The progress of Chemical Constituents Isolated from the Root of Actinidia chinensis Planch and their Biological Activities

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Abstract

The Chinese traditional plant medicine *Actinidia chinensis* Planch roots has ever been widely used in clinical for its wide spectrum of biological activities, such as antitumor, antioxidant, antiviral, detoxifying, antidiuretic, anti-hepatitis and haemostatic activities, which owe to the different bioactive compounds (flavonoids, steroids, alkaloid, organic acids and polysaccharides) in the roots of *Actinidia chinensis* Planch. In this review, we mainly summarize the phytochemical progress as well as biological activities of *A. chinensis* root, to provide the reference for its further research and relevant knowledge towards drug development.

Keywords: *Actinidia chinensis,* chemical constituents, biological activities.

Introduction

Actinidiaceae family has over fifty-four species, which are distributed mostly in tropical provinces of China [1,2]. It reported that *Actinidiaceae* family is rich in compounds of triterpenoids, anthraquinones, alkaloid, organic acids, flavonoids, steroids and polysaccharides [3-5]. *Actinidia chinensis* Planch roots commonly called *Tengligen*, used as Chinese folk medicine for treatment of tumors, such as liver cancer, gastric cancer and esophagus cancer [6-11] . In addition, it was also used as detoxifying, antidiuretic, anti-hepatitis and haemostatic agent [12], because *A. chinensis* roots is rich in these bioactive compounds [5,13-15], which possess a wide spectrum of biological activities listed above.

This review mainly focus on the phytochemicals of the *A. chinensis* roots as well as biological activities of extractions, pure compounds obtained from this folk plant medicine, to provide the reference for its further research and relevant knowledge towards drug development.

Chemical constituents

Different kinds of constituents, including triterpenoids, anthraquinones, alkaloids, organic acids, flavonoids, steroids and polysaccharides in roots of *A. chinensis* have been isolated and reported, which are classified below.

Triterpenoids

Triterpenoids are predominantly presence in the family of Actinidia species [16]. However, there are few triterpenoids reported to be presence in the A. chinensis root [13]. Six triterpenoids were also detected from the same part of this plant medicine, which were identified as 2α-hydroxyoleanolic acid (1), 2α-hydroxyursolic acid (2), euscaphic

acid (3), 23-hydroxyursolic acid (4), 3β-O-acetylursolic acid (5) and ergosta-4,6,8,(14),22-tetraen-3-one (6) [17]. In addition, 2α,3β-dihydroxyurs-12-en-28,30-olide (7) and 2α,3β,24-trihydroxyurs-12-en-28,30-olide (8) with other eight known compounds, such as 12-en-28-oic acids of oleanane or ursane type triterpenoids including oleanolic acid (9), 3-epi-corosolic acid (10), 2α,3α,24-trihydroxyurs-12-en-28-oic acid (11), 23-hydroxyursolic acid (4), asiatic acid (12), 2α,3α,19,24-tetrahydroxyurs-12-en-28-oic acid (13), 3β-hydroxyurs-12,18-dien-28-oic acid (14) and 2α,3α,23-trihydroxyursa-12,20,(30)-dien-28-oic acid (15) were also isolated and reported. Among them, compounds 2α,3β-dihydroxyurs-12-en-28,30-olide (7) and 2α,3β,24-trihydroxyurs-12-en-28,30-olide (8) were reported as the new compounds [16].

Xu et al. [18] isolated 12α-chloro-2α,3β,13β, 23-tetrahydroxyolean-28-oic acid-13-lactone (16) and 2α,3α,19α,23,24-pentahydroxyurs-12-en-28-oic acid (17) and reported as new triterpenoids with ursolic acid (18), pseudotaraxasterol (19), 2α,3β-dihydroxyolean-12-en-28-oic acid (20), 2α,3β-dihydroxyurs-12-en-28-oic acid (21), 11, 2α,3α,24-trihydroxyolean-12-en-28-oic acid (22), 2α,3β,23-trihydroxyurs-12-en-28-oic acid (23), 2α,3α,23-trihydroxyurs-12-en-28-oic acid (24), 2α,3β,24-trihydroxyurs-12-en-28-oic acid (25), 2α,3α,19,24-tetrahydroxyurs-12-en-28-oic acid (26), 2α,3β,19α,23-tetrahydroxyurs-12-en-28-oic acid (27), 2α,3α,24-trihydroxyurs-12,20(30)-dien-28-oic acid (28) and 2α,3α,19α,24-tetrahydroxyurs-12-en-28-oic acid 28-O-β-D-glucopyranoside (29) from the root of A. chinensis [18]. γ-quinide (30), 10, 18 were discovered from A. chinensis. γ-quinide (30) was isolated for the first time in this work [19].

Peng et al. [20] reported that the total contents of oleanolic acid (9) and ursolic acid (18) in roots of A. chinensis were 381.9 and 427.4 ng/g respectively. 2α,3α,19-trihydroxyurs-12-en-28-oic acid (31), 2α,3β-dihydroxyurs-12-en-28-oic acid (21), 2α, 3α,23-trihydroxyurs-12-en-28-oic acid (24), asiatic acid (12), ursolic acid (18), 2α,3α,19,24-tetrahydroxyurs-12-en-28-oic acid (13), 2α,3β,19-trihydroxyolean-12-en-28-oic acid (32), 2α, 3α, 24-trihydroxyolean-12-en-28-oic acid (22), oleanolic acid (9), 3β-O-acetyloleanolic acid (33), 2α,23-dihydroxylmicromeric acid (34) were isolated from roots of A. chinensis [21].

Cheng et al. [10] isolated 2β, 3β, 23-trihydroxyurs-12-ene-28-olic acid (35) from A. chinensis Radix. (2α, 3β)-2,3,23-trihydroxyurs-13(18)-en-28-oic acid (36) (new discovered compound) and some known compounds such as 2α,3β,19α,23-tetrahydroxyurs-12-en-28-oic acid 28-O-β-D-glucopyranoside (37), 2α,3β,23-trihydroxyursa-12,20(30)-dien-28-oic acid (38), 2α,3α,23,24-tetrahydroxyurs-12-en-28-oic acid (39) were also reported by others [25]. Jacoumaric acid (40) was isolated for the first time from the roots of A. chinensis [22]. Fupenzic acid (41), spathodic acid-28-O-β-D-glucopyranoside (42), 12-diene-30-oic acid (43) and 3-β-(2-carboxybenzoyloxy) oleanolic acid (44) were isolated and reported [24].

Wei et al. [25] isolated sixteen triterpenoids from EtOH extract of A. chinensis roots, which included compounds 11, 15, 20, 23, 24, 26, 27, 28, 38, 39 reported above and 2α,3β,23,24-tetrahydroxyurs-12-en-28-oic acid (45), 3β-hydroxyurs-12-en-28-oic acid (46), 3β-hydroxyolean-12-en-28-oic acid (47), 2β,3α,23-trihydroxyurs-12-en-28-oic acid (48), 2β,3β,23-trihydroxyurs-12-en-28-oic acid (49) (Figure 1).

Flavonoids

Michaud [26] reported the presence of (-)-epi-catechin (50), its dimer (procyanidol B2 (51)) and trimer (procyanidol C1 (52)), (-)-epi-afzelechin (53), benzylthio-(-)-epi-catechin (54), 4'- benzylthioprocyanidol B2 (55) in the root of A. chinensis Planch. Twelve compounds were discovered from the EtOH extract of the root of A. chinensis, which were classified into planchols A-D (56-59) and isomeric flavanoids ((-)-epi-afzelechin (53), (-)-epi-catechin (50), (+)-afzelechin (60), (+)-catechin (61), (-)-epi-afzelechin(4β→8)(-)-epi-afzelechin (62), (-)-epi-catechin(4β→8)(-)-catechin (63), (+)-afzelechin(4α→8) (+)-afzelechin (64), (+)-catechin(4α→8)(+)-catechin (65) [13]. (+)-catechin (61), (-)-epi-catechin (50) and 5-Hydroxy-6-methoxy-7-O- β -D-glucosyl coumarin (66) were isolated with other compounds [4]. Chen et al. [19] also reported the presence of (-)-epi-catechin (50) in the root of A. chinensis. Formononetin (67) and 7,4'-dihydroxyflavone (68) were isolated from A. chinensis root, 7,4'-dihydroxyflavone (68) reported to be firstly obtained from this medicinal plant [27]. (+)-catechins-7-phytol (69), 5-methoxy-coumarin-7-β-D-glycosidase (70), (+)-catechins (61) were isolated with other four triterpenoids EtOAc extract of the root bark of A. chinensis [24] (Figure 2).

Glucosides

Tachioside (71), Isotachioside (72), Fraxin (73), 1-O-(β-D-glucosyl)-2-[2-methoxy-4-(ω-hydroxypropyl)-phenoxy]-propan-3-ol (74) and n-butyl-β-D-fructopyranoside (75) were reported to be presence in A. chinensis [4]. Chen et al. [19] isolated sucrose (76), n-butyl-β-D-fructopyranoside (75) and stearyl-β-D-glucopyranoside (77) from the same part of this plant. 4,4'-dihydroxyl-dihydrochalcone-2'-O-β-D-glucopyranoside (78) [18, 22] and sphingolipid (79) [25]. Liu et al. [28] isolated and identified acetylated monosaccharides from A. chinensis by gas chromatography-mass spectrometry. Ding et al. [29] obtained polysaccharide liposomes in A. Chinensis root by preparative HPLC (Figure 3).

Anthraquinones

Ji and Liang [30] isolated the emodin (80), emodin-6-methyl ether (81), emodin 8-β-D- glucoside (82), emadin 8-methyl ether (83), ω-hydroxyemodin (84) and emodic acid (85) from the roots A. chinensis (Figure 4).

Steroids

Few steroids were reported to be presence in A. chinensis roots, β-sitosterol (86) [4,17,19,30], daucosterol (87) [4,19,27], 3β-hydroxystigmast-5-en-7-one (88) [22], Stigmastane-3β,6α-diol (89) and sitoindoside I (90) [23] (Figure 5).

Essential oils

Yu et al. [31] reported forty one compounds from the roots of A. chinensis, in which dodecane (91) (29.39%), octane (92) (5.16%), decane (93) (2.94%), paeonal (94) (2.81%), camphor (95) (2.77%), furfural (96) (2.59%), methyldodecane (97) (2.45%), linalool oxide (98) (2.10%), undecane (99) (2.16%), n-decanoic acid (100) (2.64%), cedrol (101) (1.98%), asarone (102) (1.96%), tau-muurolol (103) (1.79%), juniper camphor (104) (1.52%), δ-cadinol (105) (1.33%), and verbenol (106) (1.06%) were the major constituents (Figure 6).

Other components

Vanillic acid (107), uracil (108), adenine (109) and myo-inositol (110) were also isolated and identified from the root of A. chinensis [4]. Chen et al. [19] isolated lignoceric acid (111) from the root of A. chinensis. (Z)-9,10,11-trihydroxy-12-octadecenoic acid (112) and syringaldehyde (113) were isolated from the same part [27] and dotriacontanic acid (114) was also reported to be presence in roots of A. chinensis [22] (Figure 7).

Biological Activities

Antitumor activity

Lin [32] reported that the polysaccharide isolated from A. chinensis exhibited anit-tumor effect. Chang and Case [13] studied the cytotoxicity of phenolic constituents of A. chinensis root, the results showed compounds (56-57) showed significant cytotoxic effect against leukaemia P-388 and adenocarcinomic human alveolar basal epithelial (A549) cell lines. It reported that 2α,3β-dihydroxyurs-12-en-28-oic acid (21) exhibited weaker cytotoxicity against LOVO (IC$_{50}$ =2.9 μg/mL) and HepG$_2$ (IC$_{50}$=9.2 μg/mL) cell lines, and 2α,3β-dihydroxyolean-12-en-28-oic acid (20) showed
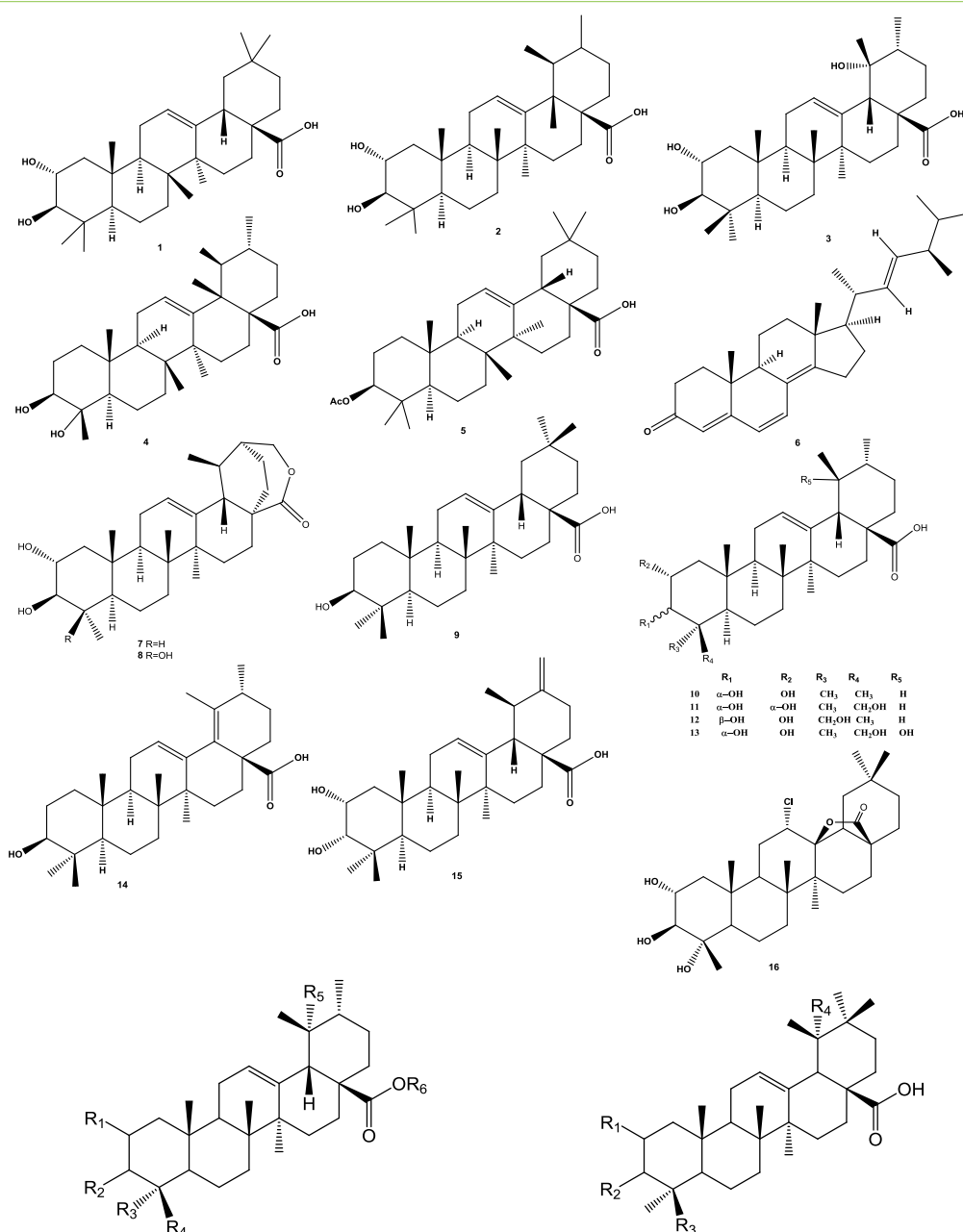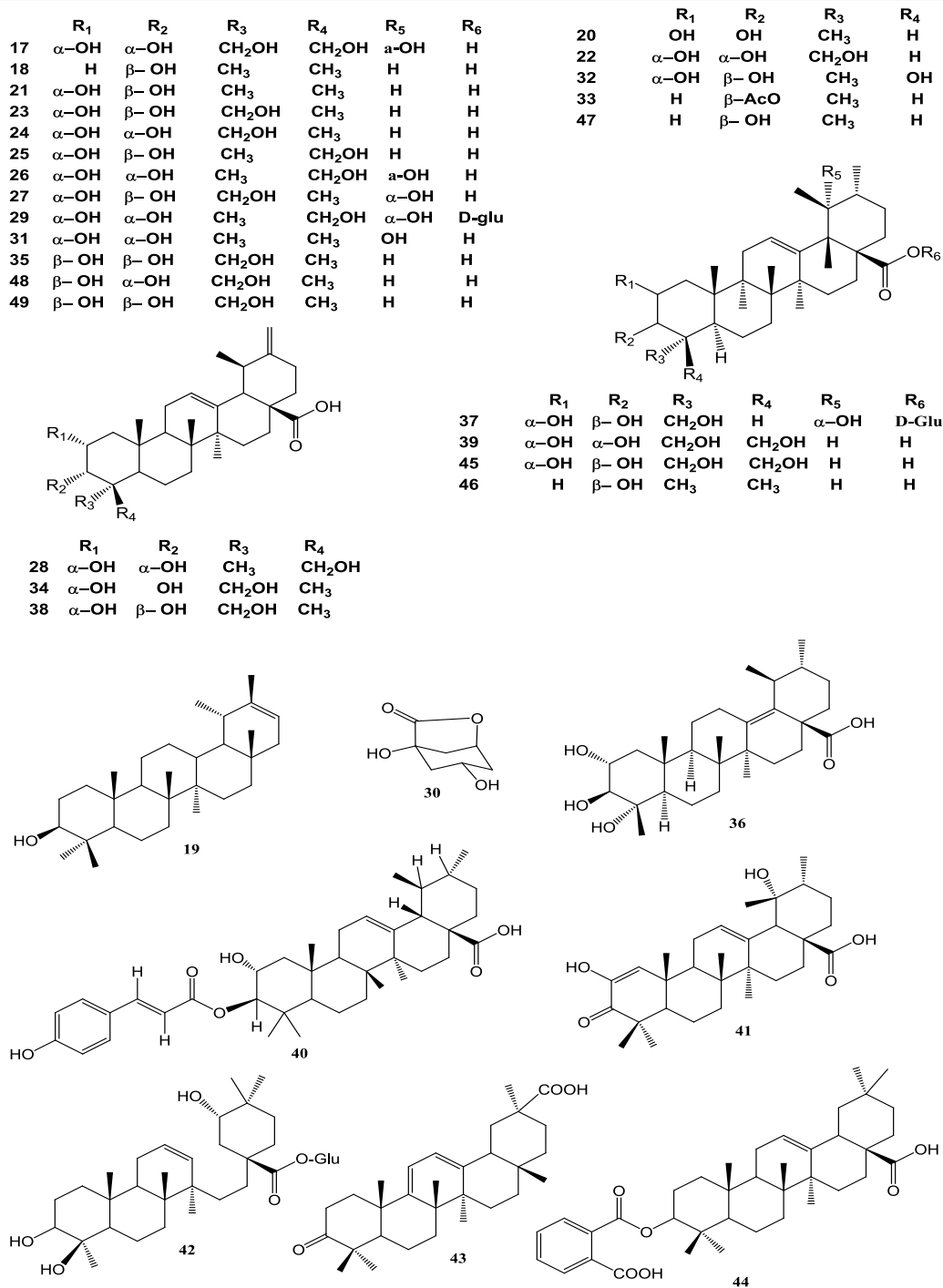
Figure 1: Structures of triterpenoids isolated from the roots of *A. chinensis.*

weaker cytotoxicity against LOVO (IC$_{50}$ = 6.0 μg/mL) cell line [20]. The round extraction of A. chinensis root showed potential inhibition to proliferation of carcinoma such as colon cancer and gastric cancer, leukemia and hepatic cancer [7, 37].

Zhang and Han [34] reported that the polysaccharide of *A. chinensis* root can reduce the H22 tumor cell proliferation, with the inhibition rate (68.5%) at the highest dose and reduce the Proliferating Cell Nuclear Antigen (PCNA) of 51.20 %. It is reported that the roots of *A. chinensis* usually used as crude drug in China for the treatment of all kinds of cancer [35], while polysaccharide derived from *A. chinensis*

root inhibited the growth of human gastric cancer SGC-7901 adenocarcinoma cells and induced apoptosis [36].

Cheng et al. [10] evaluated 2β, 3β, 23-trihydroxy-urs-12-ene-28-olic acid (35) against the lung cancer cell lines and it can trigger the apoptosis through blocking the activation of Nuclear factor- κB expression level and enhancing the activation of IκBα in NCI-H460 cells. The results showed that this compound can be regarded as the candidate for the treatment of lung cancer.

Xu et al. [22] studied the rude extraction and six main isolated compounds from A. chinensis root against P450 enzyme. The results showed that 12α-chloro-

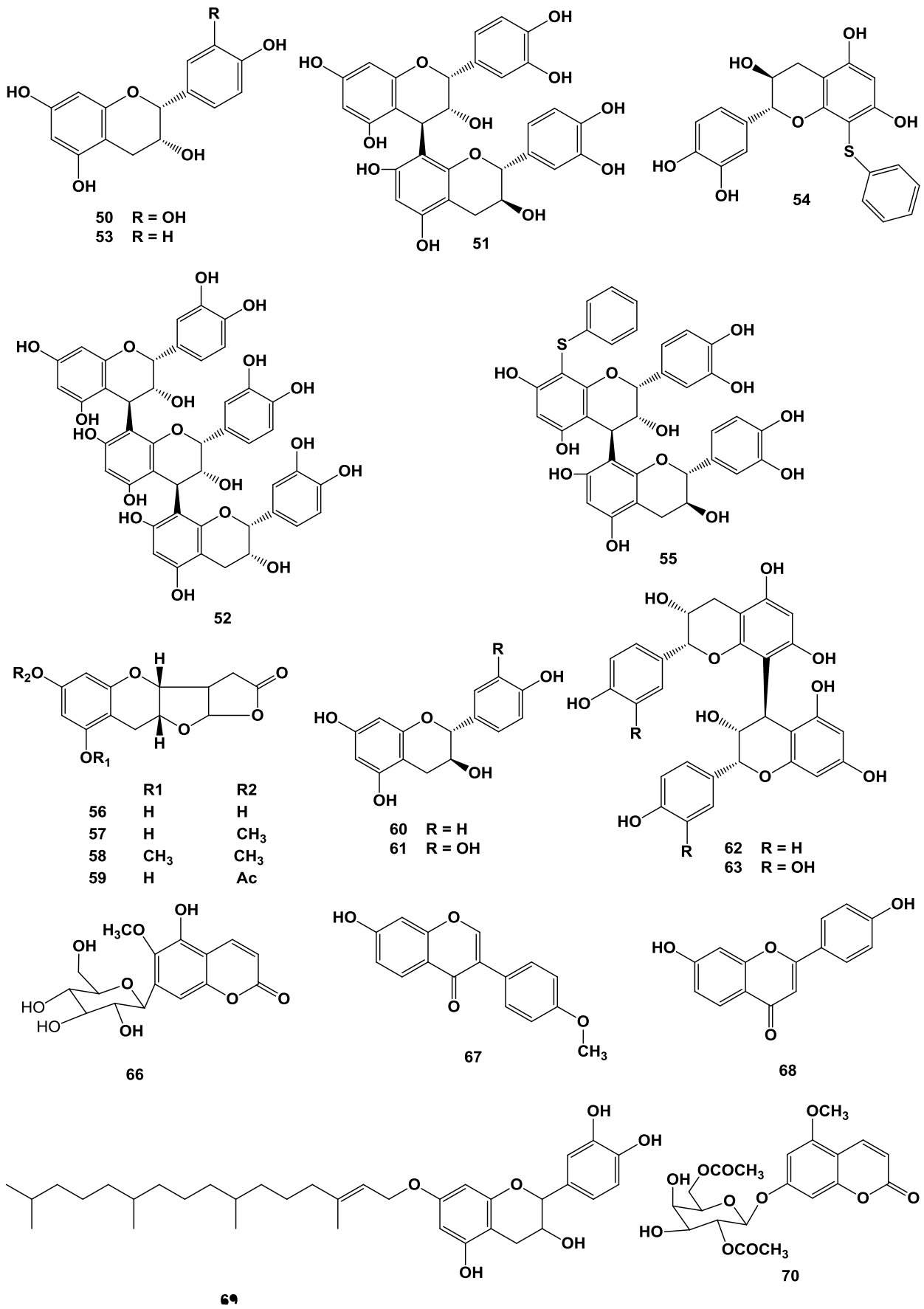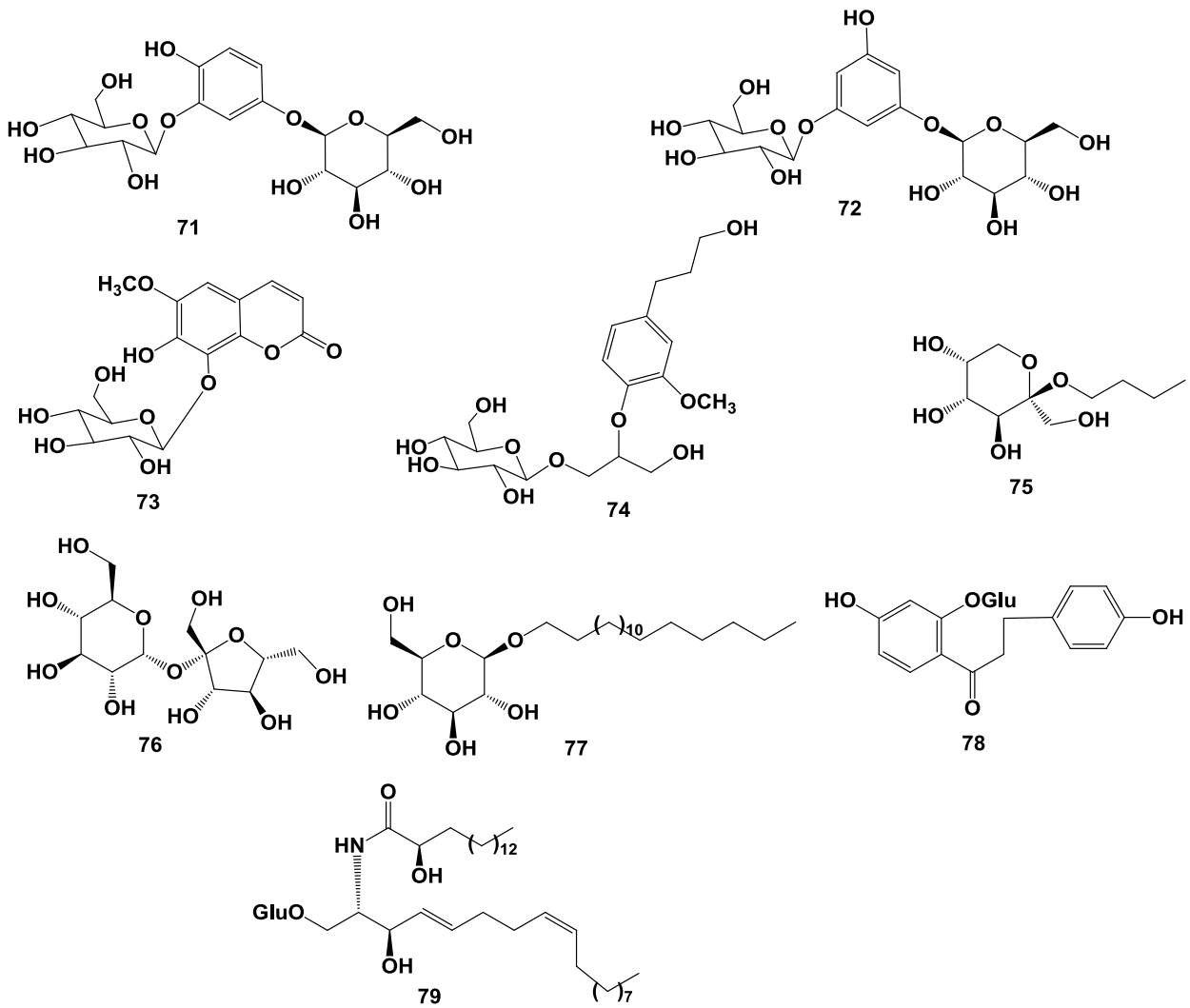**Figure 2:** Structures of flavonoids isolated from the roots of *A. chinensis*.

Figure 3: Structures of glucosides isolated from the roots of *A. chinensis*.
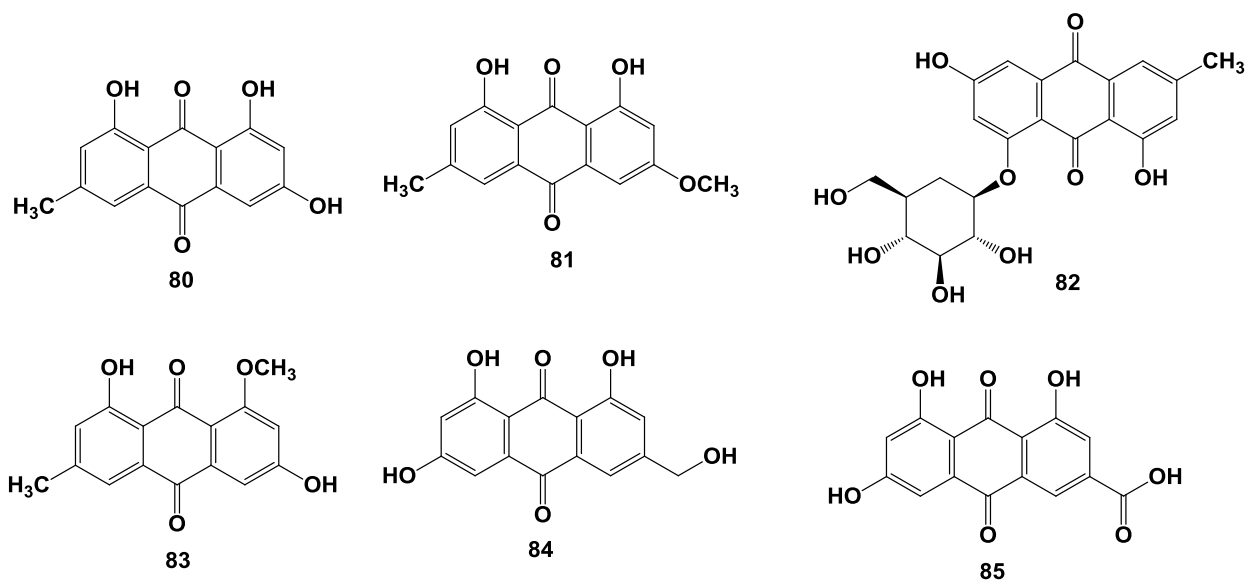

Figure 4: Structures of anthraquinones isolated from the roots of *A. chinensis*.
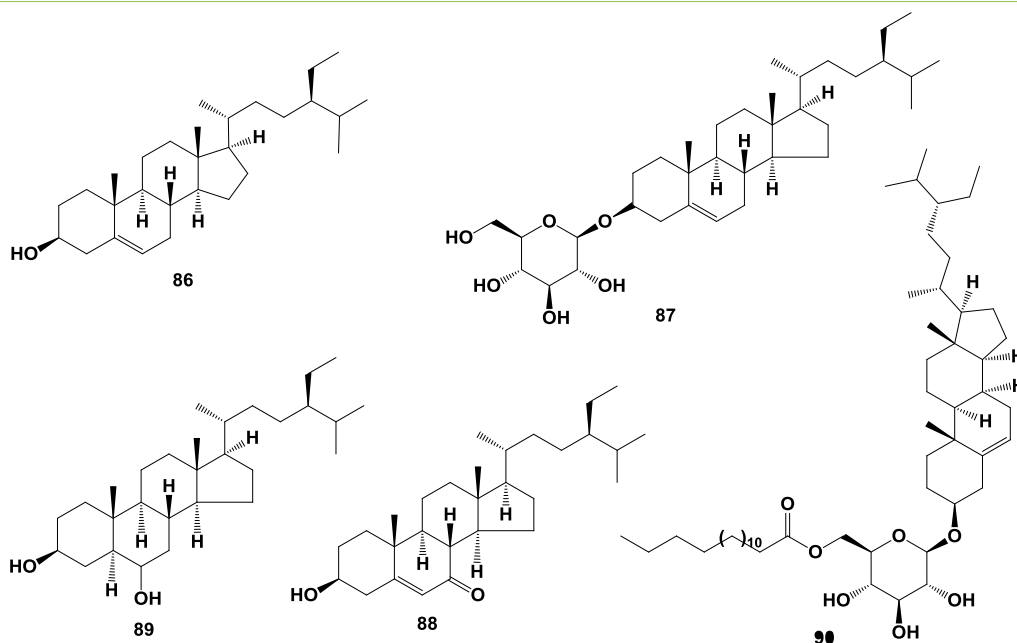
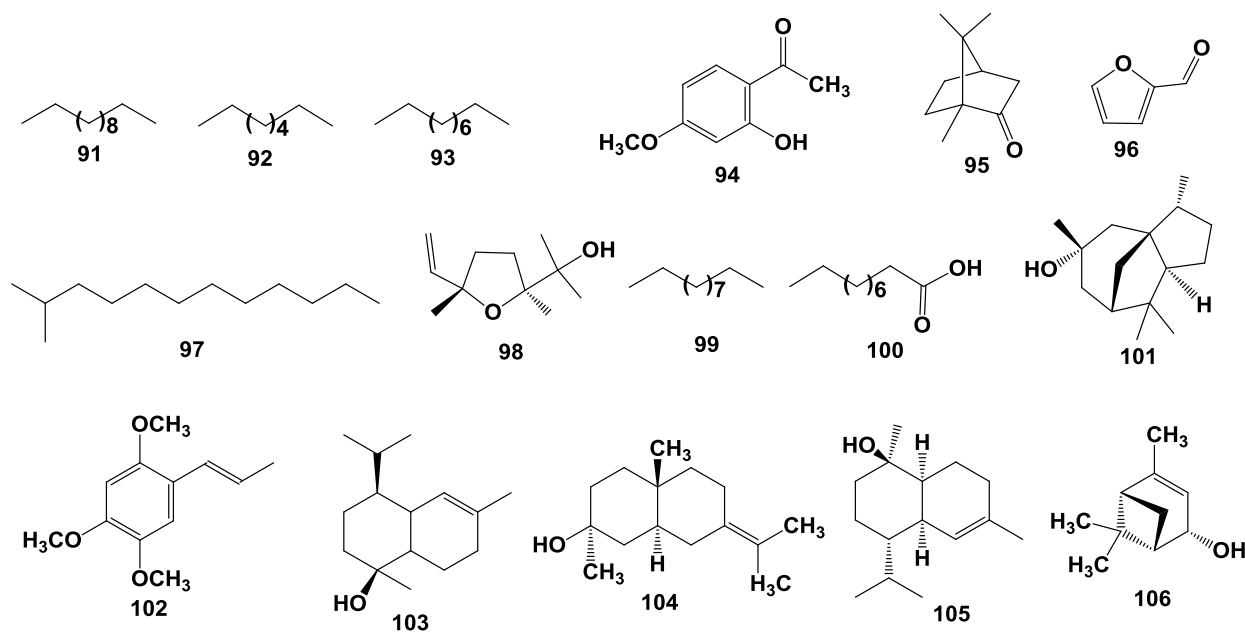**Figure 5:** Structures of steroids isolated from the roots of *A. chinensis.*

Figure 6: Structures of representative essential oils isolated from the roots of *A. chinensis.*

2α,3β,13β,23-tetrahydroxyolean-28-oic acid-13-lactone (16), 2α,3β-dihydroxyurs-12-en-28-oic acid (21), 2α,3α,24-trihydroxyurs-12-en-28-oic acid (11), 2α,3α,24-trihydroxyolean-12-en-28-oic acid (22), and 2α,3β,23-trihydroxyurs-12-en-28-oic acid (23) exhibited distinct inhibition to cytochrome P450 enzyme. While 12α-chloro-2α, 3β, 13β, 23-tetrahydroxyolean-28-oic acid-13-lactone (16) showed a significant inhibitory effect on the CYP3A4. The rude EtOH extraction of the root of A. chinensis showed strong inhibition against SW480 cells and could trigger apoptosis of tumor cell in vitro [37].

Wang et al. [38] obtained the total triterpenoids from the *A. chinensis* root and evaluated its inhibition to the proliferation rates of human colon cancer SW480 cells of colorectal carcinoma and LOVO cells, human hepatoma SMMC -7721 cells and human breast cancer MCF -7 cells. The results showed that the total triterpenoids inhibited cancer cells proliferation at Gap (G) and Synthesis (S) phase. While the rude extraction from the root of *A. chinensis* possessed anti-tumor efficacy and could significantly inhibited the cholesterol metabolism in hepatocellular carcinoma cell lines by enhancing Proprotein convertase subtilisin/Kexin type 9 (PCSK9) expression and decreasing Low-Density Lipoprotein Receptor (LDLR) expression at post-transcriptional level [39].

Wei et al. [25] investigated the cytotoxicity of pure compounds isolated from the root of A. chinensis to HepG2, A549, MCF-7, SK-OV-3 and Hela cell lines. The results
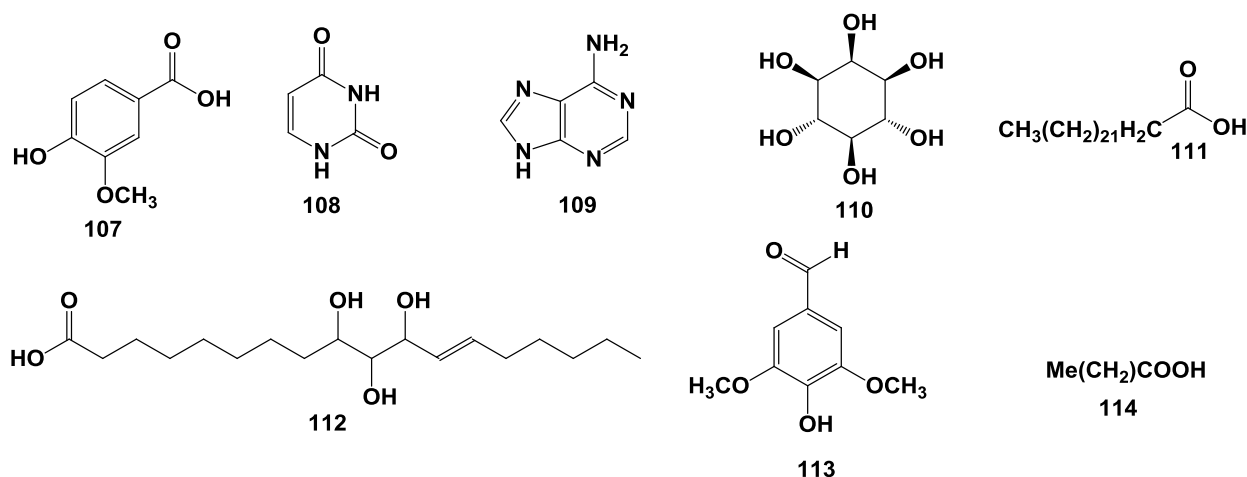
Figure 7: Structures of others isolated from the roots of *A. chinensis*.

showed that 2α, 3α, 23,24-tetrahydroxyursa-12,20(30)-dien-28-oic acid (15) is the most active compound to these five cancerous cell lines with IC$_{50}$s: 19.62 ± 0.81, 18.86 ± 1.56, 45.94 ± 3.62, 62.41 ± 2.29 and 28.74 ± 1.07 μM, respectively.

Hou *et al.* [40] tested the rude extraction from the roots of *A. chinensis* against Hepatocellular Carcinoma (HCC). The results revealed that the extraction inhibited HepG2 proliferation by affecting the S-phase cell cycle. Fang *et al.* [41] studied the extraction of *A. chinensis* root anticancer effect and the results showed that the extraction could significantly inhibit the proliferation, migration, clonality, invasion and epithelial mesenchymal transition of hepatocellular carcinoma. It also promoted the apoptosis of Hepatocellular Carcinoma (HCC) cells by cellular decrease DLX2 expression. Lv et al. [42] validated that the extraction of *A. chinensis* root could significantly inhibit lung cancer cell proliferation and metastasis via phosphatidylinositol 3-kinase/oligoadenylate synthetase L (PI$_3$K/OASL) signal pathway.

Hepatoprotective activity

Some bioactive compounds in A. chinensis root possess hepatoprotective activity [9]. Asiatic acid (12) and ursolic acid (18) have been studied and the results showed that which possessed good hepatoprotective efficacy [43-44], these compounds are of much content in A. chinensis root. Zhou et al. [18] reported that 2α, 3β-dihydroxyurs-12-en-28,30-olide (7) and 2α,3β,24-trihydroxyurs-12-en-28,30-olide (8) isolated from A. chinensis showed strong hepatoprotective activity. In China, oleanolic acid (9) has been used as clinical drug for treatment of chronic liver and human acute diseases [45], while the oleanolic acid is also of much content in A. chinensis root, which indicate that A. chinensis root can also be used for treatment of chronic liver and human acute diseases.

Antiviral activitiy

Zhang et al. [24] tested some compounds isolated from A. chinensis root for their antiviral activity and the results showed that spathodic acid-28-O-β-D-glucopyranoside (42) and 5-methoxy-coumarin-7-β-D-glycosidase (70) exhibited

the higher anti-phytoviral activity with inactivation effect range from 56.76% to 42.56% than other isolated compounds, including ningnanmycin (used as a control).

Antioxidant activity

Yang and He [46] revealed that the extract from the root of *A. chinensis* could remove the DPPH, superoxide anion radicals effectively and strongly inhibit the hydroxyl radicals production.

Antiangiogenic activities

Zhu et al. [21] evaluated the bioactive compounds isolated from the root of A. chinensis to the human umbilical vein endothelial cells (HUVEC) proliferation and tube formation. The results revealed that 2α,3β-dihydroxyurs-12-en-28-oic acid (21), 2α,3α,23-trihydroxyurs-12-en-28-oic acid (24), asiatic acid (12) and 2α,3α,24-trihydroxyolean-12-en-28-oic acid (22) exhibited strong antiangiogenic effect.

Conclusion

Extractions and some pure compounds from *A. chinensis* root have showed effective biological activities such as antitumor, antioxidant, antiviral, detoxifying agent, antidiuretic, anti-hepatitis and haemostatic agent in agreement with folkloric uses of the root of this medicinal plant. Studies have revealed that triterpenoids are abound in the root of *A. chinensis*, which are probably responsible for its anticancer capacity. To ascertain this hypothesis, further analysis and research should be carried out. For example, more and more pure compounds should be isolated from the root of *A. chinensis* and their biological evaluation should be studied, *in vitro* and *in vivo* antitumor efficacy and the mechanisms to provide the evidence for development of new drug or drug candidates.

Acknowledgements

References

1. Datson PM, Ferguson AR (2011) *Actinidia*, Wild Crop Relatives: Genomic and Breeding Resources. Tropical and Subtropical Fruits 1-20.

2. Liang J, Wang X, Zhen H, Zhong Z, Zhang W, et al. (2007) Study on anti-tumor effect of extractions from roots of *Actinidia deliciosa.* J Chin Med Mater 30: 1279-1282.

3. Fu WW, Tan CH, Lu LL, Meng XX, Luo HF, Zhu DY (2010) Chemical constituents from the root of *Actinidia deliciosa*. Chin J Nat Med 8: 247-249.

4. Zhou X, Liu Y, Tang L, Zhang P, Wu J (2010) Chemical constituents from the roots of *Actinidia chinensis*. Chem Nat Compd 46: 308-309.

5. Lai Y, Xu D (2007) Study on the chemical structure from the roots of *Actinidia deliciosa*. J Chin Med Mater 30: 166-168.

6. Wang L, Kang C, Yang W, Li M, Wang Y, et al. (2010) Experimental study on antitumor effects of extracts from *Actinidia argutaor*. Zhongguo Zhong Yao Za Zhi 35: 2184-2186.

7. Huo J, Qin F, Cai X, Ju J, Hu C, et al. (2013) Chinese medicine formula "Weikang Keli" induces autophagic cell death on human gastric cancer cell line SGC-7901. Phytomedicine 20: 159-165.

8. Jiangsu New Medical College (1986) The Dictionary of Chinese Traditional Medicine. Shanghai Press of Science and Technology 662-664

9. Jiangsu New Medical College (1977) The Dictionary of Chinese Traditional Medicine. Shanghai, Shanghai Science & Technology Press 2210.

10. Cheng QL, Li HL, Huang ZQ, Chen YJ, Liu TS (2015) 2beta, 3beta, 23-Trihydroxy-urs-12-ene-28-olic acid (TUA) isolated from *Actinidia chinensis* Radix inhibits NCI-H460 cell proliferation by de-creasing NF-kappaB expression. Chem Biol Interact 240: 1-11.

11. Song LR, Hong X, Ding XL (2001) 'Dictionary of Modern Chinese Herbal Medicine'. People's Medical Publishing House, Beijing 2453

12. Compile Group of Chinese Herbal Medicine Assembly (1996) Chinese Herbal Medicine Assembly. People's Medical Publishing House Chinese.

13. Chang J, Case R (2005) Cytotoxic phenolic constituents from the root of *Actinidia chinesnsis*. Planta Med 71: 955-959.

14. Yutaka S, Kazunori O, Noriaki M, Tsuyoshi Y (1992) Triterpenoids from the fruit galls of *Actinidia polygama.* Phytochem 31: 2801.

15. Lahlou EH, Hirai N, Kamo T, Tsuda M, Ohigashi H (2001) Actinidic acid, a new triterpene phytoalexin from unripe kiwi fruit. Biosci Biotechnol Biochem 65: 480-483.

16. Zhou XF, Zhang P, Pi HF, Zhang YH, Ruan HL, et al. (2009) Triterpenoids from the Roots of *Actinidia chinensis.* Chem Biodivers 6: 1202-1207.

17. Cui Y, Zhang XM, Chen JJ, Zhang Y, Lin XK, et al. (2007) Chemical constituents from root of *Actinidia chinensis*. *Zhongguo Zhongyao Zazhi* 32: 1663-1665.

18. Xu YX, Xiang ZB, Jin YS, Shen Y, Chen HS (2010) Two new triterpenoids from the roots of *Actinidia chinensis*. Fitoterapia 81: 920-924.

19. Chen XX, Yang SJ, Bai SY (2011) Chemical constituent in root of *Actinidia chinesis*. Chinese Traditional and Herbal Drugs 42(5).

20. Peng S, Cheng J, Zhang M, Chen M, Zhou H, et al. (2013) Analysis of two anti-tumor active ingredients in Radix *Actinidiae chinensis* by dispersive liquid–liquid microextraction coupled to high performance liquid chromatography–mass spectrometry. Anal Methods 5: 5227-5233.

21. Zhu WJ, Yu DH, Zhao M, Lin MG, Lu Q, et al. (2013) Antiangiogenic Triterpenes Isolated from Chinese Herbal Medicine Actinidia chinensis Planch. Anti-cancer agents in Medicinal Chemistry 13: 195-198.

22. Xu YX, Xiang ZB, Jin YS, Xu W, Sun LN, et al. (2016) Constituents from the Roots of *Actinidia chinensis* and Their Cytochrome P450 Enzyme Inhibitory Activities. Chemistry & biodiversity 13: 1454-1459.

23. Cui Y (2016) Study on Chemical constituents in Ethylacetate extract from the root of *Actinidia chinensis*. Hubei Agricultural Sciences 55: 5359-5361.

24. Zhang XY, Zhou Y, Wei ZP, Shen J, Wang LK, et al. (2018) Antiphytoviral toxins of *Actinidia chinensis* root bark (ACRB) extract: laboratory and semi-field trials. Pest Manag Sci 74: 1630-1636.

25. Wei LB, Ma SY, Liu HX, Huang CS, Liao N (2018) Cytotoxic Triterpenoids from Roots of *Actinidia chinensis.* Chem Biodiversity 15: 1-6.

26. Michaud J, Ane-Margail M (1977) Analytical study of catechuic tannins, Flavanolic oligomers of *Actinidia chinesis* Planchon. Bull Soc Pharm Bordeaux 116: 52-64

27. He G, Wang B, Wang H, Fan L, Hu X (2016) Study on chemical constituents of *Actinidia chinensis* Planch. China Journal of Traditional Chinese Medicine and Pharmacy 31.

28. Liu ZX, Yin H, Xiao LL, Tang M, Li JX, et al. (2013) Antifatigue and Antioxidant Activities and Monosaccharide Composition of Polysaccharide from Roots of *Kiwifruit.* Composition 34: 239-242.

29. Ding MH, Zhu YQ, Wu JJ, Li CY, Ge WH, et al. (2014) Process research of formulation and preparation on polysaccharide liposomes in Chinese *actinidia* root. CJTCMP 29: 3942-3945.

30. Ji Z, Liang XT (1985) Chemical constituents of the root of *Actinidia chinensis* Planch. Acta Pharm Sin 20: 778-81

31. Yu AN, Tian DT, Qu WY, Tan ZW, Song XJ (2009) Chemical composition of the essential oil of the roots of *Actinidia chinensis* from China. Chemistry of Natural Compounds 45: 108-109.

32. Lin PF (1988) Antitumor effect of *Actinidia chinensis* polysaccharide on murine tumor. Zhonghua Zhong Liu Za Zhi 10: 441-444.

33. Huo J, Qin F, Cai X, Ju J, Hu C, et al. (2013) Chinese medicine formula "Weikang Keli"induces autophagic cell death on human gastric cancer cell line SGC-7901. Phytomedicine 20: 159-165.

34. Zhang GJ, Han JY (2012) Mechanism study of kiwifruit root polysaccharide anti-tumor injection on tumor in vivo. CJTCMP. 27: 2177-2179

35. Zuo LL, Wang ZY, Fan ZL, Tian SQ, Liu JR (2012) Evaluation of Antioxidant and Antiproliferative Properties of Three *Actinidia* (*Actinidia kolomikta*, *Actinidia arguta*, *Actinidia chinensis*) Extracts in Vitro. Int J Mol Sci 13: 5506-5518.

36. Song WY, Xu GH, Zhang GJ (2014) Effect of *Actinidia chinensis* planch polysaccharide on the growth and apoptosis, and p-p38 ex-pression in human gastric cancer SGC-7901 cells. Zhongguo Zhong Xi Yi Jie He Za Zhi 34: 329-333.

37. Yang XD, Han T, Wang N, Gu J, Li J, et al. (2016) 'The Anti-Proliferation Effect of Triterpenoid Extracted from *Actinidia chinese.* Plant Root'. Int J Clin Exp Med 9: 16102-16109.

38. Wang Q, Lei XX, Yang XD, Xin T, Li YQ (2017) Purification of total triterpenes from the root of *Actinidia chinensis Planch* and its anti-tumor activity**.** Guangdong Medical Journal 38: 515-516.

39. He MY, Hou JY, Wang LY, Zheng MH, Fang TT, et al. (2017) *Actinidia chinensis* Planch root extract inhibits cholesterol metabolism in hepatocellular carcinoma through upregulation of PCSK9. Oncotarget 8: 42136-42148.

40. Hou J, Wang L, Wu D (2018) The root of *Actinidia chinensis* inhibits hepatocellular carcinomas cells through LAMB3. Cell Biol Toxicol 34: 321-332

41. Fang TT, Fang Y, Xu XJ, He MY, Zhao ZY, et al. (2018) Actinidia chinensis Planch Root Extract Attenuates Proliferation and Metastasis of Hepatocellular Carcinoma by Inhibiting Epithelial-Mesenchymal Transition. J Ethnopharmacol 231: 474-485

42. Lv J, Wang L, Shen H, Wang X (2018) Regulatory roles of OASL in lung cancer cell sensity to *Actinidia chinensis* Planch root extract (acRoots). Cell Biol Toxicol 34: 207-218

43. Liu J, Liu YP, Mao Q, Klaassen CD (1994) The effects of 10 triterpenoid

compounds on experimental liver-injury in mice. Fundam Appl Toxicol 22: 34-40.

44. Gao J, Chen J, Tang X, Pan L, Fang F, et al. (2006) Mechanism underlying mitochondrialprotection of asiatic acid against hepatotoxicity in mice. J Pharm Pharmacol 58: 227-233.

45. Liu J (1995) Pharmacology of Oleanolic Acid and Ursolic Acid. J Ethnopharmocol 49: 57-68.

46. Yang YJ, He HS (2012) Kiwi Root Extract *in Vitro* Antioxidant Effect Research. Food Res Dev 33: 21-24.