	ESI-MS, ¹ H-NMR, ¹³ C-NMR	[21]
49	Quercetin-3-O-[α- rhamnopyranosyl-(1-4)- rhamnopyranosyl-(1-6)-β- galactopyranoside	C ₃₇ H ₄₈ O ₂₀	812.2739	Plant material	UV, MS, ¹ H-NMR, ¹³ C-NMR	[26]
50	Kaempferol-3-O-[α- rhamnopyranosyl-(1-4)- rhamnopyranosyl-(1-6)-β- galactopyranoside	C ₃₇ H ₄₈ O ₁₉	796.2790	Plant material	¹ H-NMR, ¹³ C-NMR	[26]
51	Quercetin 3-sambubioside	C ₂₆ H ₂₈ O ₁₆	596.1377	Leaves	PC, GC, UV, ¹ H-NMR, ¹³ C-NMR	[27]
52	Quercetin 3-O-β-D-[2-O-β- D-xylopyranosyl-6-O-α-L- rhamnopyranosyl] glucopyranoside	C ₃₂ H ₃₈ O ₂₀	742.1956	Leaves	PC, GC, UV, ¹ H-NMR, ¹³ C-NMR	[27]
53	Isorhamnetin-3-O-α-L- rhamnopyranosyl-(1-3)-α- L-rhamnopyranosyl-(1-6)- β-D-galactopyranoside	C ₃₄ H ₄₂ O ₂₀	770.2269	Fruit	LC-MS/MS	[23]

UV: ultraviolet spectrophotometry; IR: infrared spectroscopy; PC: paper chromatography; GC: gas chromatography; ¹³C-NMR: carbon-13 nuclear magnetic resonance spectrometry; ¹H-NMR: hydrogen-1 nuclear magnetic resonance spectrometry; ESI-MS: electrospray ionization-mass spectrometry; MS: mass spectrometry; HMBC: ¹H-detected heteronuclear multiple bond correlation; HPLC: high-performance liquid chromatography; LC-MS/MS: liquid chromatography-mass spectrometry/mass spectrometry.

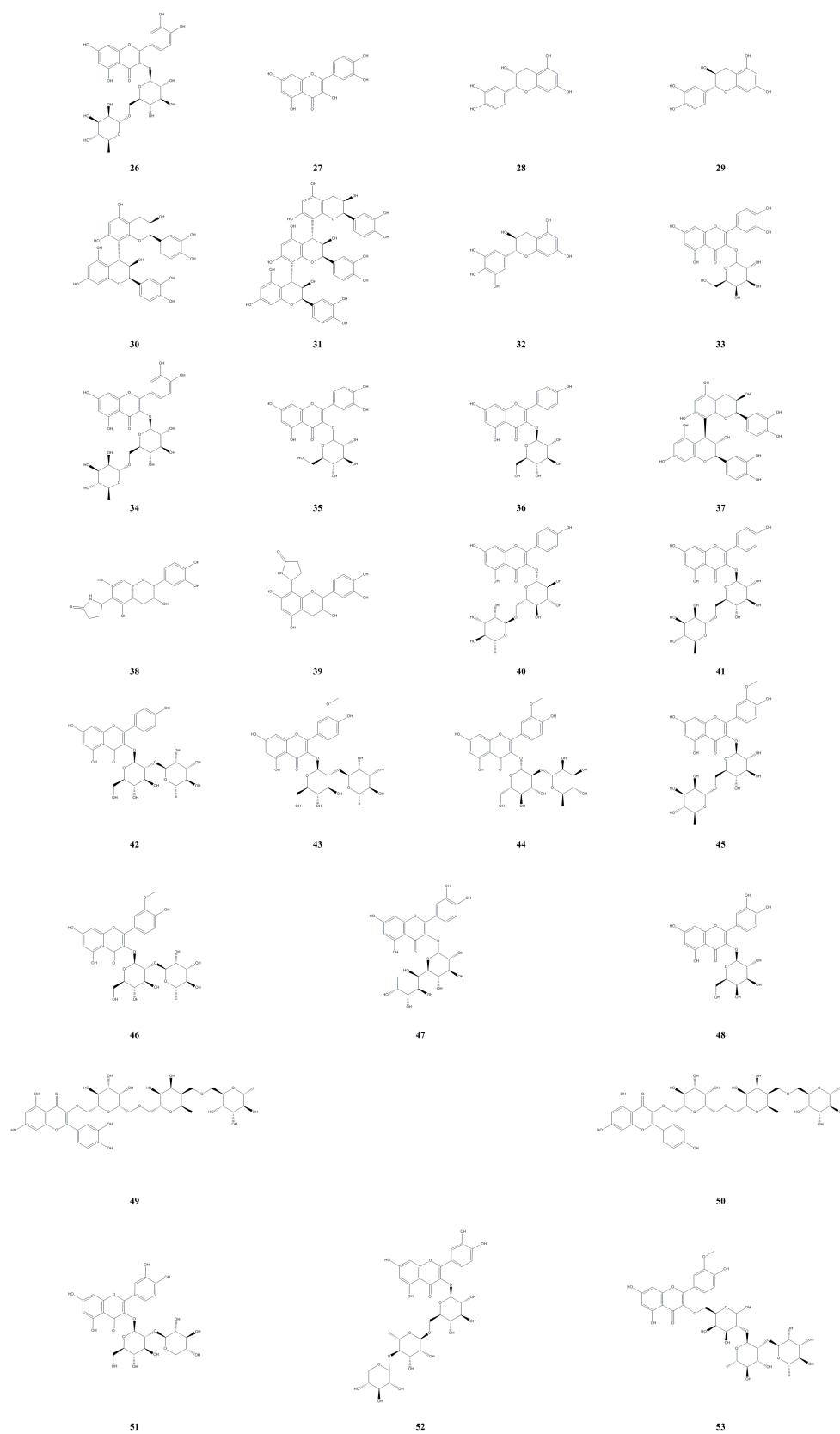


Figure 3. Chemical structures of flavonoids isolated from *Actinidia arguta*. Chemical structures were drawn using Chemdraw Professional 15.0 software.

3.3. Phenolic Compounds

Phenolic compounds are widely occurring secondary metabolites in plants and hold significant pharmacological and nutritional importance [28]. So far, researchers have isolated and identified 24 phenolic compounds from the roots, fruit, and leaves of *A. arguta* (Table 3, Figure 4). Through the use of HPLC-MS technology, three phenolic compounds were identified in the roots: planchols A and B (54 and 55) and isotachioside (56) [18]. From the leaves of *A. arguta*, researchers isolated 11 phenolic compounds, namely, *p*-hydroxybenzoic acid (57); vanillic acid (58); protocatechuic acid (59); isovanillic acid (60); hydroxytyrosol (61) [29]; caffeoylthreonic acid (62); salvianic acid A (63) [30]; maysedilactones A, B, and D (64–66) [31]; and rhodioloside (73) [21]. Additionally, 10 phenolic compounds were identified in the fruit, including argutiniosides J–L (67–69) [32], vanillic acid-4-O- β -D-glucopyranoside (70), 1-O-feruloyl- β -D-glucopyranoside (71), ferulic acid-4-O- β -D-glucopyranoside (72), 5-O-caffeoyl quinic acid methyl ester (74), 5-O-caffeoyl quinic acid butyl ester (75), 5-O-feruloyl quinic acid methyl ester (76), and 5-O-coumaroyl quinic acid methyl ester (77) [21]. Phenols 57–59 (100 μ M) exhibited weak 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging and α -glucosidase inhibitory activities, while 60 and 61 demonstrated strong DPPH radical scavenging and α -glucosidase inhibitory activities [29]. Phenols 64–66 displayed α -glucosidase inhibitory and DPPH radical scavenging activities. Specifically, 66 inhibited α -glucosidase activity by 43% and exhibited an antioxidant effect of up to 89% at a concentration of 100 μ M. This study suggests that 64–66 may be effective in treating oxidative stress related to metabolic diseases [31]. On the other hand, 67 and 68 showed mild DPPH radical scavenging activities, with percentages of 52.1% and 68.2% respectively, at a concentration of 500 μ M, while 69 exhibited weak DPPH activity [32].

Table 3. Phenolic compounds isolated from *Actinidia arguta*.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
54	Planchol A	C ₁₄ H ₁₄ O ₆	278.0790	Roots	HPLC-DAD-ESI-MS	[18]
55	Planchol B	C ₁₅ H ₁₆ O ₆	292.0947	Roots	HPLC-DAD-ESI-MS	[18]
56	Isotachioside	C ₁₃ H ₁₈ O ₈	302.1002	Roots	HPLC-DAD-ESI-MS	[18]
57	<i>p</i> -Hydroxybenzoic acid	C ₇ H ₆ O ₃	138.0317	Roots, leaves	ESI-MS, ¹ H-NMR, ¹³ C-NMR	[25,29]
58	Vanillic acid	C ₈ H ₈ O ₄	168.0423	Roots, leaves	EI-MS, ¹ H-NMR, ¹³ C-NMR	[29]
59	Protocatechuic acid	C ₇ H ₆ O ₄	154.0266	Leaves, fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[21,29]
60	Isovanillic acid	C ₈ H ₈ O ₄	168.0423	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
61	Hydroxytyrosol	C ₁₂ H ₁₆ O ₇	154.0630	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
62	Caffeoylthreonic acid	C ₁₂ H ₁₆ O ₇	298.0689	Leaves	HPLC-MS/MS	[30]
63	salvianic acid A	C ₁₀ H ₁₂ O ₅	212.0685	Leaves	HPLC-MS/MS	[30]

Table 3. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
64	Maysedilactone A	C ₁₅ H ₁₆ O ₈	324.0845	Leaves	IR, ESI-MS, HR-ESI-MS, ¹ H-NMR, ¹³ C-NMR	[31]
65	Maysedilactone D	C ₁₅ H ₁₆ O ₉	340.0794	Leaves	IR, ESI-MS, HR-ESI-MS, ¹ H-NMR, ¹³ C-NMR	[31]
66	Maysedilactone B	C ₁₆ H ₁₈ O ₉	354.0951	Leaves	HMBC, NOESY, IR, ESI-MS, HR-ESI-MS, ¹ H-NMR, ¹³ C-NMR	[31]
67	Argutinoside J	C ₁₈ H ₂₂ O ₁₁	414.1162	Fruit	HRESI-TOF-MS, IR, UV, ¹ H-NMR, ¹³ C-NMR, HMBC	[32]
68	Argutinoside K	C ₁₉ H ₂₄ O ₁₂	444.1268	Fruit	HRESI-TOF-MS, IR, UV, ¹ H-NMR, ¹³ C-NMR, HMBC	[32]
69	Argutinoside L	C ₂₀ H ₂₈ O ₁₀	428.1682	Fruit	HRESI-TOF-MS, IR, UV, ¹ H-NMR, ¹³ C-NMR, HMBC	[32]
70	Vanillic acid-4-O-β-D-glucopyranoside	C ₁₄ H ₁₈ O ₉	330.0951	Fruit	ESI-MS, ¹ H-NMR, ¹³ C-NMR	[21]
71	1-O-Feruloyl-β-D-glucopyranoside	C ₁₆ H ₂₀ O ₉	356.1107	Fruit	ESI-MS, ¹ H-NMR, ¹³ C-NMR	[21]
72	Ferulic acid-4-O-β-D-glucopyranoside	C ₁₆ H ₂₀ O ₉	356.1107	Fruit	ESI-MS, ¹ H-NMR, ¹³ C-NMR	[21]
73	Rhodioloside	C ₁₄ H ₂₀ O ₇	300.1209	Leaves	ESI-MS, ¹ H-NMR, ¹³ C-NMR	[21]
74	5-O-Caffeoyl quinic acid methyl ester	C ₁₇ H ₂₀ O ₉	368.1107	Fruit	ESI-MS, ¹ H-NMR, ¹³ C-NMR	[21]
75	5-O-Caffeoyl quinic acid butyl ester	C ₂₀ H ₂₆ O ₉	410.1577	Fruit	ESI-MS, ¹ H-NMR, ¹³ C-NMR	[21]
76	5-O-Feruloyl quinic acid methyl ester	C ₁₈ H ₂₂ O ₉	382.1264	Fruit	ESI-MS, ¹ H-NMR, ¹³ C-NMR	[21]

Table 3. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
77	5-O-Coumaroyl quinic acid methyl ester	C ₁₆ H ₂₀ O ₈	340.1158	Fruit	ESI-MS, ¹ H-NMR, ¹³ C-NMR	[21]

UV: ultraviolet spectrophotometry; IR: infrared spectroscopy; ¹³C-NMR: carbon-13 nuclear magnetic resonance spectrometry; ¹H-NMR: hydrogen-1 nuclear magnetic resonance spectrometry; ESI-MS: electrospray ionization-mass spectrometry; EI-MS: electron ionization-mass spectrometry; HMBC: ¹H-detected heteronuclear multiple bond correlation; NOESY: nuclear Overhauser effect spectroscopy; HRESI-TOF-MS: high-resolution electrospray ionization-time of flight-mass spectrometry; HPLC-MS/MS: high-performance liquid chromatography-mass spectrometry/mass spectrometry; HPLC-DAD-ESI-MS: high-performance liquid chromatography-diode array detection-electrospray ionization-mass spectrometry.

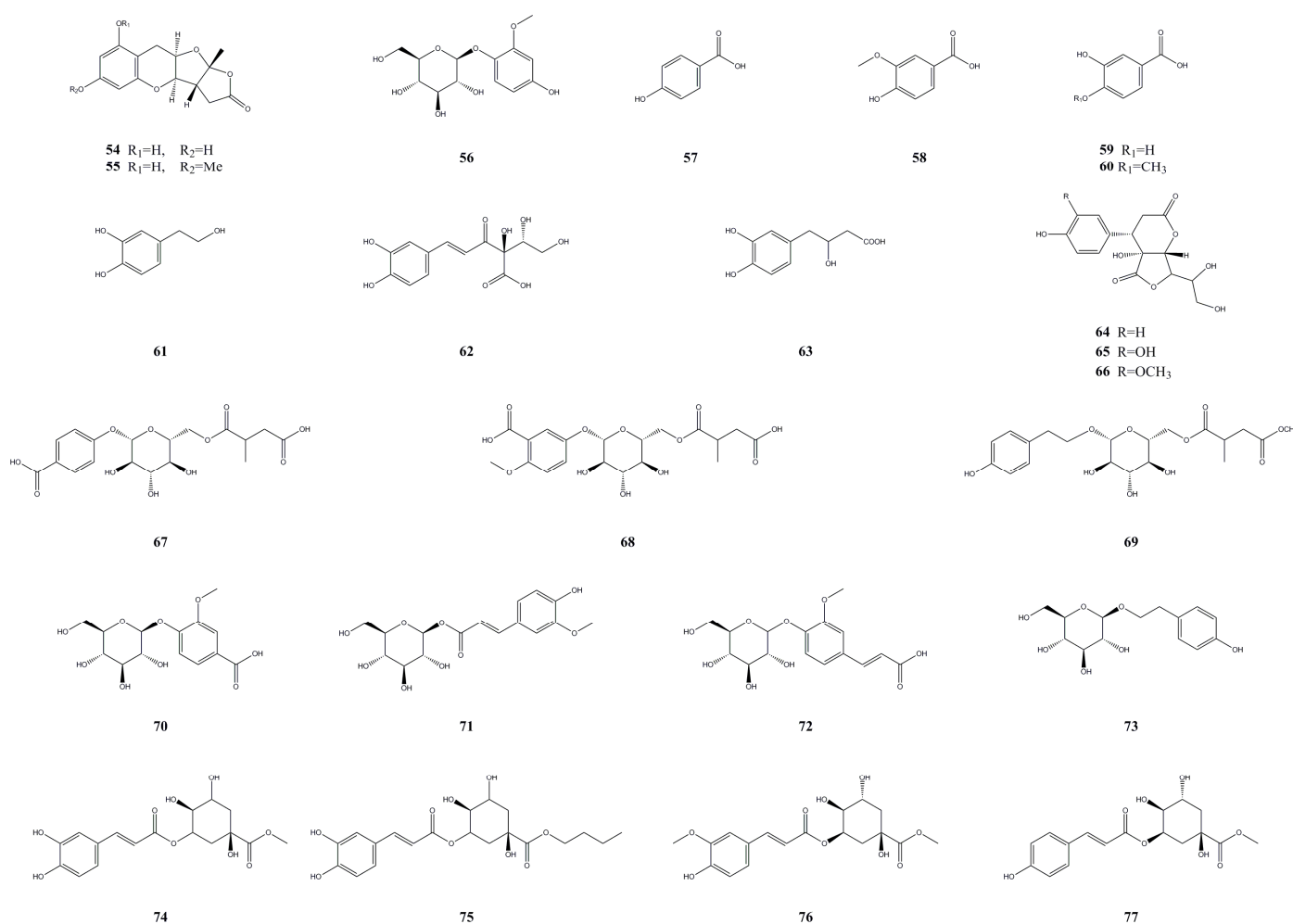


Figure 4. Chemical structures of phenolic compounds isolated from *Actinidia arguta*. Chemical structures were drawn using Chemdraw Professional 15.0 software.

3.4. Phenylpropanoid and Lignin Compounds

Phenylpropanoid and lignin compounds primarily function in regulating plant growth and resistance against viruses [33]. For the first time, researchers isolated and identified 10 phenylpropanoid compounds from the leaves of *A. arguta* (Table 4, Figure 5). These compounds include argutosides A–D (84–87), (–)-rhodolouchol (88), *p*-*E*-coumaric acid-9-O-glucopyranoside (89), *E*-ferulic acid (90), 3,5-dimethoxy-4-hydroxycinnamic alcohol (91), caffeic acid (80), and *trans*-4-hydroxycinnamic acid (81) [29], and chlorogenic acid (78) [34]. Furthermore, quinic acid (79) was identified using HPLC-MS analysis of the roots and

fruit [35]. From the leaves, researchers also isolated and identified 10 lignin compounds, namely, pinoresinol (83), 7S,8R-cedrusin (92), dehydroconiferyl alcohol (93), (7S,8S)-3-methoxy-3',7-epoxy-8,4'-oxyneoligna-4,9,9'-triol (94), pinoresinol 4-O- β -glucopyranoside (95), alutaceuol (96), alutaceuol isomer (97), (–)-(2R,3R)-secoisolaricresinol (98), glehlinoside F (99), and epipinoresinol (83) [25,29]. When the concentration of chlorogenic acid in the leaves of *A. arguta* ranges from 0.2 to 1.0 mg/mL, its ability to scavenge DPPH gradually increases, reaching a maximum scavenging rate of 92.0%. At lower concentrations, chlorogenic acid exhibits a strong ability to scavenge hydroxyl radicals, with rates exceeding 80%. As the concentration increases, the effect of increasing the scavenging rate of hydroxyl radicals becomes less significant, and the maximum scavenging rate reaches 95.0% [34].

Table 4. Phenylpropanoid and lignin compounds isolated from *Actinidia arguta*.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
78	Chlorogenic acid	C ₁₆ H ₁₈ O ₉	354.0951	Leaves	HPLC	[34]
79	Quinic acid	C ₇ H ₁₂ O ₆	192.0634	Fruit	HPLC-DAD-MS/MS	[35]
80	Caffeic acid	C ₉ H ₈ O ₄	180.0423	Roots, leaves	EI-MS, ¹ H-NMR, ¹³ C-NMR	[29]
81	trans-4-Hydroxycinnamic acid	C ₉ H ₈ O ₃	164.0473	Roots, leaves	EI-MS, ¹ H-NMR	[29]
82	Epipinoresinol	C ₂₀ H ₂₂ O ₆	358.1416	Roots	HPLC-DAD-ESI-MS	[18]
83	Pinoresinol	C ₂₀ H ₂₂ O ₆	358.1416	Roots, leaves	TLC, ESI-MS, ¹ H-NMR, ¹³ C-NMR	[25,29]
84	Argutoside A	C ₂₄ H ₂₄ O ₁₁	488.1319	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
85	Argutoside B	C ₂₃ H ₂₆ O ₁₁	465.1526	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
86	Argutoside C	C ₂₃ H ₂₆ O ₁₁	465.1526	Leaves	IR, ESI-MS, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
87	Argutoside D	C ₂₃ H ₂₆ O ₁₁	478.1475	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC, HSQC	[29]
88	(–)-Rhodolathol	C ₁₀ H ₁₄ O ₃	182.0943	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
89	p-E-Coumaric acid-9-O-glucopyranoside	C ₁₅ H ₁₈ O ₈	326.1002	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]

Table 4. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
90	<i>E</i> -Ferulic acid	C ₁₀ H ₁₀ O ₄	194.0579	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
91	3,5-Dimethoxy-4-hydroxycinnamic alcohol	C ₁₂ H ₁₆ O ₄	224.1049	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
92	7 <i>S</i> ,8 <i>R</i> -Cedrusin	C ₂₀ H ₂₄ O ₅	344.1624	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
93	Dehydroconiferyl alcohol	C ₂₁ H ₂₆ O ₅	358.1780	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
94	(7 <i>S</i> ,8 <i>S</i>)-3-Methoxy-3',7-epoxy-8,4'-oxyneoligna-4,9,9'-triol	C ₁₉ H ₂₂ O ₆	346.1416	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
95	Pinoresinol 4-O-β-glucopyranoside	C ₂₆ H ₃₂ O ₁₁	520.1945	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
96	Alutaceuol	C ₃₀ H ₃₆ O ₁₁	572.2258	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
97	Alutaceuol isomer	C ₃₀ H ₃₆ O ₁₁	572.2258	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
98	(−)-(2 <i>R</i> ,3 <i>R</i>)-Secoisolariciresinol	C ₂₀ H ₂₆ O ₆	362.1729	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
99	Glehlinside F	C ₃₅ H ₄₂ O ₁₄	686.2575	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]

HPLC: high-performance liquid chromatography; IR: infrared spectroscopy; ¹³C-NMR: carbon-13 nuclear magnetic resonance spectrometry; ¹H-NMR: hydrogen-1 nuclear magnetic resonance spectrometry; TLC: thin-layer chromatography; HMBC: ¹H-detected heteronuclear multiple bond correlation; ESI-MS: electrospray ionization-mass spectrometry; EI-MS: electron ionization-mass spectrometry; HSQC: heteronuclear singular quantum correlation; HRESI-TOF-MS: high-resolution electrospray ionization-time of flight-mass spectrometry; HPLC-DAD-ESI-MS: high-performance liquid chromatography-diode array detection-electrospray ionization mass spectrometry.

3.5. Organic Acids (Esters)

In a separate study, 29 organic acid compounds were isolated and identified for the first time from the fruit of *A. arguta* (Table 5, Figure 6). Among them, there are 10 succinic acid derivatives (100–109), 11 quinic acid derivatives (110–120), 2 shikimic acid derivatives (121–122), and 6 citric acid derivatives (123–128). The compounds were evaluated for their NF-κB transcriptional inhibitory activities using lipopolysaccharide (LPS)-induced RAW 264.7 macrophages. Among the four groups of organic acid derivatives, quinic acid derivatives with phenylpropanoids exhibited the most potent NF-κB inhibitory activities, with an IC₅₀ value of 4.0 μM, while the others showed weak activities. Two isolated

compounds, namely, **111** and **115**, demonstrated NF- κ B inhibitory activities, with IC₅₀ values of 8.7 and 4.9 μ M, respectively [36]. Additionally, ethyl stearate (**138**) was isolated and identified from the fruit by Park et al. (2011) [37]. Furthermore, researchers identified γ -quinide (**130**) [18], octeol-10-undecylenate (**131**) [38], and succinic acid (**129**) [14] from the roots, stems, and leaves. There have also been reports of identifying six fatty acids from the sprouts, namely, palmitoleic acid (**132**), stearic acid (**133**), oleic acid (**134**), α -linoleic acid (**135**), α -linolenic acid (**136**), and eicosadienoic acid (**137**) [39]. Moreover, compounds **135**, **136**, and **138** exhibit downregulatory effects on IL-4 production in A23187-stimulated RBL-2H3 cells without inducing cytotoxicity. α -linolenic acid shows the highest downregulatory effect. Both **135** and **136** are present as glycerol esters in animal and plant oils, as well as in dark green plants. They are essential fatty acids necessary for the human body's nutritional requirements. The intake of these two compounds in different proportions can impact adult blood sugar levels [40].

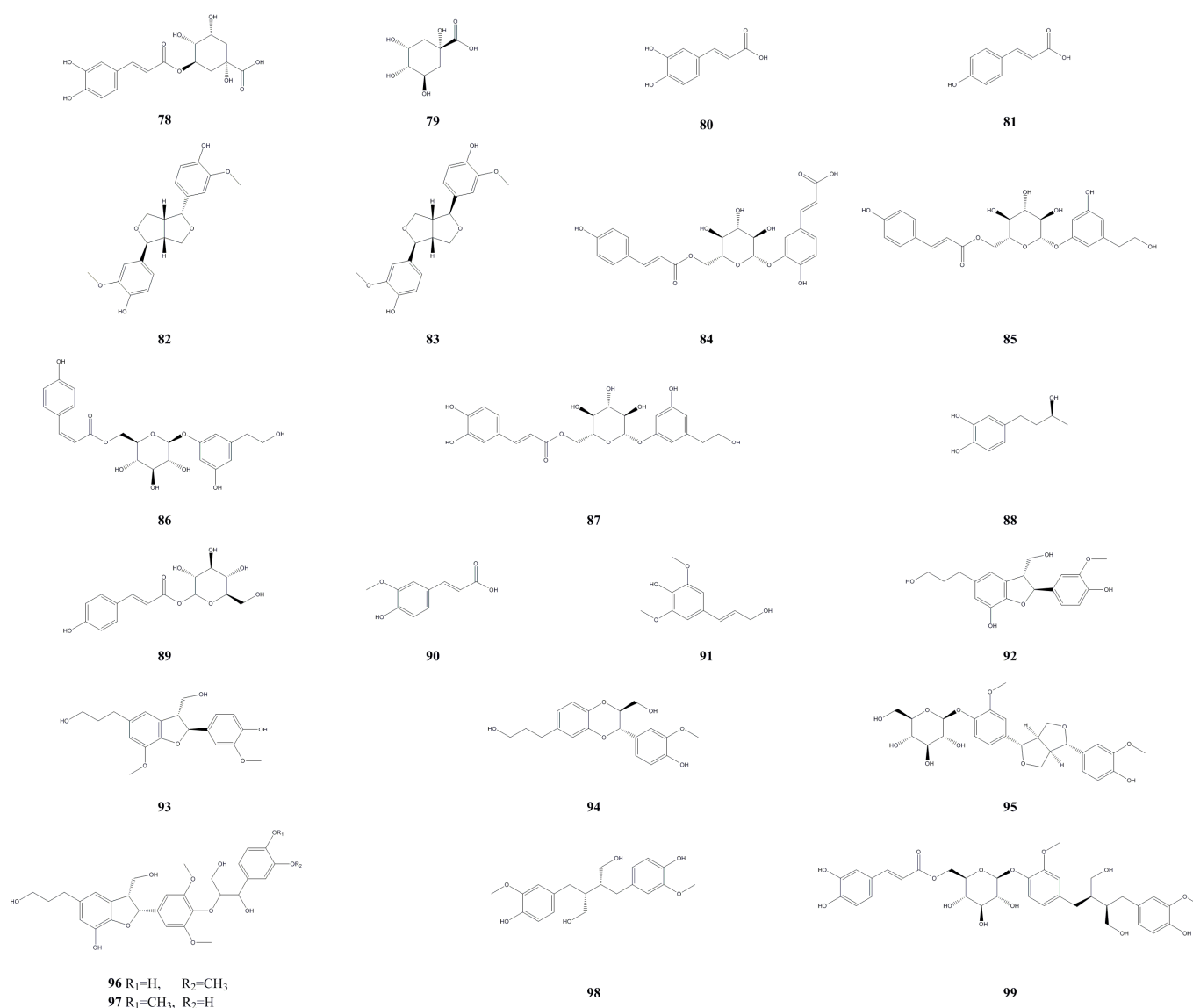


Figure 5. Chemical structures of phenylpropanoid and lignin compounds isolated from *Actinidia arguta*. Chemical structures were drawn using Chemdraw Professional 15.0 software.

Table 5. Organic acids (esters) isolated from *Actinidia arguta*.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
100	Argutinoside A	C ₂₀ H ₂₄ O ₁₂	456.1238	Fruit	HPLC	[36]
101	Argutinoside B	C ₂₁ H ₂₆ O ₁₂	470.1424	Fruit	HPLC-DAD-MS/MS	[36]
102	Argutinoside C	C ₂₀ H ₂₄ O ₁₁	440.1319	Fruit	EI-MS, ¹ H-NMR, ¹³ C-NMR	[36]
103	Argutinoside D	C ₂₁ H ₂₆ O ₁₁	454.1475	Fruit	EI-MS, ¹ H-NMR	[36]
104	Argutinoside E	C ₂₁ H ₂₆ O ₁₁	454.1475	Fruit	HPLC-DAD-ESI-MS	[36]
105	Argutinoside F	C ₂₁ H ₂₆ O ₁₂	470.1424	Fruit	TLC, ESI-MS, ¹ H-NMR, ¹³ C-NMR	[36]
106	Argutinoside G	C ₂₁ H ₂₆ O ₁₂	470.1424	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]
107	Argutinoside H	C ₂₂ H ₂₈ O ₁₂	484.1581	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]
108	Argutinoside I	C ₂₁ H ₂₆ O ₁₂	470.1424	Fruit	IR, ESI-MS, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]
109	Butyl 2-hydroxysuccinate	C ₈ H ₁₄ O ₅	190.0841	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC, HSQC	[36]
110	3-O- <i>trans-p</i> -Coumaroyl quinic acid methyl ester	C ₁₈ H ₂₂ O ₈	366.1315	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]
111	3-O- <i>cis-p</i> -Coumaroyl quinic acid methyl ester	C ₁₈ H ₂₂ O ₈	366.1315	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]
112	3-O- <i>Trans-p</i> -Caffeoyl quinic acid methylester	C ₁₈ H ₂₂ O ₉	382.1264	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]
113	5-O- <i>trans-p</i> -Caffeoyl quinic acid methyl ester	C ₁₈ H ₂₂ O ₈	366.1315	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]
114	5-O- <i>cis-p</i> -Caffeoyl quinic acid methyl ester	C ₁₈ H ₂₂ O ₈	366.1315	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]
115	5-O- <i>trans-p</i> -Coumaroyl quinic acid methyl ester	C ₁₈ H ₂₂ O ₉	382.1264	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]

Table 5. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
116	5- <i>O</i> - <i>cis</i> - <i>p</i> -Coumaroyl quinic acid methyl ester	C ₁₈ H ₂₂ O ₉	382.1264	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]
117	3- <i>O</i> - <i>trans</i> - <i>p</i> -Caffeoyl quinic acid butyl ester	C ₂₁ H ₂₈ O ₉	424.1733	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]
118	4- <i>O</i> - <i>trans</i> - <i>p</i> -Caffeoyl quinic acid butyl ester	C ₂₁ H ₂₈ O ₉	424.1733	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]
119	5- <i>O</i> - <i>trans</i> - <i>p</i> -Caffeoyl quinic acid butyl ester	C ₂₁ H ₂₈ O ₈	408.1784	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]
120	5- <i>O</i> - <i>trans</i> - <i>p</i> -Coumaroyl quinic acid butyl ester	C ₂₁ H ₂₈ O ₉	424.1733	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]
121	4- <i>O</i> - <i>trans</i> - <i>p</i> -Coumaroyl shikimic acid	C ₁₇ H ₂₀ O ₇	336.1209	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]
122	3- <i>O</i> - <i>cis</i> - <i>p</i> -Coumaroyl shikimic acid	C ₁₇ H ₂₀ O ₇	336.1209	Fruit	HPLC	[36]
123	1-Methyl-5-ethyl citrate	C ₉ H ₁₄ O ₇	234.0740	Fruit	HPLC-DAD-MS/MS	[36]
124	1,6-Dimethyl citrate	C ₈ H ₁₂ O ₇	220.0583	Fruit	EI-MS, ¹ H-NMR, ¹³ C-NMR	[36]
125	1,5,6-Trimethyl citrate	C ₉ H ₁₄ O ₇	234.0740	Fruit	EI-MS, ¹ H-NMR	[36]
126	1,6-Dimethyl-5-ethyl citrate	C ₁₀ H ₁₆ O ₇	248.0896	Fruit	HPLC-DAD-ESI-MS	[36]
127	5-Butyl citrate	C ₁₀ H ₁₆ O ₇	248.0896	Fruit	TLC, ESI-MS, ¹ H-NMR, ¹³ C-NMR	[36]
128	1-Methyl-6-butyl citrate	C ₁₁ H ₁₈ O ₇	262.1053	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[36]
129	Succinic acid	C ₂₀ H ₂₄ O ₁₂	118.0266	Leaves	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[14]
130	γ-Quinide	C ₇ H ₁₀ O ₅	174.0528	Roots	IR, ESI-MS, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[18]
131	Octeyl-10-undecylenate	C ₁₉ H ₃₆ O ₂	296.2715	Stems	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC, HSQC	[38]

Table 5. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
132	Palmitoleic acid	C ₁₆ H ₃₀ O ₂	254.2246	Sprouts	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[39]
133	Stearic acid	C ₁₈ H ₃₆ O ₂	284.2715	Sprouts	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[39]
134	Oleic acid	C ₁₈ H ₃₄ O ₂	282.2559	Sprouts	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[39]
135	α-Linoleic acid	C ₁₈ H ₃₂ O ₂	280.2402	Fruit, sprouts	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[37,39]
136	α-Linolenic acid	C ₁₈ H ₃₀ O ₂	278.2246	Fruit, sprouts	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[37,39]
137	Eicosadienoic acid	C ₂₀ H ₃₆ O ₂	308.2715	Sprouts	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[39]
138	Ethyl stearate	C ₁₉ H ₃₇ O ₂	297.2794	Fruit	IR, HRESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[37]

IR: infrared spectroscopy; UV: ultraviolet spectrophotometry; ¹³C-NMR: carbon-13 nuclear magnetic resonance spectrometry; ¹H-NMR: hydrogen-1 nuclear magnetic resonance spectrometry; ESI-MS: electrospray ionization-mass spectrometry; EI-MS: electron ionization-mass spectrometry; HMBC: ¹H-detected heteronuclear multiple bond correlation; HSQC: heteronuclear singular quantum correlation; HRESI-TOF-MS: high-resolution electrospray ionization-time of flight-mass spectrometer; HPLC-DAD-ESI-MS: high-performance liquid chromatography-diode array detection-electrospray ionization-mass spectrometry; GC: gas chromatography.

3.6. Volatile Compounds

All volatile compounds, except for *n*-docosane, were identified using gas chromatography-mass spectrometry (GC-MS) analysis. So far, 327 volatile compounds have been analyzed and identified from *A. arguta* (Table 6, Figure 7), primarily from fruit, with a smaller portion from roots and seeds. Matich et al. (2003) identified over 200 volatile components from flowers and fruit, mainly including linalool derivatives and sesquiterpenoids [41]. Yang et al. (2012) also identified 32 volatile components from the fruit, mainly phenolics, alcohols, and alkenes [42]. Other researchers isolated 12 components from the fruit, predominantly lipids and alcohols. Notably, ethyl butyrate accounts for a significant relative content of 86.89%, which gives the fruit its strong aroma. Although ethyl butyrate is widely used in the food, spice, and tobacco industries, the synthetic form raises concerns about its toxicity. Given the current preference for natural spices, the high relative content of ethyl butyrate in *A. arguta* volatile oil presents an excellent opportunity for natural extraction [43]. Xin et al. (2009) utilized a solid-phase microextraction device and employed GC-MS to identify 21 volatile components in *A. arguta* [44]. Sun et al. (2012) isolated 10 volatile components from the fruit [45]. Recently, Wang et al. (2022) discovered 33 volatile components from the fruit [46]. Additionally, 13 volatile components were extracted from the fruit and seeds of *A. arguta* [47–49]. Yang et al. (2000) identified 17 compounds from the roots, mainly consisting of aliphatic compounds [50].

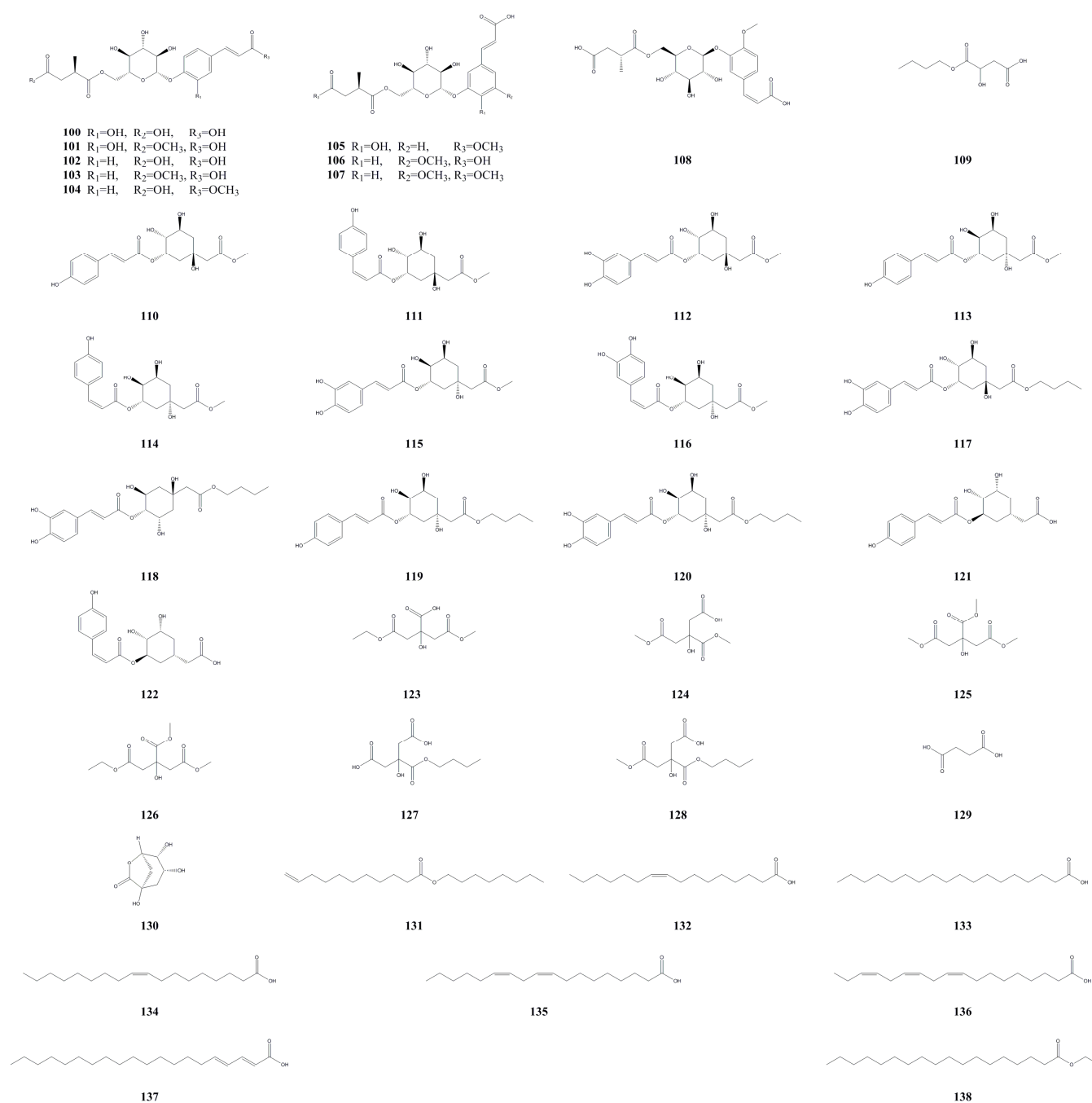


Figure 6. Chemical structures of organic acids (esters) isolated from *Actinidia arguta*. Chemical structures were drawn using Chemdraw Professional 15.0 software.

Table 6. Volatile components isolated from *Actinidia arguta*.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
139	<i>m</i> -Xylene	C ₈ H ₁₀	106.0783	Roots	GC-MS	[50]
140	Naphthalene	C ₁₀ H ₈	128.0626	Roots, flowers	GC-MS	[41,50]
141	<i>n</i> -Undecane	C ₁₁ H ₂₄	156.1878	Roots	GC-MS	[50]
142	<i>n</i> -Dodecane	C ₁₂ H ₂₆	170.2035	Roots, fruit	GC-MS	[41,50]
143	<i>n</i> -Tetradecane	C ₁₄ H ₃₀	198.2348	Roots, fruit	GC-MS	[41,50]
144	<i>n</i> -Heptadecane	C ₁₇ H ₃₆	240.2817	Roots, flowers, fruit	GC-MS	[41,46,50]
145	<i>n</i> -Eicosane	C ₂₀ H ₄₂	282.3287	Roots, flowers	GC-MS	[41,46,50]
146	2,6,10-Trimethyldodecane	C ₁₅ H ₃₂	212.2504	Roots	GC-MS	[50]
147	2,6,10,14-Tetramethylpentadecane	C ₁₉ H ₄₀	268.3130	Roots	GC-MS	[50]
148	8-Methylheptadecane	C ₁₈ H ₃₈	254.2974	Roots	GC-MS	[50]
149	Ethylmethylnundecanol	C ₁₄ H ₃₀ O	214.2297	Roots	GC-MS	[50]
150	Methyl pentadecanoate	C ₁₆ H ₃₂ O ₂	256.2402	Roots	GC-MS	[50]
151	Dibutyl phthalate	C ₁₆ H ₂₂ O ₄	278.1518	Roots	GC-MS	[50]
152	2,4,6-Trimethyl decanoic acid	C ₁₃ H ₂₆ O ₂	214.1933	Roots	GC-MS	[50]
153	3,7-Dimethyl-1,8-Nonadiene	C ₁₁ H ₂₀	152.1565	Roots	GC-MS	[50]
154	(3 <i>E</i>)-3-Undecene	C ₁₁ H ₂₂	154.1722	Roots	GC-MS	[50]
155	1,6-Nonadien-3-ol,3,7-dimethyl-,acetate	C ₁₃ H ₂₂ O ₂	210.1620	Roots	GC-MS	[50]
156	Ethyl acetate	C ₄ H ₈ O ₂	88.0524	Flowers, fruit	GC-MS	[41,43]
157	Butanoic acid, methyl ester	C ₅ H ₁₀ O ₂	102.0681	Fruit	GC-MS	[43]
158	Pyridine	C ₅ H ₅ N	79.0422	Fruit	GC-MS	[43]
159	(<i>E</i>)-2-Hexenal	C ₆ H ₁₀ O	98.0732	Fruit	GC-MS	[43]
160	1-Hexanol	C ₆ H ₁₄ O	102.1045	Flowers, fruit	GC-MS	[41–43,46]
161	Hexanoic acid, ethyl ester	C ₈ H ₁₆ O ₂	144.1150	Fruit	GC-MS	[43]
162	3-Cyclohexen-1-ol,4-methyl-1-(methylethyl)	C ₁₀ H ₁₈ O	154.1358	Fruit	GC-MS	[43]
163	Ethyl butyrate	C ₆ H ₁₂ O ₂	116.0837	Fruit	GC-MS	[42,46]
164	2-Furaldehyde	C ₅ H ₄ O ₂	96.0211	Fruit	GC-MS	[42]
165	2-Hexenal	C ₆ H ₁₀ O	98.0732	Fruit	GC-MS	[42,46]
166	(<i>E</i>)-3-Hexen-1-ol	C ₆ H ₁₂ O	100.0888	Fruit	GC-MS	[42]
167	<i>cis</i> -Hex-2-en-1-ol	C ₆ H ₁₂ O	100.0888	Fruit	GC-MS	[42]
168	2-Hexen-1-ol	C ₆ H ₁₂ O	100.0888	Fruit	GC-MS	[42,43]
169	Dihydrofuran-2(3 <i>H</i>)-one	C ₄ H ₆ O ₂	86.0386	Fruit	GC-MS	[42]
170	(1 <i>S</i>)-(–)- α -Pinene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[42]
171	Benzaldehyde	C ₇ H ₆ O	106.0419	Fruit	GC-MS	[42]
172	5-Methylfurfural	C ₆ H ₆ O ₂	110.0368	Fruit	GC-MS	[42]
173	1-Octen-3-ol	C ₈ H ₁₆ O	128.1201	Fruit	GC-MS	[42]
174	Benzene,1-methyl-2-(1-methylethyl)-	C ₁₀ H ₁₄	134.1096	Fruit	GC-MS	[42]
175	1-Methyl-4-methyl ethenyl cyclohexene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[42]
176	1,3,3-Trimethyl-2-oxabicyclo[2.2.2]octane	C ₁₀ H ₁₈ O	154.1358	Fruit	GC-MS	[42]

Table 6. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
177	Benzyl alcohol	C ₇ H ₈ O	108.0575	Flowers, fruit	GC-MS	[42]
178	<i>o</i> -Cresol	C ₇ H ₈ O	108.0575	Fruit	GC-MS	[42]
179	Phenylacetaldehyde	C ₈ H ₈ O	120.0575	Fruit	GC-MS	[42]
180	4-Isopropyl-1-methyl-1,4-cyclohexadiene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[42]
181	α -Terpinolene	C ₁₀ H ₁₆	136.1252	Flowers, fruit	GC-MS	[41,42,45]
182	1-Methyl-4-(prop-1-en-2-yl)benzene	C ₁₀ H ₁₂	132.0939	Fruit	GC-MS	[42]
183	Methyl benzoate	C ₈ H ₈ O ₂	136.0524	Fruit	GC-MS	[41,42]
184	1,6-Octadien-3-ol,3,7-dimethyl	C ₁₀ H ₁₈ O	154.1358	Fruit	GC-MS	[42]
185	Ethyl benzoate	C ₉ H ₁₀ O ₂	150.0681	Fruit	GC-MS	[41,42]
186	Terpinen-4-ol	C ₁₀ H ₁₈ O	154.1358	Fruit	GC-MS	[42]
187	Trimethylbenzene	C ₉ H ₁₂	120.0939	Flowers, fruit	GC-MS	[41,42]
188	α -Terpineol	C ₁₀ H ₁₈ O	154.1358	Fruit	GC-MS	[42,46]
189	Trimethylcyclohex-2-en-1-yl)but-3-en-2-one	C ₁₃ H ₂₀ O	192.1514	Fruit	GC-MS	[42]
190	N,N-Dibutylformamide	C ₉ H ₁₉ NO	157.1467	Fruit	GC-MS	[42]
191	2-Methoxy-4-vinylphenol	C ₉ H ₁₀ O ₂	150.0681	Fruit	GC-MS	[42]
192	2-(Benzo[d][1,3]dioxol-5-yl)-6-chloroimidazo[1,2-b]pyridazine	C ₁₃ H ₈ N ₃ O ₂ Cl	273.0305	Fruit	GC-MS	[42]
193	Triethyl citrate	C ₁₂ H ₂₀ O ₇	276.1209	Fruit	GC-MS	[42]
194	Methyl tetradecanoate	C ₁₅ H ₃₀ O ₂	242.2246	Fruit	GC-MS	[42]
195	Myristic acid	C ₁₄ H ₂₈ O ₂	228.2089	Fruit	GC-MS	[42]
196	1,2-Benzene-3,4,5,6-d ₄ -dicarboxylicacid, bis(2-methylpropyl) ester	C ₁₆ H ₂₂ O ₄	282.1769	Fruit	GC-MS	[42]
197	1-(2,4-Difluorophenyl)piperazine	C ₁₀ H ₁₂ F ₂ N ₂	198.0969	Fruit	GC-MS	[42]
198	Ethyl palmitate	C ₁₈ H ₃₆ O ₂	284.2715	Fruit	GC-MS	[42]
199	Methyl linolenate	C ₁₉ H ₃₂ O ₂	292.2402	Fruit	GC-MS	[41,42]
200	Ethyl linoleate	C ₂₀ H ₃₆ O ₂	308.2715	Fruit	GC-MS	[41,42]
201	Ethyl linolenate	C ₂₀ H ₃₄ O ₂	306.2559	Fruit	GC-MS	[41,42]
202	Ethanol	C ₂ H ₆ O	46.0619	Fruit	GC-MS	[44]
203	α -Pinene	C ₁₀ H ₁₆	136.1252	Flowers, fruit	GC-MS	[41,44]
204	β -Pinene	C ₁₀ H ₁₆	136.1252	Flowers, fruit	GC-MS	[41,44]
205	β -Myrcene	C ₁₀ H ₁₆	136.1252	Flowers, fruit	GC-MS	[41,44]
206	Benzene,1-methyl-3-(1-methylethyl)-	C ₁₀ H ₁₄	134.1096	Fruit	GC-MS	[44]
207	Dipentene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[44]
208	(1 <i>R</i> - <i>trans</i>) 1-Methyl-4-(1-methylethenyl)-2-cyclohexene-1-ol	C ₁₀ H ₁₆ O	152.1201	Fruit	GC-MS	[44]
209	4,6,6-Trimethyl-bicyclo[3.1.1]hept-3-en-2-one	C ₁₀ H ₁₄ O	150.1045	Fruit	GC-MS	[44]

Table 6. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
210	9,12-Octadecadienoic acid	C ₁₈ H ₃₂ O ₂	280.2402	Fruit, seeds	GC-MS	[47,48]
211	Palmitic acid	C ₁₆ H ₃₂ O ₂	256.2402	Fruit, seeds	GC-MS	[48]
212	Linolenic acid	C ₁₈ H ₃₀ O ₂	278.2246	Fruit, seeds	GC-MS	[48]
213	Erucic acid	C ₂₂ H ₄₂ O ₂	338.3815	Seeds	GC-MS	[48]
214	Gondoic acid	C ₂₀ H ₃₈ O ₂	310.2872	Seeds	GC-MS	[48]
215	(10Z,13Z)-Octadeca-10,13-dienoic acid	C ₁₈ H ₃₂ O ₂	280.2402	Fruit	GC-MS	[47]
216	Eicosanoic-12,12,13,13-d ₄ -acid	C ₂₀ H ₄₀ O ₂	316.3279	Fruit	GC-MS	[47]
217	9-Octadecenoic acid	C ₁₈ H ₃₄ O ₂	282.2559	Seeds	GC-MS	[49]
218	Eucalyptol	C ₁₀ H ₁₈ O	154.1358	Flowers, fruit	GC-MS	[41,44]
219	1-Methyl-4-(1-methylethenyl)-cyclohexene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[44]
220	Dimethylbicyclo[3.2.1]oct-2-ene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[44]
221	Methyl acetate	C ₃ H ₆ O ₂	74.0368	Fruit	GC-MS	[41,45]
222	Acetic acid	C ₂ H ₄ O ₂	60.0211	Flowers, fruit	GC-MS	[41,45]
223	1,3,5,7-Cyclooctatetraene	C ₈ H ₈	104.0626	Fruit	GC-MS	[45]
224	Styrene	C ₈ H ₈	104.0626	Fruit	GC-MS	[41,45]
225	2-Methyl-bicyclo[3.1.0]hexan-2-en	C ₇ H ₁₀	94.0783	Fruit	GC-MS	[45]
226	<i>p</i> -Cymene	C ₁₀ H ₁₄	134.1096	Fruit	GC-MS	[41,45]
227	3-Carene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[45]
228	4-Isopropyl-1-methyl-1,4-cyclohexadiene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[45]
229	Methyl heptenone	C ₈ H ₁₄ O	126.1045	Fruit	GC-MS	[45]
230	1-Ethyl-3,5-dimethylbenzene	C ₁₀ H ₁₄	134.1096	Fruit	GC-MS	[45]
231	Camphor	C ₁₀ H ₁₆ O	152.1201	Flowers, fruit	GC-MS	[41]
232	β -Caryophyllene	C ₁₅ H ₂₄	204.1878	Flowers	GC-MS	[41]
233	2,6-Dimethyl-6-hydroxyocta-2,7-dienal	C ₁₀ H ₁₆ O ₂	168.1150	Flowers	GC-MS	[41]
234	2,6-Dimethylocta-3,7-diene-2,6-diol	C ₁₀ H ₁₈ O ₂	170.1307	Flowers	GC-MS	[41]
235	<i>E,E</i> - α -Farnesene	C ₁₅ H ₂₄	204.1878	Flowers	GC-MS	[41]
236	<i>Z,E</i> -Farnesol	C ₁₅ H ₂₆ O	222.1984	Flowers	GC-MS	[41]
237	<i>E,E</i> -Farnesyl acetate	C ₁₇ H ₂₈ O ₂	264.2089	Flowers	GC-MS	[41]
238	Geranylacetone	C ₁₃ H ₂₂ O	194.1671	Flowers	GC-MS	[41]
239	Germacrene D	C ₁₅ H ₂₈ O	208.2191	Flowers	GC-MS	[41]
240	Hexahydrofarnesylacetone	C ₁₈ H ₃₆ O	268.2766	Flowers	GC-MS	[41]
241	<i>E</i> -8-Hydroxylinalool	C ₁₀ H ₁₈ O ₂	170.1307	Flowers	GC-MS	[41]
242	<i>Z</i> -8-Hydroxylinalool	C ₁₀ H ₁₈ O ₂	170.1307	Flowers	GC-MS	[41]
243	Lilac alcohol a	C ₁₀ H ₁₈ O ₂	170.1307	Flowers	GC-MS	[41]
244	Lilac alcohol b	C ₁₀ H ₁₈ O ₂	170.1307	Flowers	GC-MS	[41]
245	Lilac alcohol c	C ₁₀ H ₁₈ O ₂	170.1307	Flowers	GC-MS	[41]
246	Lilac alcohol d	C ₁₀ H ₁₈ O ₂	170.1307	Flowers	GC-MS	[41]
247	Lilac aldehyde 1	C ₁₀ H ₁₆ O ₂	168.1150	Flowers	GC-MS	[41]
248	Lilac aldehyde 2	C ₁₀ H ₁₆ O ₂	168.1150	Flowers	GC-MS	[41]
249	Lilac aldehyde 3	C ₁₀ H ₁₆ O ₂	168.1150	Flowers	GC-MS	[41]

Table 6. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
250	Lilac aldehyde 4	C ₁₀ H ₁₆ O ₂	168.1150	Flowers	GC-MS	[41]
251	Limonene	C ₁₀ H ₁₆	136.1252	Flowers, fruit	GC-MS	[41]
252	Linalool	C ₁₀ H ₁₈ O	154.1358	Flowers, fruit	GC-MS	[41]
253	<i>cis</i> -Linalool oxide	C ₁₀ H ₁₈ O ₂	170.1307	Flowers	GC-MS	[41]
254	<i>trans</i> -Linalool oxide	C ₁₀ H ₁₈ O ₂	170.1307	Flowers	GC-MS	[41]
255	6-Methylhept-5-en-2-one	C ₈ H ₁₄ O	126.1045	Flowers, fruit	GC-MS	[41]
256	Ocimene	C ₁₀ H ₁₆	136.1252	Flowers	GC-MS	[41]
257	<i>E</i> - β -Ocimene	C ₁₀ H ₁₆	136.1252	Flowers, fruit	GC-MS	[41]
258	Phytol	C ₂₀ H ₄₀ O	296.3079	Flowers	GC-MS	[41]
259	Squalene	C ₃₀ H ₅₀	410.3913	Flowers, fruit	GC-MS	[41,46]
260	3,7,11,15-Tetramethyl hexadeca-6,10,14-trienol	C ₂₀ H ₃₆ O	292.2766	Flowers	GC-MS	[41]
261	Camphene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[41]
262	2-Carene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[41]
263	<i>cis</i> -Carveol	C ₁₀ H ₁₆ O	152.1201	Fruit	GC-MS	[41]
264	Carvone	C ₁₀ H ₁₄ O	150.1045	Fruit	GC-MS	[41]
265	<i>Endo</i> -5,5,6-trimethylnorbornan-2-one	C ₁₀ H ₁₆ O	152.1201	Fruit	GC-MS	[41]
266	<i>p</i> -Mentha-1,3,8-triene	C ₁₀ H ₁₄	134.1096	Fruit	GC-MS	[41]
267	<i>p</i> -Menth-1-en-4-ol	C ₁₀ H ₁₈ O	154.1358	Fruit	GC-MS	[41]
268	Menthol	C ₁₀ H ₂₀ O	156.1514	Fruit	GC-MS	[41]
269	1-Methyl-4-(1-methylethenyl)benzene	C ₁₀ H ₁₂	132.0939	Fruit	GC-MS	[41]
270	1-Methyl-4-(1-methylethyl)-cyclohex-2-enol	C ₁₀ H ₁₈ O	154.1358	Fruit	GC-MS	[41]
271	<i>Z</i> - β -Ocimene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[41]
272	β -Phellandrene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[41]
273	Sabinene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[41]
274	α -Terpinene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[41]
275	β -Terpinene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[41]
276	δ -Terpinene	C ₁₀ H ₁₆	136.1252	Fruit	GC-MS	[41]
277	α -Terpineol	C ₁₀ H ₁₈ O	154.1358	Fruit	GC-MS	[41]
278	Ethylbenzaldehyde	C ₉ H ₁₀ O	134.0732	Flowers	GC-MS	[41]
279	Benzene	C ₆ H ₆	78.0470	Flowers	GC-MS	[41]
280	Benzyl benzoate	C ₁₄ H ₁₂ O ₂	212.0837	Flowers, fruit	GC-MS	[41]
281	Ethylbenzaldehyde	C ₉ H ₁₀ O	134.0732	Flowers, fruit	GC-MS	[41]
282	2-(4-Hydroxyphenyl)ethanol	C ₈ H ₁₀ O ₂	138.0681	Flowers	GC-MS	[41]
283	Methoxybenzene	C ₈ H ₁₀ O	122.0732	Flowers	GC-MS	[41]
284	2-(4-Methoxyphenyl)ethanol	C ₉ H ₁₂ O ₂	152.0837	Flowers, fruit	GC-MS	[41]
285	Methyl 4-Methoxybenzoate	C ₉ H ₁₀ O ₃	166.0630	Flowers	GC-MS	[41]
286	Methyl salicylate	C ₈ H ₈ O ₃	152.0473	Flowers	GC-MS	[41]
287	Phenol	C ₆ H ₆ O	94.0619	Flowers	GC-MS	[41]

Table 6. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
288	2-Phenylethanal	C ₈ H ₈ O	120.0575	Flowers	GC-MS	[41]
289	2-Phenylethanol	C ₈ H ₁₀ O	122.0732	Flowers	GC-MS	[41]
290	2-Phenylethyl acetate	C ₁₀ H ₁₂ O ₂	164.0837	Flowers	GC-MS	[41]
291	Dimethylbenzaldehyde	C ₉ H ₁₀ O	134.0732	Fruit	GC-MS	[41]
292	1,2-Dimethylbenzene	C ₈ H ₁₀	106.0783	Fruit	GC-MS	[41]
293	Hex-3(Z)-enyl acetate	C ₈ H ₁₄ O ₂	142.0994	Flowers	GC-MS	[41]
294	3-Methylbutyl acetate	C ₇ H ₁₄ O ₂	130.0994	Flowers	GC-MS	[41]
295	Butyl acetate	C ₆ H ₁₂ O ₂	116.0837	Fruit	GC-MS	[41]
296	Dimethyl carbonate	C ₃ H ₆ O ₃	90.0317	Fruit	GC-MS	[41]
297	Ethyl (2E)-2-butenate	C ₆ H ₁₀ O ₂	114.0681	Fruit	GC-MS	[41]
298	Ethyl butanoate	C ₆ H ₁₂ O ₂	116.0837	Fruit	GC-MS	[41]
299	Ethyl decanoate	C ₁₂ H ₂₄ O ₂	200.1776	Fruit	GC-MS	[41]
300	Ethyl heptanoate	C ₉ H ₁₈ O ₂	158.1307	Fruit	GC-MS	[41]
301	Ethyl hexadecanoate	C ₁₈ H ₃₆ O ₂	284.2715	Fruit	GC-MS	[41]
302	Ethyl hexadec-9-enoate	C ₁₈ H ₃₄ O ₂	282.2559	Fruit	GC-MS	[41]
303	Ethyl hexanoate	C ₈ H ₁₆ O ₂	144.1150	Flowers, fruit	GC-MS	[41]
304	Ethyl hexa-2,4-dienoate	C ₈ H ₁₂ O ₂	140.0837	Fruit	GC-MS	[41]
305	Ethyl hex-2-enoate	C ₈ H ₁₄ O ₂	142.0994	Fruit	GC-MS	[41]
306	Ethyl hex-3-enoate	C ₈ H ₁₄ O ₂	142.0994	Fruit	GC-MS	[41]
307	Ethyl 2-methylbutanoate	C ₇ H ₁₄ O ₂	130.0994	Fruit	GC-MS	[41]
308	Ethyl 3-methylbutanoate	C ₇ H ₁₄ O ₂	130.0994	Fruit	GC-MS	[41]
309	Ethyl 2-methylpropanoate	C ₆ H ₁₂ O ₂	116.0837	Fruit	GC-MS	[41]
310	Ethyl octanoate	C ₁₀ H ₂₀ O ₂	172.1463	Fruit	GC-MS	[41]
311	Ethyl (4Z)-oct-4-enoate	C ₁₀ H ₁₈ O ₂	170.1307	Fruit	GC-MS	[41]
312	Ethyl oleate	C ₂₀ H ₃₈ O ₂	310.2872	Fruit	GC-MS	[41]
313	Ethyl pentanoate	C ₇ H ₁₄ O ₂	130.0994	Fruit	GC-MS	[41]
314	Ethyl propanoate	C ₅ H ₁₀ O ₂	102.0681	Fruit	GC-MS	[41]
315	Hexadecyl acetate	C ₁₈ H ₃₆ O ₂	284.2715	Fruit	GC-MS	[41]
316	Methyl butanoate	C ₅ H ₁₀ O ₂	102.0681	Fruit	GC-MS	[41]
317	1-Methylethyl tetradecanoate	C ₁₇ H ₃₄ O ₂	270.2559	Fruit	GC-MS	[41]
318	Methyl hexadecanoate	C ₁₇ H ₃₄ O ₂	270.2559	Fruit	GC-MS	[41]
319	Methyl linoleate	C ₁₉ H ₃₄ O ₂	294.2559	Fruit	GC-MS	[41]
320	Methyl octadecanoate	C ₁₉ H ₃₈ O ₂	298.2872	Fruit	GC-MS	[41]
321	Methyl oleate	C ₁₉ H ₃₆ O ₂	296.2715	Fruit	GC-MS	[41]
322	Methyl prop-2-enoate	C ₄ H ₆ O ₂	86.0368	Fruit	GC-MS	[41]
323	Propyl butanoate	C ₇ H ₁₄ O ₂	130.0994	Fruit	GC-MS	[41]
324	2-Methylbutanal	C ₅ H ₁₀ O	86.0732	Flowers	GC-MS	[41]
325	3-Methylbut-2-enal	C ₅ H ₈ O	84.0575	Flowers	GC-MS	[41]
326	2-Methylpropanal	C ₄ H ₈ O	72.0575	Flowers	GC-MS	[41]
327	Undecanal	C ₁₁ H ₂₂ O	170.1671	Flowers	GC-MS	[41]
328	Acetaldehyde	C ₂ H ₄ O	44.0262	Flowers, fruit	GC-MS	[41]
329	Decanal	C ₁₀ H ₂₀ O	156.1514	Flowers, fruit	GC-MS	[41]
330	(2E,4E)-2,4-Heptadienal	C ₇ H ₁₀ O	110.0732	Fruit	GC-MS	[41]
331	Heptanal	C ₇ H ₁₄ O	114.1045	Flowers, fruit	GC-MS	[41]
332	(2Z)-2-Heptenal	C ₇ H ₁₂ O	112.0888	Fruit	GC-MS	[41]
333	Hexanal	C ₆ H ₁₂ O	100.0888	Flowers, fruit	GC-MS	[41,46]
334	(2E)-2-Hexenal	C ₆ H ₁₀ O	98.0732	Fruit	GC-MS	[41]
335	(2Z)-2-Hexenal	C ₆ H ₁₀ O	98.0732	Fruit	GC-MS	[41]

Table 6. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
336	(3E)-3-Hexenal	C ₆ H ₁₀ O	98.0732	Fruit	GC-MS	[41]
337	(3Z)-3-Hexenal	C ₆ H ₁₀ O	98.0732	Fruit	GC-MS	[41]
338	3-Methylbutanal	C ₅ H ₁₀ O	86.0732	Flowers, fruit	GC-MS	[41]
339	2-Methylpentenal	C ₆ H ₁₀ O	98.0732	Fruit	GC-MS	[41]
340	(2E,6Z)-Nona-2,6-dienal	C ₉ H ₁₄ O	138.1045	Fruit	GC-MS	[41]
341	Nonanal	C ₉ H ₁₈ O	142.1358	Flowers, fruit	GC-MS	[41]
342	(2E)-Non-2-enal	C ₉ H ₁₆ O	140.1201	Fruit	GC-MS	[41]
343	Octanal	C ₈ H ₁₆ O	128.1201	Flowers, fruit	GC-MS	[41]
344	(2E)-Oct-2-enal	C ₈ H ₁₄ O	126.1045	Fruit	GC-MS	[41]
345	Propanal	C ₃ H ₆ O	58.0419	Fruit	GC-MS	[41]
346	Acetone	C ₃ H ₆ O	58.0419	Flowers, fruit	GC-MS	[41]
347	Butan-2-one	C ₄ H ₈ O	72.0575	Flowers, fruit	GC-MS	[41]
348	Butane-2,3-dione	C ₄ H ₆ O ₂	86.0368	Flowers	GC-MS	[41]
349	3-Hydroxybutan-2-one	C ₄ H ₈ O ₂	88.0524	Flowers, fruit	GC-MS	[41]
350	7,8-Dehydro- β -ionone	C ₁₃ H ₂₂ O	194.1671	Flowers	GC-MS	[41]
351	β -Ionone	C ₁₃ H ₂₀ O	192.1514	Flowers	GC-MS	[41]
352	Jasmone	C ₁₁ H ₁₆ O	164.1201	Flowers	GC-MS	[41]
353	2-Methylpentan-3-one	C ₆ H ₁₂ O	100.0888	Flowers	GC-MS	[41]
354	4-Methylpentan-2-one	C ₆ H ₁₂ O	100.0888	Flowers	GC-MS	[41]
355	Octan-3-one	C ₈ H ₁₆ O	128.1201	Flowers	GC-MS	[41]
356	Pentadecan-2-one	C ₁₅ H ₃₀ O	226.2297	Flowers	GC-MS	[41]
357	Cyclopentanone	C ₅ H ₈ O	84.0575	Fruit	GC-MS	[41]
358	4-Hydroxy-4-methylpentan-2-one	C ₆ H ₁₂ O ₂	116.0837	Fruit	GC-MS	[41]
359	4-Methylpent-3-en-2-one	C ₆ H ₁₀ O	98.0732	Fruit	GC-MS	[41]
360	Octan-2,3-dione	C ₈ H ₁₄ O ₂	142.0994	Fruit	GC-MS	[41]
361	Penten-3-one	C ₅ H ₈ O	84.0575	Fruit	GC-MS	[41]
362	(3E)-3-Penten-2-one	C ₅ H ₈ O	84.0575	Fruit	GC-MS	[41]
363	Butanol	C ₄ H ₁₀ O	74.0732	Flowers	GC-MS	[41]
364	Butan-2-ol	C ₄ H ₁₀ O	74.0732	Flowers	GC-MS	[41]
365	2-Ethylhexanol	C ₈ H ₁₈ O	130.1358	Flowers	GC-MS	[41]
366	Hexadecanol	C ₁₆ H ₃₄ O	242.2610	Flowers, fruit	GC-MS	[41]
367	Methanol	CH ₄ O	32.0262	Flowers	GC-MS	[41]
368	1-Methoxypropan-2-ol	C ₄ H ₁₀ O ₂	90.0681	Flowers	GC-MS	[41]
369	2-Methylbutanol	C ₅ H ₁₂ O	88.0888	Flowers	GC-MS	[41]
370	3-Methylbutanol	C ₅ H ₁₂ O	88.0888	Flowers, fruit	GC-MS	[41]
371	3-Methylbut-2-enol	C ₅ H ₁₀ O	86.0732	Flowers	GC-MS	[41]
372	3-Methylbut-3-enol	C ₅ H ₁₀ O	86.0732	Flowers	GC-MS	[41]
373	2-Methylbut-3-en-2-ol	C ₅ H ₁₀ O	86.0732	Flowers	GC-MS	[41]
374	2-Methylpropanol	C ₄ H ₁₀ O	74.0732	Flowers, fruit	GC-MS	[41]
375	Nonanol	C ₉ H ₂₀ O	144.1514	Flowers, fruit	GC-MS	[41]
376	Pentanol	C ₅ H ₁₂ O	88.0888	Flowers, fruit	GC-MS	[41]

Table 6. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
377	Pentan-2-ol	C ₅ H ₁₂ O	88.0888	Flowers	GC-MS	[41]
378	Pentan-3-ol	C ₅ H ₁₂ O	88.0888	Flowers	GC-MS	[41]
379	Penten-3-ol	C ₅ H ₁₀ O	86.0732	Flowers, fruit	GC-MS	[41]
380	Propanol	C ₃ H ₈ O	60.0575	Flowers, fruit	GC-MS	[41]
381	Octanol	C ₈ H ₁₈ O	130.1358	Flowers	GC-MS	[41]
382	Octan-4-ol	C ₈ H ₁₈ O	130.1358	Flowers	GC-MS	[41]
383	Oct-1-en-3-ol	C ₈ H ₁₆ O	128.1201	Flowers	GC-MS	[41]
384	Decanol	C ₁₀ H ₂₂ O	158.1671	Fruit	GC-MS	[41]
385	Dodecanol	C ₁₂ H ₂₆ O	186.1984	Fruit	GC-MS	[41]
386	Heptanol	C ₇ H ₁₆ O	116.1201	Fruit	GC-MS	[41]
387	(2E)-2-Hexen-1-ol	C ₆ H ₁₂ O	100.0888	Fruit	GC-MS	[41]
388	(2Z)-2-Hexen-1-ol	C ₆ H ₁₂ O	100.0888	Fruit	GC-MS	[41]
389	(3Z)-3-Hexen-1-ol	C ₆ H ₁₂ O	100.0888	Fruit	GC-MS	[41]
390	Octanol	C ₈ H ₁₈ O	130.1358	Fruit	GC-MS	[41]
391	Oct-1-en-3-ol	C ₈ H ₁₆ O	128.1201	Fruit	GC-MS	[41]
392	(2E)-2-Penten-1-ol	C ₅ H ₁₀ O	86.0732	Fruit	GC-MS	[41]
393	Dodecanoic acid	C ₁₂ H ₂₄ O ₂	200.1776	Flowers	GC-MS	[41]
394	Heptanoic acid	C ₇ H ₁₄ O ₂	130.0994	Flowers	GC-MS	[41]
395	Hexanoic acid	C ₆ H ₁₂ O ₂	116.0837	Flowers	GC-MS	[41]
396	3-Methylbutanoic acid	C ₅ H ₁₀ O ₂	102.0681	Flowers	GC-MS	[41]
397	Nonanoic acid	C ₉ H ₁₈ O ₂	158.1307	Flowers	GC-MS	[41]
398	Octanoic acid	C ₈ H ₁₆ O ₂	144.1150	Flowers	GC-MS	[41]
399	Butanoic acid	C ₄ H ₈ O ₂	88.0524	Fruit	GC-MS	[41]
400	Heptacosane	C ₂₇ H ₅₆	380.4382	Flowers	GC-MS	[41,46]
401	Hexacosane	C ₁₈ H ₅₄	366.4226	Flowers	GC-MS	[41,46]
402	Hexadecane	C ₁₆ H ₃₄	226.2661	Flowers, fruit	GC-MS	[41]
403	Hexa-1,4-diene	C ₆ H ₁₀	82.0783	Flowers	GC-MS	[41]
404	(2Z,4Z)-2,4-Hexadiene	C ₆ H ₁₀	82.0783	Flowers	GC-MS	[41]
405	3-Methylcyclopentene	C ₆ H ₁₀	82.0783	Flowers	GC-MS	[41]
406	3-Methylpenta-1,3-diene	C ₆ H ₁₀	82.0783	Flowers	GC-MS	[41]
407	Nonacosane	C ₂₉ H ₆₀	408.4695	Flowers	GC-MS	[41,46]
408	Nonadecane	C ₁₉ H ₄₀	268.3130	Flowers, fruit	GC-MS	[41,46]
409	Nonane	C ₉ H ₂₀	128.1565	Flowers	GC-MS	[41]
410	Octane	C ₈ H ₁₈	114.1409	Flowers	GC-MS	[41]
411	Pentacosane	C ₂₅ H ₅₂	352.4069	Flowers	GC-MS	[41,46]
412	Pentadecane	C ₁₅ H ₃₂	212.2504	Flowers, fruit	GC-MS	[41]
413	Tricosane	C ₂₃ H ₄₈	324.3756	Flowers	GC-MS	[41,46]
414	2,6-Dimethyldecane	C ₁₂ H ₂₆	170.2035	Fruit	GC-MS	[41]
415	2-Methylpenta-1,3-diene	C ₆ H ₁₀	82.0783	Fruit	GC-MS	[41]
416	2-Methoxy-2-methylpropane	C ₅ H ₁₂ O	88.0888	Fruit	GC-MS	[41]
417	Octadecane	C ₁₈ H ₃₈	254.2974	Fruit	GC-MS	[41,46]
418	Tridecane	C ₁₃ H ₂₈	184.2191	Fruit	GC-MS	[41]
419	Bis(1-methylethyl)disulphide	C ₆ H ₁₄ S ₂	150.0537	Flowers, fruit	GC-MS	[41]
420	Carbon disulphide	CS ₂	75.9441	Flowers	GC-MS	[41]
421	Dimethyl disulphide	C ₂ H ₆ S ₂	93.9911	Flowers	GC-MS	[41]
422	Butanenitrile	C ₄ H ₇ N	69.0578	Flowers	GC-MS	[41]
423	Methenamine	C ₆ H ₁₂ N ₄	140.1062	Flowers	GC-MS	[41]
424	2-Methylbutanenitrile	C ₅ H ₉ N	83.0735	Flowers	GC-MS	[41]

Table 6. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
425	Tetrahydrofuran	C ₄ H ₈ O	72.0575	Flowers, fruit	GC-MS	[41]
426	Ethyl 2-furancarboxylate	C ₇ H ₈ O ₃	140.0473	Fruit	GC-MS	[41]
427	2-Furancarboxaldehyde	C ₅ H ₄ O ₂	96.0211	Fruit	GC-MS	[41]
428	4-Methoxy-2,5-dimethyl-3(2H)-furanone	C ₇ H ₁₀ O ₃	142.0630	Fruit	GC-MS	[41]
429	2-Methylfuran	C ₅ H ₆ O	82.0419	Fruit	GC-MS	[41]
430	5-Methyl-2-furfural	C ₆ H ₆ O ₂	110.0368	Fruit	GC-MS	[41]
431	Methyl 2-furoate	C ₆ H ₆ O ₃	126.0317	Fruit	GC-MS	[41]
432	<i>n</i> -Docosane	C ₂₁ H ₄₄	296.3443	Stems	IR, EI-MS	[38,46]
433	Benzeneethanol	C ₈ H ₁₀ O	122.0732	Fruit	GC-MS	[46]
434	Benzoic acid ethyl ester	C ₉ H ₁₀ O ₂	150.0681	Fruit	GC-MS	[46]
435	1-Eicosanol	C ₂₀ H ₄₂ O	298.3236	Fruit	GC-MS	[46]
436	Neophytadiene	C ₂₀ H ₃₈	278.2974	Fruit	GC-MS	[46]
437	Cyclotetradecane	C ₁₄ H ₂₈	196.2191	Fruit	GC-MS	[46]
438	Isopropyl palmitate	C ₁₉ H ₃₈ O ₂	298.2872	Fruit	GC-MS	[46]
439	1-Octadecene	C ₁₈ H ₃₆	252.2817	Fruit	GC-MS	[46]
440	Heneicosane	C ₂₁ H ₄₄	296.3443	Fruit	GC-MS	[46]
441	Decylcyclohexane	C ₁₆ H ₃₂	224.2504	Fruit	GC-MS	[46]
442	Hexadecanamide	C ₁₆ H ₃₃ NO	255.2562	Fruit	GC-MS	[46]
443	1-Naphthalenamine, N-phenyl-	C ₁₆ H ₁₃ N	219.1048	Fruit	GC-MS	[46]
444	9-Octadecenamide	C ₁₈ H ₃₅ NO	281.2719	Fruit	GC-MS	[46]
445	Octadecanamide	C ₁₈ H ₃₇ NO	283.2875	Fruit	GC-MS	[46]
446	Tetracosane	C ₂₄ H ₅₀	338.3913	Fruit	GC-MS	[46]
447	Linoleic acid butyl ester	C ₂₂ H ₄₀ O ₂	336.3028	Fruit	GC-MS	[46]
448	Octacosane	C ₂₈ H ₅₈	394.4539	Fruit	GC-MS	[46]
449	Schizandrin	C ₂₄ H ₃₂ O ₇	432.2148	Fruit	GC-MS	[46]
450	Octadecane	C ₁₈ H ₃₈	254.2974	Fruit	GC-MS	[46]
451	Triacontane	C ₃₀ H ₆₂	422.4852	Fruit	GC-MS	[46]
452	β -Tocopherol	C ₂₈ H ₄₈ O ₂	416.3654	Fruit	GC-MS	[46]
453	Hentriacontane	C ₃₁ H ₆₄	436.5008	Fruit	GC-MS	[46]
454	Hexacosanol	C ₂₆ H ₅₄ O	382.4175	Fruit	GC-MS	[46]
455	Trtriacontane	C ₃₃ H ₆₈	464.5321	Fruit	GC-MS	[46]
456	Cholest-5-en-3-ol	C ₂₇ H ₄₆ O	386.3549	Fruit	GC-MS	[46]
457	Campesterol	C ₂₈ H ₄₈ O	400.3705	Fruit	GC-MS	[46]
458	Stigmasta-5,22-dien-3-ol	C ₂₉ H ₄₈ O	412.3705	Fruit	GC-MS	[46]
459	γ -Sitosterol	C ₂₉ H ₅₀ O	414.3862	Fruit	GC-MS	[46]
460	β -Amyrin	C ₃₀ H ₅₀ O	426.3862	Fruit	GC-MS	[46]
461	α -Amyrin	C ₃₀ H ₅₀ O	426.3862	Fruit	GC-MS	[46]
462	Stigmast-7-en-3-ol	C ₂₉ H ₅₀ O	414.3862	Fruit	GC-MS	[46]
463	9,19-Cyclolanostan-3-ol,24-methylene	C ₃₁ H ₅₂ O	440.4018	Fruit	GC-MS	[46]
464	9,19-Cyclolanostan-3-ol,acetate	C ₃₂ H ₅₄ O ₂	470.4124	Fruit	GC-MS	[46]
465	D:A-Friedooleanan-3-one	C ₃₀ H ₅₀ O	426.3862	Fruit	GC-MS	[46]

GC-MS: Gas chromatography-mass spectrometry.

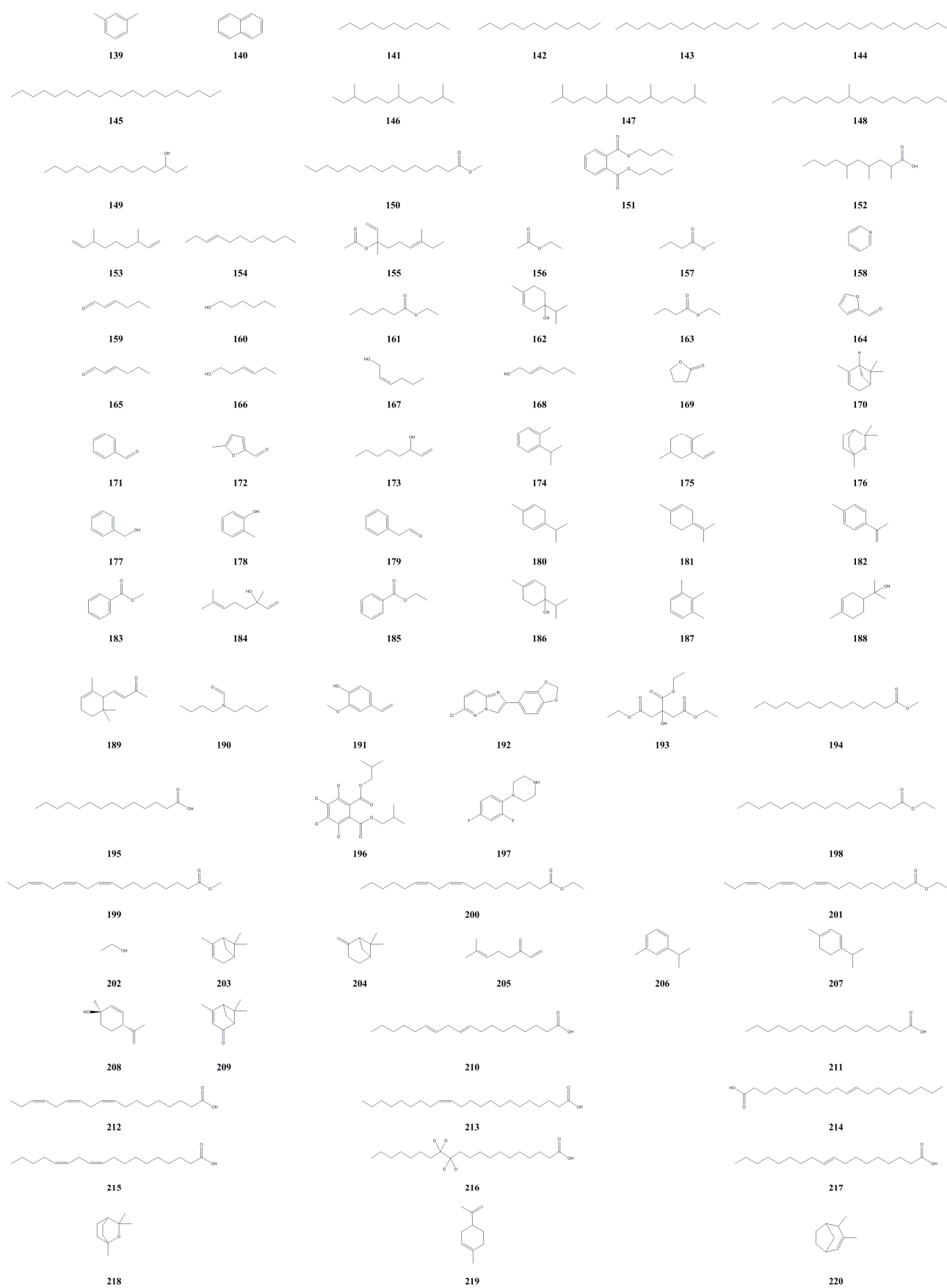


Figure 7. Cont.

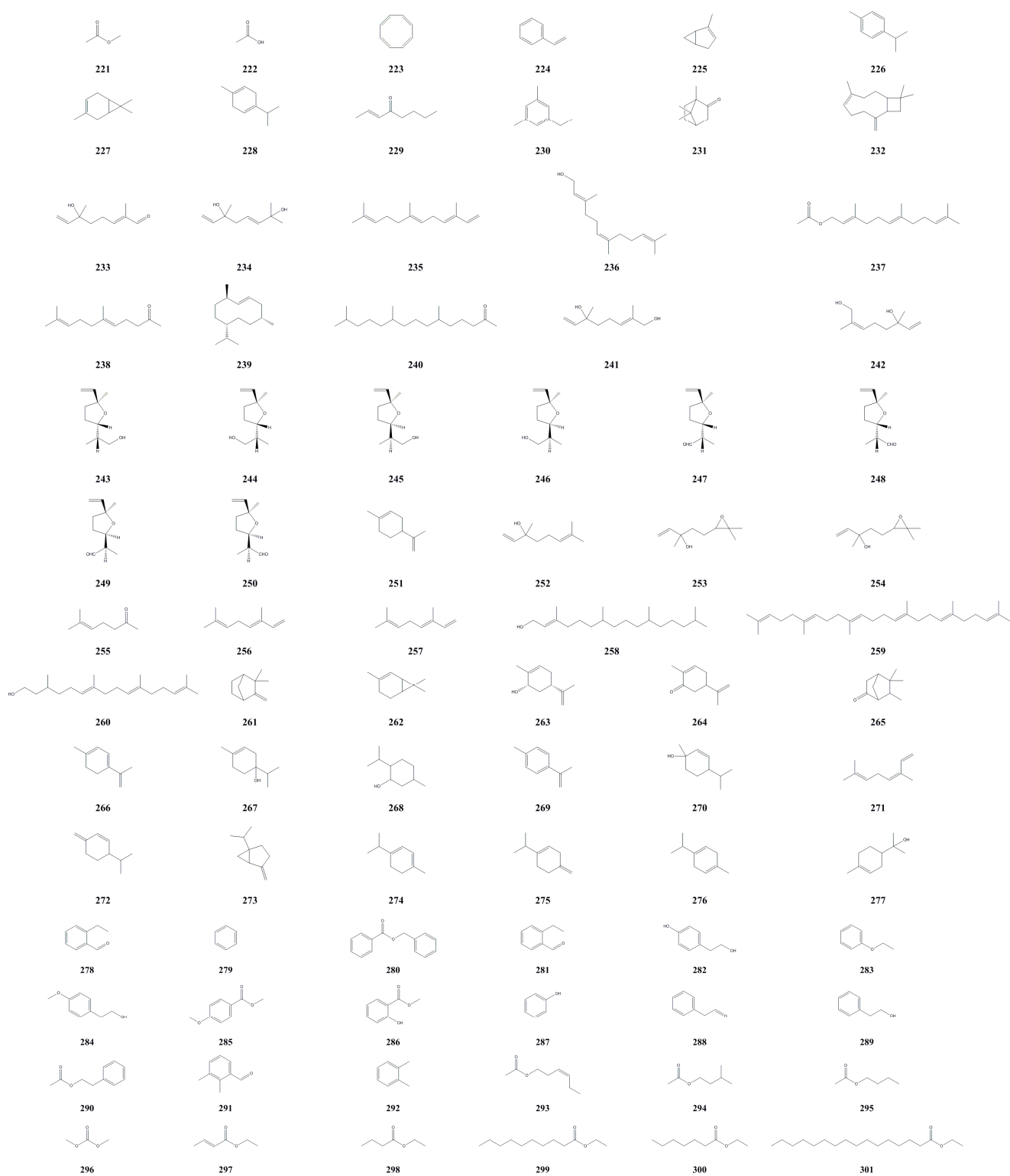


Figure 7. Cont.

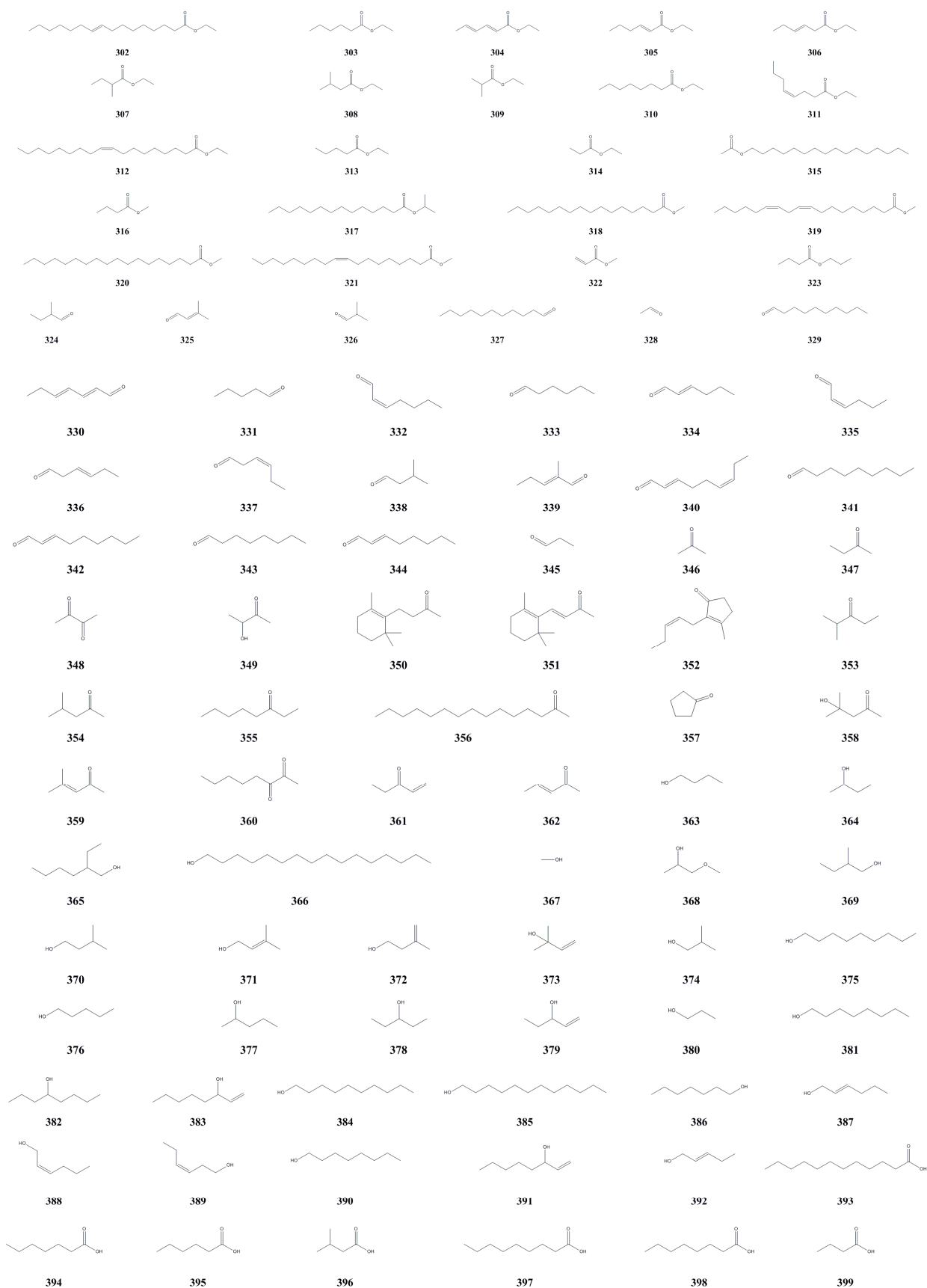


Figure 7. Cont.



Figure 7. Cont.

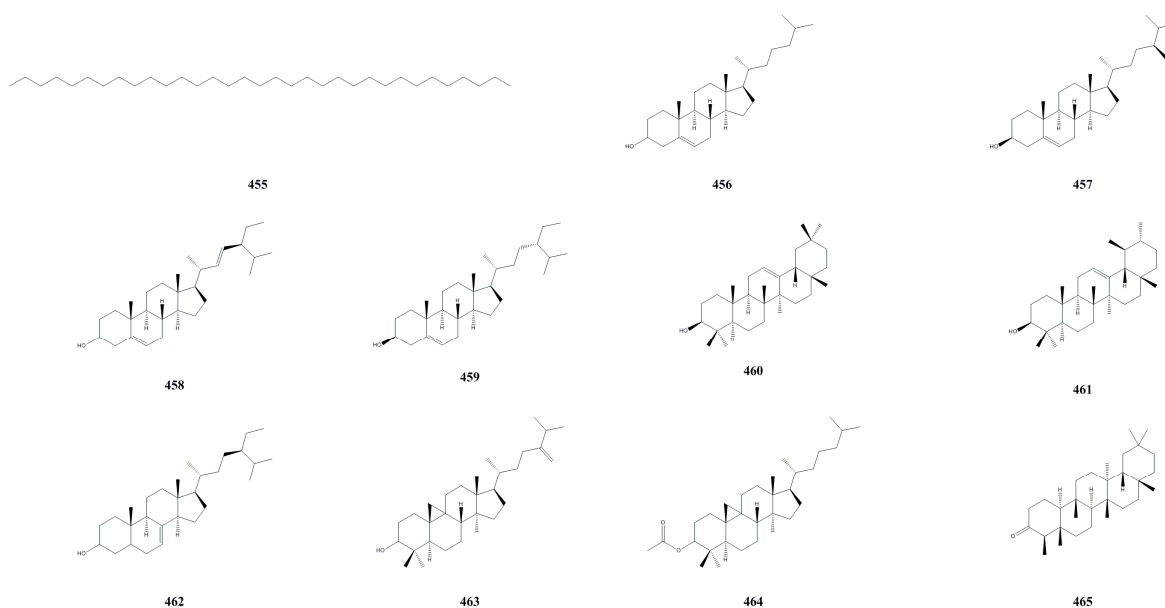


Figure 7. Chemical structures of volatile components isolated from *Actinidia arguta*. Chemical structures were drawn using Chemdraw Professional 15.0 software.

3.7. Other Compounds

Apart from the aforementioned compound types, an additional 45 different types of compounds were also isolated from *A. arguta* (Table 7, Figure 8). Most of these compounds were obtained from the fruit, while a few were derived from its roots, stems, leaves, buds, and seeds. These compounds primarily include alkaloids [51], anthraquinones [52], coumarins [18,29], amino acids [53], sterols [17,19], sugars, and glycols [39,54]. Notably, argutosides E (479), esculetin (482), and 7,8-dihydroxycoumarin (483) exhibited potent antioxidant and α -glucosidase inhibitory activities. However, esculetin 7-O-(6'-O-*trans*-coumaroyl)- β -glucopyranoside (480), umbelliferone 7-O-(6'-O-*trans*-coumaroyl)- β -glucopyranoside (481), 7,8-dihydroxycoumarin (483), and umbelliferone (484) displayed moderate antioxidant and α -glucosidase inhibitory activity.

Table 7. Other compounds isolated from *Actinidia arguta*.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
466	β -Sitosterol	C ₂₉ H ₅₀ O	414.3862	Roots	IR, EI-MS, ¹ H-NMR	[17]
467	Daucosterol	C ₃₅ H ₆₀ O ₆	576.4390	Stems	TLC, IR, ¹³ C-NMR	[19]
468	Ergosterol-4,6,8 (14), 22-tetraene-3-one	C ₂₈ H ₃₉ O ₂	407.2950	Roots	HPLC-DAD-ESI-MS	[18]
469	Aconitine	C ₃₄ H ₄₇ NO ₁₁	645.3149	Fruit	HPLC-MS	[51]
470	Berberine	C ₂₀ H ₁₈ NO ₄	336.1230	Fruit	HPLC-MS	[51]
471	Corydaline	C ₃₄ H ₄₇ NO ₁₁	369.1940	Fruit	HPLC-MS	[51]
472	Tetrahydropalmatine	C ₃₄ H ₄₇ NO ₁₁	355.1784	Fruit	HPLC-MS	[51]
473	Hypaconitine	C ₃₃ H ₄₅ NO ₁₀	615.3043	Fruit	HPLC-MS	[51]
474	Physostigmine	C ₃₄ H ₄₇ NO ₁₁	275.1634	Fruit	HPLC-MS	[51]
475	Atropine	C ₁₇ H ₂₃ NO ₃	289.1678	Fruit	HPLC-MS	[51]
476	Actinidine	C ₁₀ H ₁₃ N	147.1048	Fruit	HPLC-MS	[51]

Table 7. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
477	5-Hydroxy-6-methoxy-7-O- β -D-glucopyranosyloxy-coumarin	C ₁₆ H ₁₈ O ₁₀	370.0900	Roots	HPLC-DAD-ESI-MS	[18]
478	Bis(2-ethylhexyl) phthalate	C ₂₄ H ₃₈ O ₄	390.2770	Roots	HPLC-DAD-ESI-MS	[18]
479	Argutosides E	C ₂₄ H ₂₄ O ₁₂	504.1268	Leaves	IR, ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR, HMBC	[29]
480	Eculetin 7-O-(6'-O- <i>trans</i> -coumaroyl)- β -glucopyranoside	C ₂₄ H ₂₄ O ₁₁	488.1319	Leaves	IR, ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR	[29]
481	Umbelliferone 7-O-(6'-O- <i>trans</i> -coumaroyl)- β -glucopyranoside	C ₂₄ H ₂₄ O ₁₀	472.1369	Leaves	IR, ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR	[29]
482	Esculetin	C ₉ H ₆ O ₄	178.0266	Leaves	IR, ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR	[29]
483	7,8-Dihydroxycoumarin	C ₉ H ₆ O ₄	178.0266	Leaves	IR, ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR	[29]
484	Umbelliferone	C ₉ H ₆ O ₃	162.0317	Leaves	IR, ESI-TOF-MS, ¹ H-NMR, ¹³ C-NMR	[29]
485	Aspartic acid	C ₄ H ₇ NO ₄	133.0375	Fruit, seeds	Amino acid analyzer	[53]
486	Threonine	C ₄ H ₉ NO ₃	119.0582	Fruit, seeds	Amino acid analyzer	[53]
487	Serine	C ₃ H ₇ NO ₃	105.0426	Fruit, seeds	Amino acid analyzer	[53]
488	Glutamate	C ₅ H ₉ NO ₄	147.0532	Fruit, seeds	Amino acid analyzer	[53]
489	Glycine	C ₂ H ₅ NO ₂	75.0320	Seeds	Amino acid analyzer	[53]
490	Alanine	C ₃ H ₇ NO ₂	89.0744	Seeds	Amino acid analyzer	[53]
491	Cystine	C ₆ H ₁₂ N ₂ O ₄ S ₂	240.0238	Fruit, seeds	Amino acid analyzer	[53]
492	Valine	C ₅ H ₁₁ NO ₂	117.0790	Fruit	Amino acid analyzer	[53]
493	Methionine	C ₅ H ₁₁ O ₂ NS	149.0510	Fruit	Amino acid analyzer	[53]
494	isoleucine	C ₆ H ₁₃ NO ₂	131.0946	Fruit	Amino acid analyzer	[53]
495	Leucine	C ₆ H ₁₃ NO ₂	131.0946	Fruit	Amino acid analyzer	[53]
496	Tyrosine	C ₉ H ₁₁ NO ₃	181.0739	Fruit	Amino acid analyzer	[53]

Table 7. Cont.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
497	Phenylalanine	C ₉ H ₁₁ NO ₂	165.0790	Fruit	Amino acid analyzer	[53]
498	Lysine	C ₆ H ₁₄ N ₂ O ₂	146.1055	Fruit	Amino acid analyzer	[53]
499	Histidine	C ₆ H ₉ N ₃ O ₂	155.0695	Fruit	Amino acid analyzer	[53]
500	Arginine	C ₆ H ₁₄ N ₄ O ₂	147.1117	Fruit	Amino acid analyzer	[53]
501	Proline	C ₅ H ₉ NO ₂	115.0633	Seeds	Amino acid analyzer	[53]
502	Inositol	C ₆ H ₁₂ O ₆	180.0634	Roots	¹ H-NMR	[54]
503	Sucrose	C ₁₂ H ₂₂ O ₁₁	342.1162	Sprouts	HPLC	[39]
504	Glucose	C ₆ H ₁₂ O ₆	180.0634	Sprouts	HPLC	[39]
505	Fructose	C ₆ H ₁₂ O ₆	180.0634	Sprouts	HPLC	[39]
506	Maltose	C ₁₂ H ₂₂ O ₁₁	342.1162	Sprouts	HPLC	[39]
507	Xylose	C ₅ H ₁₀ O ₅	150.0528	Sprouts	HPLC	[39]
508	Emodin	C ₁₅ H ₁₀ O ₅	270.0528	Roots	HPLC	[52]
509	Chrysophanol	C ₁₅ H ₁₀ O ₄	254.0579	Roots	HPLC	[52]
510	3-Hydroxy-1-(4-O-β-D-glucopyranosyl-3-methoxyphenyl)propan-1-one	C ₁₆ H ₂₂ O ₉	358.1264	Fruit	ESI-MS, ¹ H-NMR, ¹³ C-NMR	[21]

IR: infrared spectroscopy; TLC: thin-layer chromatography; HPLC-MS: high-performance liquid chromatography-mass spectrometry; ¹³C-NMR: carbon-13 nuclear magnetic resonance spectrometry; ¹H-NMR: hydrogen-1 nuclear magnetic resonance spectrometry; HMBC: 1H-detected heteronuclear multiple bond correlation; ESI-MS: electrospray ionization-mass spectrometry; EI-MS: electron ionization-mass spectrometry; HPLC: high-performance liquid chromatography; HRESI-TOF-MS: high-resolution electrospray ionization-time of flight-mass spectrometry; HPLC-DAD-ESI-MS: high-performance liquid chromatography-diode array detection-electrospray ionization mass spectrometry.

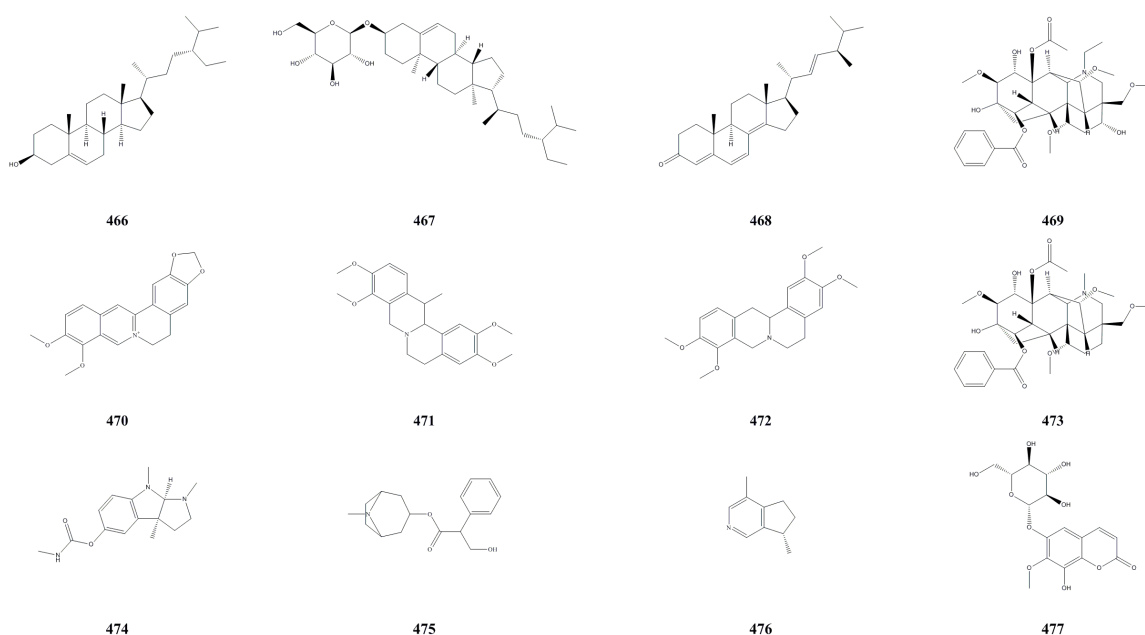


Figure 8. Cont.

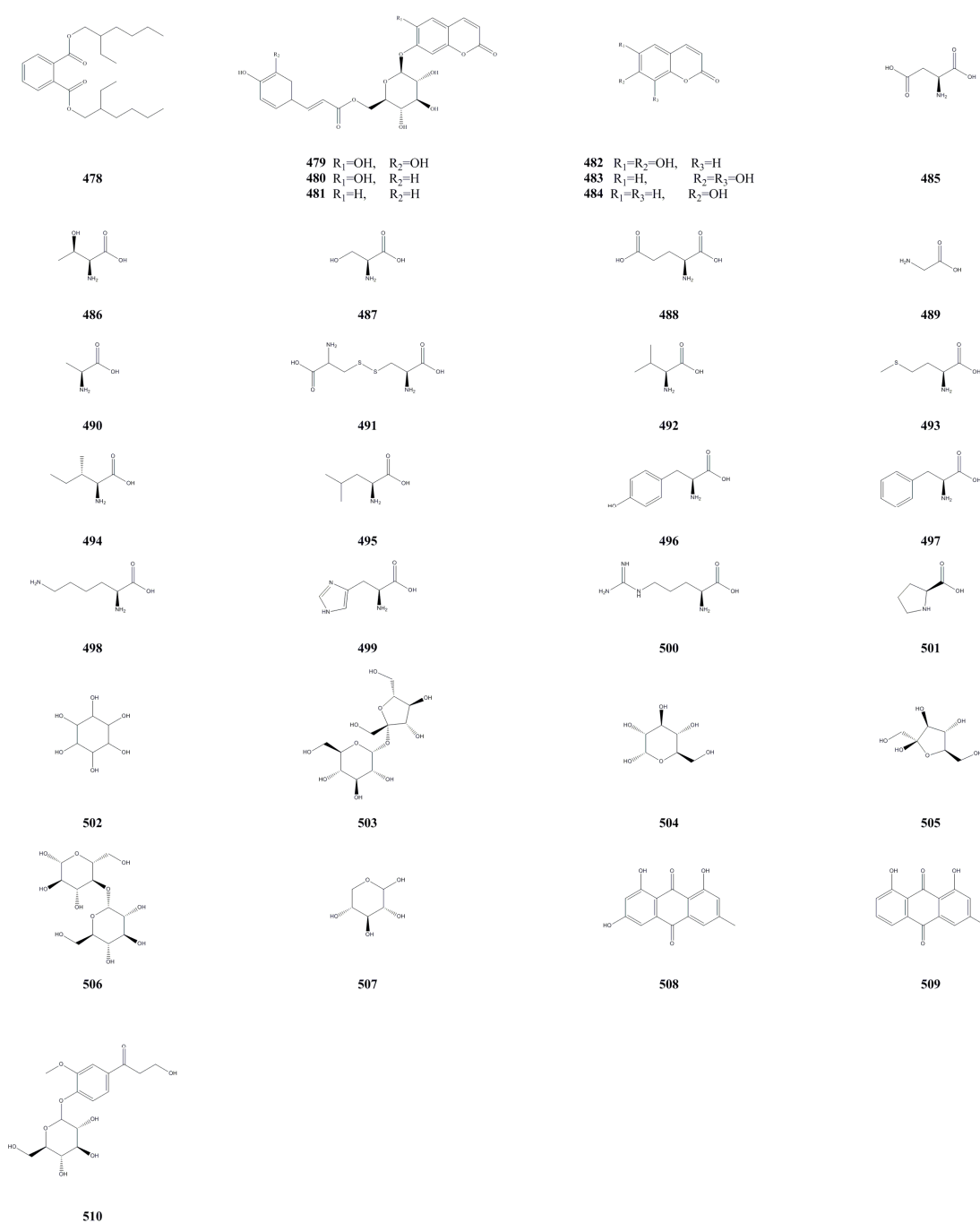


Figure 8. Chemical structures of other compounds isolated from *Actinidia arguta*. Chemical structures were drawn using Chemdraw Professional 15.0 software.

3.8. Inorganic Elements

The report indicates that *A. arguta* contains 29 inorganic elements (Table 8), many of which have beneficial effects on the human body [55].

Table 8. Inorganic elements isolated from *Actinidia arguta*.

No.	Name	Formula	Exact Theoretical Molecular Weight	Source	Characterization Method	Refs.
511	Calcium	Ca	39.9626	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
512	Kalium	K	38.9637	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
513	Magnesium	Mg	23.9850	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
514	Phosphorus	P	30.9738	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
515	Sodium	Na	22.9898	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
516	Aluminium	Al	26.9815	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
517	Ferrum	Fe	55.9349	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
518	Barium	Ba	137.9052	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
519	Strontium	Sr	87.9056	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
520	Manganese	Mn	54.9380	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
521	Lithium	Li	7.0160	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
522	Zinc	Zn	63.9291	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
523	Boron	B	11.0093	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
524	Cuprum	Cu	62.9296	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
525	Titanium	Ti	47.9479	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
526	Molybdenum	Mo	97.9054	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
527	Lead	Pb	207.9766	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
528	Chromium	Cr	51.9405	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
529	Nickel	Ni	57.9353	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
530	Indium	In	114.9039	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
531	Vanadium	V	50.9440	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
532	Arsenic	As	74.9216	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
533	Zirconium	Zr	89.9047	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
534	Cobalt	Co	58.9332	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
535	Cadmium	Cd	113.9034	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
536	Mercury	Hg	201.9706	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
537	Beryllium	Be	9.0122	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
538	Selenium	Se	79.9165	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]
539	Yttrium	Y	88.9058	Fruit, leaves, branches, stems, roots, velamina, fibers	FPD, ICP, AAS, AFS	[55]

FPD: flame photometric detector; AAS: atomic absorption spectroscopy; ICP: inductively coupled plasma; AFS: atomic fluorescence spectrometry.

4. Pharmacological Activities

As both a medicinal and edible plant, *A. arguta* not only bears edible fruit but its entire plant can also be employed for medicinal purposes. Modern pharmacological studies verified various pharmacological effects of *A. arguta*, including antioxidant, anti-inflammatory, anti-tumor, anti-aging, anti-fatigue, hypoglycemic, lipid-lowering, antibacterial, anti-glycation, anti-radiation, and immune regulation activities.

4.1. Antioxidant Activity

The continuous generation of reactive oxygen species (ROS) during oxidative metabolism is regarded as a major contributor to human aging [56]. Excessive accumulation of ROS in organisms may lead to oxidative stress, causing immune injury, rheumatoid arthritis, and atherosclerosis [57]. However, there is growing evidence suggesting that synthetic antioxidants can result in liver damage and even cancer [58]. Consequently, the search for natural antioxidants from plants has gained prominence in recent years [59–62].

An et al. (2016) extracted total flavonoids and polyphenols from three varieties of *A. arguta* and assessed their antioxidant capacities using DPPH, 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt (ABTS), and oxygen radical absorbance capacity (ORAC) methods. The results indicated that every 100 g of fresh fruit possessed an antioxidant capacity equivalent to containing 203.4 mg, 135.5 mg, and 115.0 mg of vitamin C, respectively [63]. Additionally, the addition of citric acid was observed to enhance the extraction rate of total polyphenols from *A. arguta*, thereby augmenting its antioxidant activity [64]. The flavonoids of *A. arguta* effectively scavenge DPPH at relatively low concentrations, with the EC₅₀ value reached at a concentration of 174.2 mg/L, which is similar to vitamin C. Additionally, at a concentration of 750 mg/L, the scavenging rate of DPPH exceeds 90%. Furthermore, *A. arguta* demonstrates a certain ability to scavenge hydroxyl radicals and superoxide anion free radicals, which increases with the concentration of flavonoids [65].

A separate study extracted quercetin from *A. arguta* and evaluated its antioxidant capacity. The results show no significant difference in the total antioxidant capacity between quercetin and vitamin C at the same molar concentration in vitro. However, the IC₅₀ of quercetin and vitamin C in the anti-lipid peroxidation assay was 0.79 mg/mL and 1.41 mg/mL, respectively, indicating the former's superior strength. Moreover, when combined, quercetin and vitamin C exhibited synergistic antioxidant effects. Quercetin's antioxidant capacity was further evaluated in vivo using a carbon tetrachloride-induced mouse oxidative liver injury model experiment. The results demonstrated that quercetin had significantly better antioxidant capacity in vivo compared with vitamin C. At the same time, combining quercetin with vitamin C resulted in enhanced antioxidant abilities [66]. This could be attributed to quercetin being a lipophilic antioxidant that is primarily distributed near the biofilm's surface, while vitamin C, which is a hydrophilic antioxidant, is located outside the membrane where it can scavenge ROS that diffuse outside the membrane [67].

Lee et al. (2014) analyzed the antioxidant activities of different solvent extracts from the stem of *A. arguta*. The ethyl acetate fraction (IC₅₀, 14.28 µg/mL) and *n*-butanol fraction (IC₅₀, 48.27 µg/mL) exhibited high DPPH scavenging activity. In addition, the ethyl acetate fraction (200 µg/mL) effectively inhibited nitric oxide (NO) production in RAW 264.7 cells induced by LPS, in contrast with other fractions [68]. Gao et al. (2019) measured the antioxidant capacities of different solvent extracts (ethyl acetate, *n*-butanol, water, methanol, and ethanol) from the adventitious roots of *A. arguta*. The ethyl acetate extract showed the strongest antioxidant capacity, with a DPPH scavenging rate of 88.09% at a concentration of 0.1 mg/mL. The ABTS scavenging rate at a concentration of 1.0 mg/mL was 95.62%. The chelating ability of iron ions was positively correlated with the concentration of the extract [69]. Khromykh et al. (2022) studied the antioxidant activities of components such as polyphenols in the peels and pulps of *A. arguta*. The results indicated that the peels had stronger reducing power and total antioxidant capacity compared with the pulps [70]. The best processing extract of *A. arguta* exhibited exceptional antioxidant and antiradical activities, including ABTS, ferric-reducing antioxidant power (FRAP), superoxide anion radical, hypochlorous acid, and peroxy radical scavenging [71].

Plant polysaccharides, in addition to multifunctional compounds, such as flavonoids, phenolics, and anthraquinones, also possess significant antioxidant capacity [72]. Polysaccharides from *A. arguta* fruit exhibited a strong scavenging ability for DPPH and alkyl radicals, with IC₅₀ values of 0.497 mg/mL and 0.547 mg/mL, respectively. At a concentration of 1 mg/mL, the polysaccharides showed scavenging rates of 86.4% and 87.1% for

DPPH and alkyl radicals, similar to vitamin C [73]. Moreover, polysaccharides from *A. arguta* fruit demonstrated the ability to scavenge hydroxyl radicals [74], indicating their strong antioxidant potential and promising prospects for development. Polysaccharides extracted from *A. arguta* leaves and stems also exhibited DPPH scavenging activities, with IC₅₀ values of 0.71 mg/mL and 0.72 mg/mL, respectively. These findings suggest that polysaccharides derived from *A. arguta* leaves and stems could be further developed and utilized as natural antioxidants [75].

The alkaloids found in *A. arguta* show scavenging effects on DPPH, hydroxyl radicals, and superoxide anion radicals. These alkaloids were also found to inhibit lipid peroxidation and possess a strong iron ion reduction ability [51]. The volatile components of *A. arguta* demonstrated certain antioxidant activity. The essential oil of *A. arguta* exhibited strong scavenging activity with DPPH (IC₅₀ = 117.60 µg/mL), which was comparable with the synthetic antioxidant butylated hydroxytoluene (BHT) [46]. Furthermore, the storage temperature was found to impact the antioxidant activity of *A. arguta*. Storage at 0 °C significantly inhibited the browning and respiratory intensity of *A. arguta* compared with 5 °C and 10 °C. Additionally, storage at 0 °C maintained higher fruit hardness and vitamin C, glutathione (GSH), and flavonoid contents while inhibiting relative conductivity; malondialdehyde (MDA) content; and peroxidase, and polyphenol oxidase activities. Storage at 0 °C also maintained higher superoxide dismutase (SOD), catalase, and glutathione reductase activities [76].

4.2. Anti-Inflammatory Activity

Inflammatory reactions can protect the human body from bacteria and tumors. However, chronic inflammation resulting from the continuous activation of macrophages can lead to serious health issues, including heart disease, gastrointestinal problems, and a sore throat. *A. arguta* contains various anti-inflammatory compounds, such as (+)-catechin, chlorogenic acid, (–)-epi-catechin, quercetin, rutin, and caffeic acid. Experimental results suggest that the chloroform layer of *A. arguta* stems exerts anti-inflammatory effects by inhibiting mitogen-activated protein kinase phosphorylation and the nuclear translocation of NF-κB [77]. In vitro experiments showed that the methanol extract of *A. arguta* leaves (12.5, 25, and 50 µg/mL) specifically inhibits NLRP3 ubiquitination, thereby suppressing the secretion of caspase-1 and IL-1β. This conclusion was also confirmed in in vivo experiments on a mouse model of peritonitis [78]. The results of anti-inflammatory activity research showed that when the total triterpenoid concentration of *A. arguta* branches reached 4 mg/mL, the inhibition rates of hyaluronidase activity and bovine serum albumin denaturation reached 81.48% and 71.09%, respectively. The anti-inflammatory activity was slightly lower than that of the positive control, namely, diclofenac sodium. The results confirmed the anti-inflammatory activities of total triterpenoids in *A. arguta* branches, which can effectively reduce the production and development of inflammation and maintain normal physiological functions [79]. However, the mechanism of its anti-inflammatory effect still needs to be studied. The anti-inflammatory effects of the fruit of *A. arguta* were investigated using an LPS-stimulated RAW 264.7 murine macrophage cell line. The polyphenols and flavonoids in the fruit of *A. arguta* can effectively inhibit the release of interleukin-6 (IL-6) and tumor necrosis factor-α (TNF-α), and their effects on the release of NO are dose-dependent. Therefore, inhibition of this pathway could be a possible mechanism of the anti-inflammatory effects of the fruit of *A. arguta* [63].

4.3. Anti-Tumor Activity

The anti-tumor effect is mainly reflected in inhibiting the proliferation and growth of tumor cells, promoting tumor cell apoptosis, enhancing the body's immunity, and alleviating symptoms. *A. arguta* exhibits a significant anti-tumor effect, with its roots, stems, leaves, and fruit containing various anti-tumor active ingredients, such as flavonoids, anthraquinones, and polysaccharides. A mouse model of reduced bone marrow function was created using a single intravenous injection of 5-fluorouracil at a dose of 150 mg/kg.

Methanol extract from *A. arguta* stems (100 mg/kg/d) promotes the proliferation of mouse bone marrow cells, in which (+)-catechin and (−)-epi-catechin play a role [80]. (+)-catechin (1 and 10 mg/kg/d) was found to be effective in promoting bone marrow cell proliferation and combating the hematotoxicity of 5-fluorouracil in mice [81]. Five types of human cancer cells were cultured in Dulbecco's Modified Eagle Medium (DMEM) supplemented with 10% fetal bovine serum in a 5% CO₂-humified incubator at 37 °C. It was observed that *A. arguta* fruit exhibits anti-proliferative activities against Hep3B and HeLa cell lines but has no effect on HT-29, HepG2, and LoVo cells [82]. The inhibitory effect of extracts on leukemia cells was detected using the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl-2H-tetrazolium bromide (MTT) assay.

Anthraquinone compounds extracted from *A. arguta* roots exhibited significant inhibitory effects on four leukemia cell lines, namely, JARKET, RAJI, L1210, and K562. The inhibitory rate shows a positive correlation with the concentration of the extract [83]. Furthermore, the polysaccharide derived from *A. arguta* stems (20 mg/mL) inhibited the proliferation of transplanted S180 tumor cells in Swiss mice, and this anti-tumor effect might be attributed to the enhanced immune function of the body [84]. *A. arguta* juice has the ability to block the formation of *N*-nitroso morpholine (a known carcinogen) under simulated gastric juice conditions, with a blocking rate of 79.52%. This rate is higher than that of an equivalent amount of vitamin C solution, indicating the strong anti-tumor effects of *A. arguta* juice [85]. The volatile components of *A. arguta* also exhibit cytotoxic activities. The cytotoxicity of *A. arguta* essential oil was studied using the MTT assay, yielding IC₅₀ values of 6.067 mg/mL, 11.905 mg/mL, and 13.646 mg/mL for the A549, HT-29, and PC-3 cell lines, respectively [46]. The antiproliferative activities of *A. arguta* extract against HepG2 and HT-29 cells (0–100 mg/mL and 0–200 mg/mL, respectively) were found to be 1.44–4.25 times higher than that of *Actinidia kolomikta* or *Actinidia chinensis* extracts, likely due to the higher flavonoid content in *A. arguta* extract. Therefore, *A. arguta* extract shows potential as a chemotherapeutic agent against HepG2 and HT-29 cells [86].

4.4. Anti-Aging Activity

Modern medicine recognizes skin aging as a physiological or pathological change influenced by various factors and is categorized as either endogenous aging or exogenous aging [87]. Endogenous aging is influenced by genetic or endocrine factors, while exogenous aging is influenced by external environmental factors that can lead to skin laxity, roughness, and deepening wrinkles [88]. Traditional Chinese medicine contains active ingredients, such as saponins, polysaccharides, and flavonoids, that possess anti-aging effects by scavenging free radicals, regulating immunity, reducing mitochondrial DNA damage, improving substance metabolism, and enhancing microcirculation [89].

In one study, 14-month-old TA₁ pure-strain mice were fed *A. arguta* juice for 50 d [90]. The results showed that male and female mice had 75.17% and 76.25% inhibition rates of MAO-B activity in the brain, indicating that *A. arguta* juice can modulate the central aging clock by regulating brain monoamine levels and exerting anti-aging effects. *A. arguta* juice also significantly reduced lipofuscin content in mouse myocardial cells, demonstrating its antioxidant effect and ability to inhibit free radical production. Moreover, it reduced the hydroxyproline content in the tail tendons of 14-month-old TA₁ pure-strain mice, suggesting its potential to delay aging. Additionally, *A. arguta* juice decreased the levels of total bile acid (TBA) and increased SOD activity. However, further research is needed to determine the specific mechanisms behind its anti-aging effects [91]. In another study, Gan et al. (2004) administered *A. arguta* juice to elderly Wistar rats aged 20–22 months with a weight of 400 ± 30 g at doses of 3 g/kg and 6 g/kg for 30 d. The measurements of red blood cell and liver SOD, whole blood glutathione peroxidase (GSH-Px) activity, serum MDA, and lipofuscin content in brain and heart tissues revealed a significant increase in red blood cell SOD, liver SOD, and whole blood GSH-Px activity. Additionally, the levels of serum MDA and lipofuscin in brain and heart tissues were significantly reduced. These

findings indicate that *A. arguta* juice could enhance the activities of antioxidant enzymes, reduce lipid peroxidation, and delay the aging process in the bodies of elderly rats [92].

4.5. Anti-Fatigue Effect

Effervescent tablets were produced using *A. arguta* fruit through spray drying and tablet pressing technologies in certain studies. The dose was divided into low-, medium-, and high-dose groups, with an administration of 0.2 mL per 20 g weight of medication for 20–22 g Kunming male mice. Compared with the control group, the effervescent tablet low-, medium-, and high-dose groups exhibited significant differences in terms of prolonged exhaustive swimming time in mice, with increases of 35.03%, 61.15%, and 89.81%, respectively. Similarly, the fatigue rotation time of mice increased by 58.10%, 122.86%, and 157.14% in the low-, medium-, and high-dose groups, respectively. While the low-dose group displayed a significant difference, the medium- and high-dose groups showed extremely significant differences. Furthermore, effervescent tablets were found to enhance exercise endurance and improve parameters such as lactate dehydrogenase activity, liver glycogen, and muscle glycogen content in mice. Additionally, they reduced serum urea nitrogen and blood lactate content, demonstrating significant anti-fatigue effects [93]. In another experiment, 28 Kunming mice were randomly allocated into four groups and administered doses of 0, 50, 100, and 200 mg/kg/d of crude alkaloid extract from *A. arguta* for 28 d raised in an SPF barrier system. The evaluation of exercise abilities included forelimb strength training and weight-bearing swimming time, while anti-fatigue abilities were assessed by measuring the glycogen content in the liver and muscles, as well as observing morphological changes in the longitudinal profiles of striated and skeletal muscles. The results indicated that the crude alkaloid extract improved the endurance and grip strength of mice and prolonged their swimming time under load, with the 100 mg/kg/d group displaying the most significant prolongation. Compared with the control group, the experimental group showed significant decreases in the levels of lactate, ammonia, and creatine kinase, accompanied by an increase in tissue glycogen content. Moreover, no changes were observed in the morphology of striated and skeletal muscles [94].

4.6. Hypoglycemic Activity

Plant polysaccharides have the beneficial effect of reducing blood sugar levels. They are safe, with minimal toxic and side effects, and show positive effects in individuals with hyperglycemia. As a result, an increasing number of researchers are dedicated to utilizing plant polysaccharides in the development of safe, affordable, and effective natural medications for blood sugar reduction [95,96]. *A. arguta* polysaccharides exhibit hypoglycemic effects, and studies indicate that the main active compounds responsible for this effect in *A. arguta* are flavonoids and polysaccharides [97,98]. In one study, mice induced with type II diabetes through a high-fat and high-sugar diet, combined with streptozocin (STZ), were administered low, medium, and high doses of *A. arguta* flavonoids at 90, 180, and 270 mg/kg/d, respectively. The results show a significant improvement in the symptoms of the diabetic mice, specifically in reduced fasting blood glucose levels and serum insulin levels. The fasting blood glucose level decreased correspondingly as the dose increased. Additionally, it was observed that the expression level of the glucokinase gene in the liver of the diabetic mice increased, thereby enhancing the glucokinase activity. The hypoglycemic effect of flavonoids on type II diabetic mice is thought to be mediated by upregulating the expression of the glucokinase gene, repairing damaged pancreatic islet β cells, improving serum insulin levels, inhibiting α -glucosidase activity, and enhancing glucokinase activity, thus maintaining glucose homeostasis in the liver [98].

The polyphenol fraction of *A. arguta*, which contains quercetin-3-O-glucoside and quercetin-3-O-galactoside, exhibits inhibitory activity against α -glucosidase and maltase. Male KK-A^y mice, which is a type II diabetic model, and C57BL/6J mice, which is a non-diabetic control model of KK-A^y mice, in addition to male Sprague Dawley (SD) rats, were used for a single-dose test. In an oral glucose tolerance test conducted on KK-A^y mice fed with quercetin-3-O-glucoside for 4 weeks, blood glucose levels tended to be lower 60 min

after glucose administration. These findings suggest that *A. arguta* possesses antidiabetic effects, and quercetin-3-O-glucoside, which is a component of *A. arguta*, may be useful in the prevention of type II diabetes by suppressing gluconeogenesis and enhancing lipid β -oxidation [99].

To explore the hypoglycemic effect of polysaccharides, a model of type II diabetic mice was established by feeding them with a high-fat and high-sugar diet and intraperitoneal injection of a low-dose STZ. Polysaccharides derived from *A. arguta* branches were orally administered to mice in low-, medium-, and high-dose groups at 10, 20, and 40 mg/kg, respectively. Another group of mice was administered 40 mg/kg of metformin as a positive control. After 28 d of continuous administration, there was a significant decrease in total cholesterol, total triglycerides, and low-density lipoprotein cholesterol, while high-density lipoprotein cholesterol levels significantly increased. This indicates an improvement in the abnormal blood lipid profile found in diabetic mice. Moreover, the content of MDA in serum significantly decreased, while the content of SOD increased, suggesting that polysaccharides may have a hypoglycemic effect by inhibiting peroxidation reactions in the body. An examination of organ indices and histomorphology revealed that the high-dose polysaccharide group exhibited a protective effect on the pancreas and liver of STZ-induced diabetic mice. Therefore, it can be inferred that polysaccharides regulate blood sugar levels and lipid metabolism in diabetic mice while also reducing insulin resistance [100].

A. arguta fruit polysaccharide has a reparative effect on the islets of the pancreas in diabetic mice induced by intraperitoneal injection of alloxan. It increases insulin secretion, improves glucose and lipid metabolism, significantly reduces fasting blood sugar, increases glucose tolerance, boosts liver glycogen, and lowers blood lipid levels [101]. However, the exact mechanism still requires further exploration. Compared with the control group, rats with STZ-induced diabetes that were fed with the 70% ethanol extract (400 mg/kg) of *A. arguta* experienced a significant reduction in postprandial blood glucose by inhibiting α -glucosidase activity [102]. Additionally, in a study using mice fed with a high-fat and high-sugar diet, an extract of *A. arguta* not only reduced barbituric acid reactive substances but also increased GSH levels [103]. Another study showed that a polyphenol extract in the fruit of *A. arguta* also inhibited α -glucosidase activity [103]. Furthermore, an aqueous extract of *A. arguta* stem exhibited appreciable inhibitory activity against the α -glucosidase enzyme, with an IC_{50} of 1.71 mg/mL [68].

4.7. Hypolipidemic Activity

In recent years, the incidence rate of hyperlipidemia has been increasing. Hyperlipidemia is a sign of a lipid metabolism disorder and one of the main triggers for atherosclerosis, heart disease, and fatty liver [104]. Preventing the occurrence and development of hyperlipidemia is of great significance for reducing the incidence rate of cardiovascular and cerebrovascular diseases [104]. The search for lipid-lowering drugs from natural plants is currently a prominent research topic [105,106]. Leontowicz et al. (2016) investigated the protective effects of *A. arguta* fruit on the aorta and liver of hypercholesterolemic rats. They fed 71 male Wistar rats with 1% cholesterol to induce a model and then randomly divided them into groups. In the *A. arguta* group, the levels of total cholesterol, low-density lipoprotein cholesterol, the total cholesterol/high-density lipoprotein cholesterol atherosclerosis index, and triglyceride in the liver serum were reduced, accompanied by an increase in high-density lipoprotein cholesterol. Additionally, the serum's antioxidant capacity became stronger. Rat liver fibrosis decreased, the prothrombin time was prolonged, and serum peroxidase decreased. This suggests that *A. arguta* can effectively reduce the probability of hyperlipidemia [107].

There are also reports of a study that selected 36 male mice and randomly divided them into three groups: blank control, high-fat model, and high-fat+polysaccharide groups, each containing 12 mice. The high-fat+polysaccharide group was fed a high-fat diet daily, while *A. arguta* fruit polysaccharide (300 mg/kg) was administered via gavage. The results demonstrated that polysaccharides significantly reduced the content of total cholesterol and

triglycerides in both the serum and liver of mice while increasing the level of high-density lipoprotein cholesterol in the liver. Pathological observations of liver tissue indicated that polysaccharides significantly improved and alleviated the symptoms of liver fat and hyperlipidemia. Determining the lipid levels in mouse feces revealed that polysaccharides significantly increased the total fat, cholesterol, and triglyceride contents in the feces of high-fat mice, suggesting that the polysaccharide's effect on reducing cholesterol levels is achieved by promoting the cholesterol excretion pathway [108].

4.8. Other Pharmacological Effects

A. arguta also exhibits other pharmacological effects, such as antibacterial, antiglycated, anti-radiation, and immune-regulation properties. Studies have reported the in vitro antibacterial activity of *A. arguta*. The results indicate that *A. arguta* volatile oil has significant antibacterial activity against *Staphylococcus aureus* and *Saccharomyces cerevisiae*, with inhibition zones of 19.5 mm and 20.5 mm, respectively. The antibacterial activities against *Bacillus subtilis* and *Microsporium canis* are moderate, with inhibition zones of 17.2 mm and 16.8 mm, respectively. However, *A. arguta* shows weak antibacterial activities against *Escherichia coli* and *Pseudomonas aeruginosa*, with inhibition zones of 8.5 mm and 10 mm, respectively [46]. Additionally, studies indicate that *A. arguta* fruit polysaccharides have inhibitory effects on *Bacillus subtilis*, *Escherichia coli*, *Staphylococcus aureus*, and other bacteria. The antibacterial effect increases as the concentration of polysaccharides increases, with a minimum inhibitory concentration (MIC) ranging from 10 to 25 mg/mL. However, no antibacterial effect was observed against *Candida tropicalis*. Temperature and pH values also impact the antibacterial effect of polysaccharides, with a higher temperature resulting in a more pronounced effect. Polysaccharides exhibit a better antibacterial effect within a pH range of 4–5 [109]. The total flavonoids of *A. arguta* have inhibitory effects on *Escherichia coli*, *Staphylococcus aureus*, *Rhizopus*, *Aspergillus oryzae*, *Candida tropicalis*, and *Saccharomyces cerevisiae*. The inhibitory effect increases as the concentration of total flavonoids increases, with an MIC ranging from 25 to 50 mg/mL. No inhibitory effect was observed against *Aspergillus niger*. Similar to polysaccharides, temperature and pH values also affect the antibacterial effect of total flavonoids, with a higher temperature having a more pronounced effect. Total flavonoids exhibit a better antibacterial effect within a pH range of 5–6 [110]. Another study investigated the antibacterial activity of *A. arguta* fruit and leaves. The crude extracts of *A. arguta* fruit and leaves notably inhibited clinical strains of *Pseudomonas aeruginosa* and *Escherichia coli*, which were resistant to the action of ofloxacin. The inhibitory effects of the plant extracts on clinical strains of *Klebsiella pneumoniae* and *Acinetobacter baumannii* were comparable with the effect of ofloxacin [70]. In addition, Macedo et al. (2023) studied an extract of *A. arguta*, which displayed antimicrobial activities against *Staphylococcus aureus* (MIC = 32 mg/mL) and *Pseudomonas gingivalis* (MIC = 64 mg/mL) and reduced the growth rate of *Escherichia coli* [71].

A novel cell wall polysaccharide (AAPs) was extracted from *A. arguta* fruit and separated into four parts, namely, water-eluted polysaccharide, salt-eluted polysaccharide (SPS)-1, SPS-2, and SPS-3. All four types of polysaccharides exhibited the ability to scavenge free radicals, chelate iron ions, inhibit lipid peroxidation, and inhibit protein glycation. However, SPS showed significantly stronger effects compared with the water-eluted polysaccharide. Particularly, SPS-3 demonstrated the highest antioxidant and anti-glycated activities. Furthermore, the inhibitory effect of AAPs on advanced glycation end product formation can be attributed to their ability to inhibit the production of protein carbonyl groups and protect protein thiol groups. This effect is not related to the scavenging capacity of dicarbonyl compounds. These findings suggest that the mechanisms underlying the antiglycated effects of AAPs may be linked to their antioxidant activities [111]. Moreover, more than 20% of *A. arguta* fruit polysaccharides significantly enhanced the survival rate of yeast cells after ultraviolet radiation, indicating the radiation-protective effects of these polysaccharides on cells [112].

Studies also demonstrated that *A. arguta* stem polysaccharides have a notable immune-promoting effect and act as effective immune regulators in mice (20 ± 2 g). These polysaccharides enhance the proliferation of T and B lymphocytes both in vivo and in vitro, with the most significant effect observed at a dose of 100 mg/kg. Additionally, they promote mitosis and stimulate the production of lymphokines in mice. Furthermore, *A. arguta* stem polysaccharides enhance the primary response of B cells to SRBC antibodies and improve the phagocytic ability of macrophages [113]. Other research indicates that *A. arguta* fruit polysaccharides briefly increase the proportion of total T cells and helper T cells in 6-week-old female mouse peripheral blood, have a long-term inhibitory effect on the proportion of B cells and toxic T cells in mouse peripheral blood, and exhibit delayed and instantaneous promotion of the proportion of NK cells in mouse peripheral blood [114]. Moreover, high doses of *A. arguta* fruit polysaccharides promote the growth of SD rats and significantly increase their spleen index. The medium- and high-dose groups also exhibit significant increases in the thymic index, phagocytic index, and concanavalin A (Con A)-induced splenic lymphocyte transformation index in rats. These findings confirm that polysaccharides enhance the immune system by promoting the growth of immune organs, enhancing cellular immune function, and improving the phagocytic ability of monocytes and macrophages [115]. In terms of safety, three solvent extracts (water, water:ethanol (50:50), and ethanol) of *A. arguta* leaves showed no adverse effects on caco-2 and HT29-MTX cells at concentrations below 100 $\mu\text{g/mL}$ and 1000 $\mu\text{g/mL}$, respectively. This suggests that *A. arguta* leaves are relatively safe for consumption [116].

5. Discussion

We conducted a comprehensive review of the phytochemistry and pharmacological research of *A. arguta*, which is a traditional medicinal plant. A total of 539 compounds were reported, showing that *A. arguta* contains a variety of phytochemicals, including terpenoids, flavonoids, phenolics, phenylpropanoids, lignin, organic acids, volatile components, alkanes, coumarins, anthraquinones, alkaloids, polysaccharides, and inorganic elements. We also elucidated the various pharmacological studies on these compounds and various extracts of *A. arguta*. This thorough literature review indicates that *A. arguta* has excellent antioxidant, anti-inflammatory, and anti-tumor properties. Furthermore, it has broad application prospects for improving glucose metabolism, anti-aging, anti-fatigue, and immune regulation. In particular, flavonoids, phenolics, and polysaccharides, which were identified as the main components responsible for mediating these pharmacological effects, were extensively studied and reported multiple times.

Additionally, the roots of *A. arguta* have long been known for their unique anticancer effects and are highlighted in the “Dietary Materia Medica”, along with the “Compendium of Materia Medica”. Therefore, a significant amount of academic research is dedicated to revealing the active ingredient of its anticancer efficacy. In recent years, *A. arguta*, as a new fruit, has gradually been accepted by more and more people due to its excellent taste and rich nutritional value. It is used to prepare jam, canned food, and wine, making it an emerging resource for research and processing in the food industry. This has driven a surge in demand in both domestic and international markets, leading to the large-scale planting of *A. arguta*. Consequently, researchers have been inspired to explore the different medicinal parts of the plant and strive to broaden their research scope. Amongst these sections, the leaves of *A. arguta* have received attention due to their unique characteristics similar to tea. However, current research on the chemical composition of *A. arguta* mainly focuses on the isolation and identification of individual compounds, with limited research on the changes in component content in different regions and plant parts. Additionally, further exploration is needed to establish quality standards for *A. arguta*. It is important to highlight future research in these areas, as it is crucial for enhancing the standardized application and quality control of *A. arguta*.

Of particular interest in *A. arguta* are flavonoids and phenolics. Researchers discovered a total of 52 compounds from these categories in *A. arguta*, which showed extensive clinical

efficacy in clinical studies regarding anti-aging and hypoglycemic effects. It is noteworthy that *A. arguta* contains compounds with specific structures, such as (2*R*,6*R*,9*R*)-trihydroxy-megastigmane-4,7*E*-dien-3-one-9-*O*- β -D-glucopyranoside, which is a methylcyclohexene-type sesquiterpenoid glycoside compound that has not been reported in the literature. These unique chemical characteristics make *A. arguta* a promising subject for further exploration of the biological activity of these novel terpenoids and the potential discovery of safe and effective compounds with therapeutic applications.

Moreover, numerous studies revealed the various pharmacological activities of *A. arguta*, mainly focusing on its antioxidant, anti-inflammatory, and anti-tumor effects. However, it is important to note that some studies only utilize extracts from different parts or solvents of *A. arguta*, rather than pure compounds. Additionally, the research on other pharmacological activities of *A. arguta* is not comprehensive enough, with many mechanisms of action remaining unidentified. Currently, research on the pharmacokinetics of *A. arguta* is limited, despite its significant role in elucidating metabolic pathways. Therefore, further exploration of the pharmacological activity and pharmacokinetics of *A. arguta* is necessary.

This review, however, has certain limitations. First, the methods used for collecting literature and data were limited, which may lead to the omission of relevant studies. Second, the quality of some collected research literature may have flaws, potentially affecting the reliability of the review's results. Another significant limitation was the lack of research on the toxicity and clinical reports of *A. arguta*, especially regarding its significant therapeutic effect on gastrointestinal tumors. Further studies should address these limitations and delve into unexplored areas, such as toxicity, pharmacokinetics, and clinical research.

6. Conclusions

However, there is currently a dearth of comprehensive and detailed documentation on the phytochemistry and pharmacology of *A. arguta*. As a result, the main objective of this review was to thoroughly explore the existing research on *A. arguta* by examining multiple databases and addressing these aforementioned aspects. Additionally, this review aimed to establish a strong foundation for further exploration of the potential uses of *A. arguta*, as well as providing guidance for future research. First, it was demonstrated that the roots of *A. arguta* exhibit remarkable efficacy as an anti-tumor agent, particularly in the treatment of gastrointestinal tumors. This finding suggests its potential as a valuable addition to the arsenal of anti-cancer drugs. Second, given the deep-rooted love for tea culture in East Asian countries, products such as health teas derived from the leaves of *A. arguta* hold tremendous potential for development. These teas could cater to the growing demand for natural and beneficial beverages, offering unique flavors and potential health benefits. Furthermore, the fruit of *A. arguta* is not only nutritionally rich but also boasts an appealing taste, making it increasingly popular among consumers. As awareness of the fruit's health benefits spreads, it is expected that more and more individuals will embrace and enjoy the fruit of *A. arguta*. Building upon this extensive review, further investigations into *A. arguta* are likely to lead to the isolation and identification of additional chemical components. Additionally, ongoing research will undoubtedly uncover more effective and practical pharmacological effects, ultimately benefiting humanity and contributing to the advancement of medical science.

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