

## MINI REVIEW

### Flavonoids of the Genus of Acer

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The genus of *Acer*, usually known as maple, is an important genus of the family Aceraceae. Some *Acer* plants (*i.e.*, red maple, sugar maple and black maple) are used to tapping sap, which were thermally evaporated to produce maple syrup in North America. There are *ca.* 200 *Acer* species widely distributed in Asia, North America and Europe regions. More than 200 chemical constituents have been isolated and identified from nearly 30 *Acer* species, including flavonoids, tannins, diarylheptanoids, phenyl propanoids, phenylethanoid glycosides, terpenoids, phytosterols, benzoic acid derivatives and other compounds. Among those constituents, flavonoids and tannins were two major and characteristic constituents existing in *Acer* species. Herein we made a mini-review about the flavonoids constituents from the *Acer* plants. A checklist of 60 flavonoids from the genus is given and 42 references are cited.

**Key Words:** *Acer*, Flavonoids, Chemical constituents.

## INTRODUCTION

The genus *Acer* (Aceraceae), commonly known as maple, contains *ca.* 200 species, which were widely distributed in Asia, North America and Europe regions<sup>1</sup>. Some species are used as folk medicine in China and North America. For example, the red maple (*Acer rubrum* L.) was used to cure the sore eyes by native peoples of eastern Canada and treat various pains and diseases<sup>2</sup>, *Acer truncatum* Bunge was used as a Chinese folk medicine for the treatment of coronary artery cirrhosis, cerebrovascular diseases and angina pectoris<sup>3</sup>, *Acer ginnala* was used to treat acute diarrhea and tonsillitis<sup>4</sup>. Extensive studies of the chemical components of *Acer* have led to the identification more than 200 chemical constituents from nearly 30 *Acer* species, including flavonoids, tannins, diarylheptanoids, phenyl propanoids, phenylethanoid glyco-

ides, terpenoids, phytosterols, benzoic acid derivatives and other compounds. In this review, we will summarize the flavonoids constituents progress referring to 21 species from the genus *Acer* (Table-1) and list all the 60 flavonoids compounds isolated over the past few decades (Tables 2-5).

**Flavonoids constituents:** Flavonoids are the major components of this genus. 60 flavonoids compounds were isolated and identified from 21 *Acer* species over the past few decades, including the flavonol and flavanonol, anthocyanidin, flavone and flavanone, flavan-3-ol, isoflavone and chalone. The main aglycones of these compounds were apigenin, naringenin and luteolin (flavones), kaempferol, quercetin, myrecetin and isorhamnetin (flanonols). The main glycosyls were L-rhamnose, D-glucose, D-galactose, L-arabinose and D-xylose. Flavonols (glycosides of quercetin, kaempferol and isorhamnetin) were abundant in many *Acer* species (Figs. 1 and 2).

TABLE-1  
FLAVONOIDS INVESTIGATION OF 21 SPECIES FROM THE GENUS *Acer*

Species	Designation	Species	Designation	Species	Designation
<i>A. diabolicum</i>	A	<i>A. mono</i>	H	<i>A. rubrum</i>	O
<i>A. barbinerve</i>	B	<i>A. nikoense</i>	I	<i>A. saccharum</i>	P
<i>A. cissifolium</i>	C	<i>A. negundo</i>	J	<i>A. aizuense</i>	Q
<i>A. ginnala</i>	D	<i>A. okamotoanum</i>	K	<i>A. truncatum</i>	R
<i>A. glabrum</i>	E	<i>A. marmoratum</i>	L	<i>A. oblongum</i>	S
<i>A. macrophyllum</i>	F	<i>A. palmatum</i>	M	<i>A. tegmentosum</i>	T
<i>A. mandshuricum</i>	G	<i>A. platanoides</i>	N	<i>A. carpinifolium</i>	U

TABLE-2  
FLAVONOLS ISOLATED FROM THE GENUS OF *Acer*

No.	Name	Species	Ref.
1	Quercetin	C, D, H, I, R, S	3-11
2	Quercetin-3-O- $\beta$ -D-arabinoside	E, R	3, 12, 13
3	Quercetin-3-O- $\beta$ -D-galactoside	B, J, K, R, T	13-18
4	Quercetin-3-O- $\alpha$ -L-rhamnoside	A-E, H, I, K, L, O, P, R, T, U,	3, 5, 7, 9, 10, 12-23
5	Quercetin-3-O- $\beta$ -D-glucoside	B-E, G, H, J, O, T	5, 9, 10, 12, 15, 17, 18, 20, 24, 25
6	Quercetin-3-O-neohesperidoside	G	24
7	Rutin	D, E, J, O	9, 12, 20, 25
8	Quercetin-3-O-[ $\beta$ -D-xyloside-(1 $\rightarrow$ 2)- $\beta$ -D-glucoside]	T	18
9	2"-O-Galloylquercitrin	D, O	9, 22, 23
10	3"-O-Galloylquercitrin	D, O	22, 23
11	Quercetin-3-O-(2"-Galloyl)- $\alpha$ -L-arabinoside	K	14
12	Quercetin-3-O-(2"-Galloyl)- $\beta$ -D-galactoside	K	14
13	Quercetin-3-O-(2", 6"-di-Galloyl)- $\beta$ -D-galactoside	K	14
14	Isorhamnetin	E	12
15	Isorhamnetin-3-O- $\beta$ -D-arabinoside	R	3, 13
16	Isorhamnetin-3-O- $\alpha$ -L-rhamnoside	R	3
17	Isorhamnetin-3-O-rutinoside	J	25, 26
18	Kaempferol	C, G, S	6, 10, 24
19	Kaempferol-3-O- $\alpha$ -L-rhamnoside	A, C, K, L, O, R, T, U	3, 10, 13-15, 18, 20
20	Kaempferol-3-O- $\beta$ -D-galactoside	E, J, O	12, 15, 20
21	Kaempferol-3-O- $\beta$ -D-glucoside	G, J, O, R	16, 20, 24, 25
22	Kaempferol-3-O- $\alpha$ -L-arabinoside	K	14
23	Kaempferol-3-O-neohesperidoside	G	24
24	Kaempferol-3-O-rutinoside	J, O	20, 26
25	Myricetin-3-O- $\alpha$ -L-rhamnoside	R, T	3, 13, 18
26	6-Hydroxy-quercetin-3-O-galactoside	T	18
27	5,3'-Dihydroxy-3,7,4'-trimethoxy flavone	T	27
28	3,7,3',4'-Tetramethyl-quercetin	T	27
29	Kaempferol-3,7-di-glucoside	J	26

TABLE-3  
ANTHOCYANIDINS ISOLATED FROM THE GENUS OF *Acer*

No.	Name	Species	Ref.
30	Cyanidin-3-O- $\beta$ -glucoside	M, N	28-30
31	Cyanidin-3-O-(2"-Galloyl)- $\beta$ -glucoside]	N	28, 31
32	Cyanidin-3-O-(2", 3"-di-Galloyl)- $\beta$ -glucoside]	N	28
33	Cyanidin-3-O-rutinoside	M	29, 30
34	Cyanidin-3-O-[2"-O-(Galloyl)-6"-O-( $\alpha$ -L-rhamnoside)- $\beta$ -D-glucoside]	N	31
35	Cyanidin-3-O-[2"-O-( $\beta$ -D-xyloside)-6"-O-( $\alpha$ -L-rhamnoside)- $\beta$ -D-glucoside]	F	32
36	Delphinidin	Q	33
37	Delphinidin-3,5-di-glucoside	Q	33

TABLE-4  
FLAVONES AND FLAVANONES ISOLATED  
FROM THE GENUS OF *Acer*

No.	Name	Species	Ref.
38	Apigenin	M, S	6, 34
39	Apigenin-8-C- $\beta$ -D-glucoside	M	34, 35
40	Apigenin-6-C- $\beta$ -D-glucoside	M	34
41	Luteolin-8-C- $\beta$ -D-glucoside	M	34
42	Luteolin-6-C- $\beta$ -D-glucoside	M	34
43	Luteolin-4'-O- $\beta$ -D-glucoside	C	36
44	Naringenin	H	5
45	Naringenin-7-O- $\beta$ -D-glucoside	H	5
46	Eriodictyol	H	5
47	Eriodictyol-7-O- $\beta$ -D-glucoside	H	5

**Flavonol and flavanonol:** Twenty nine flavonols (1-29) have been reported from most species of this genus except four species (*i.e.*, *A. macrophyllum*, *A. palmatum*, *A. platanoides* and *A. aizuense*). Quercetin and kaempferol were

two major aglycones, the rhamnoside of quercetin (4) and kaempferol (19) were appearance in many *Acer* species. It is supposed that the two components were characteristic for this genus. It is noteworthy that some species (*i.e.*, *A. ginnala*, *A. rubrum* and *A. okamotoanum*) of the genus contain large amounts of Galloyl substituent of quercetin glycosides (9-13)<sup>9,14,22,23</sup>. Two polymethoxyflavones (PMF, 27 and 28) were isolated from *A. tegmentosum*<sup>27</sup> and kaempferol-3,7-di-glucoside (29) were isolated from *A. negundo*<sup>26</sup>. Two flavanonols dihydromyricetin (48) and morin-3-O- $\alpha$ -L-xyloside (49) were isolated from *A. tegmentosum*<sup>18,27</sup>.

**Anthocyanidin:** Anthocyanidins are the pigment compositions in *Acer* species. Eight anthocyanidin (30-37) compounds were isolated from four *Acer* species (*i.e.*, *A. macrophyllum*, *A. palmatum*, *A. platanoides* and *A. aizuense*). Cyanidin and delphinidin were the aglycones of those anthocyanidins<sup>28-33</sup>.

No.	Name	Species	Ref.
50	Catechin	B, G, I, O, T	7, 17, 18, 20, 23, 24, 37-42
51	Gallocatechin	T	18
52	(+)-Catechin-3-O-(3,4-dihydroxybenzoyl)	T	18
53	Epicatechin	B, I, O	17, 20, 23, 40, 41
54	Epicatechin-3-O-gallate	B, O	17, 23
55	Procyanidin dimer	O	42
56	Procyanidin trimer	O	42
57	Procyanidin A2	O	23
58	Procyanidin A6	O	23

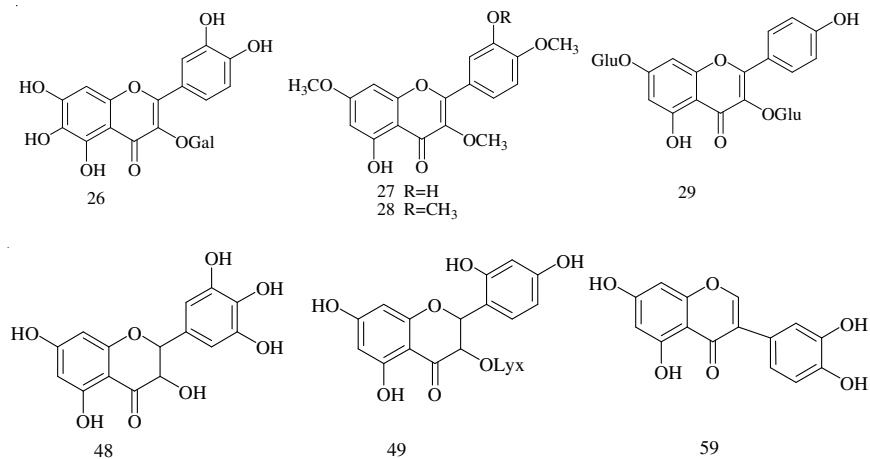
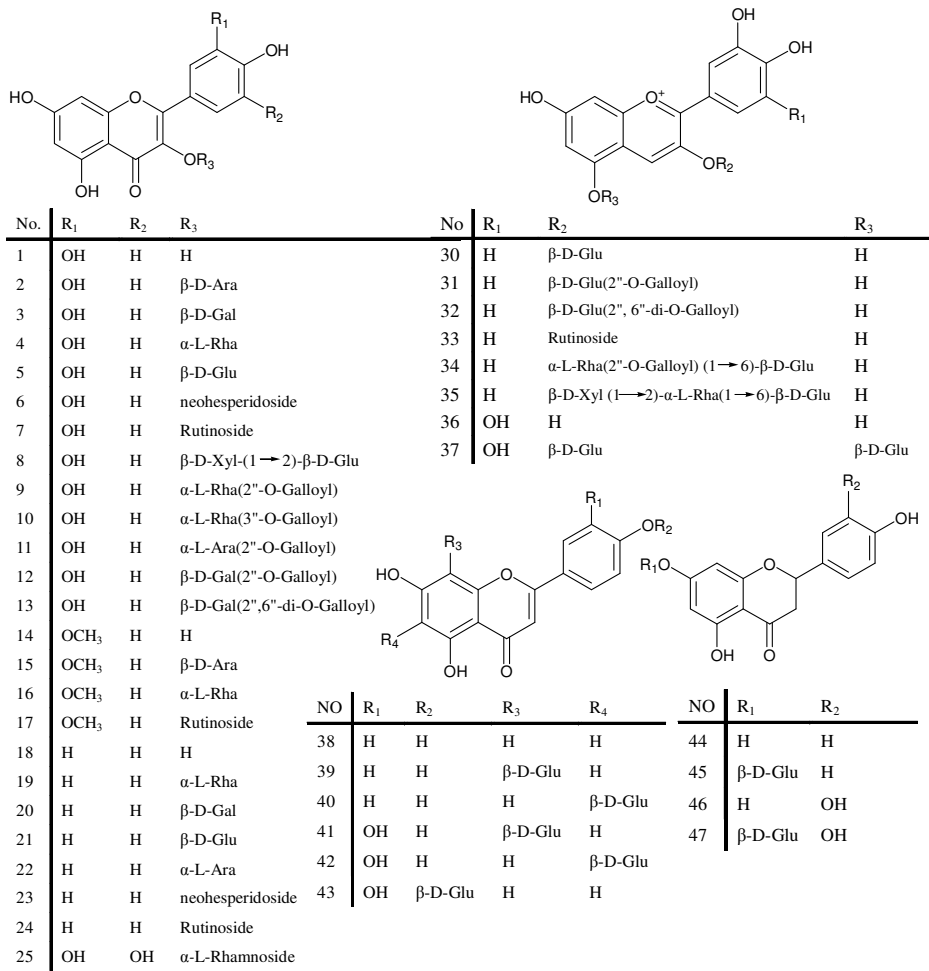


Fig. 1. Chemical structure of flavonoids isolated from the genus of *Acer*

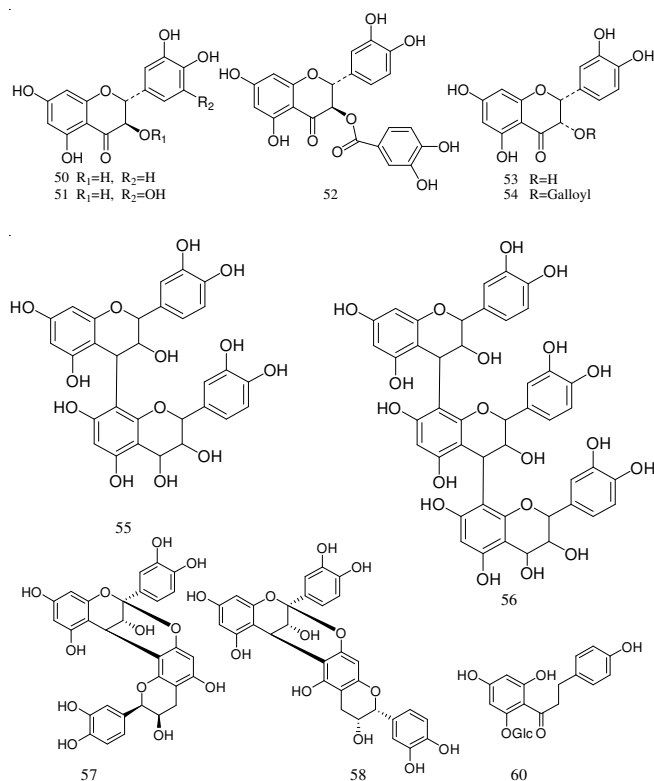


Fig. 2. Chemical structure of flavonoids isolated from the genus of *Acer*

**Flavone and flavanone:** Six flavones (**38-43**) with the aglycones of apigenin and luteolin were isolated from *A. palmatum*, *A. oblongum* and *A. cissifolium*<sup>34-36</sup>. Compounds **39-42** were four flavone C-glycosides isolated from *A. palmatum*<sup>34</sup>. Four flavanonols (**44-47**) with the aglycones of naringenin and eriodictyol were isolated from *A. mono*<sup>5</sup>.

**Flavan-3-ol:** Nine flavan-3-ol (**50-58**) were isolated from *A. barbinerve*, *A. mandshuricum*, *A. rubrum*, *A. tegmentosum* and *A. nikoense*<sup>17,18,20-23,40-42</sup>. Catechin (**50**) was appearance in many *Acer* species and most of the flavan-3-ol compounds were isolated from *Acer rubrum*. Recently we also had isolated two A-type procyanidins (procyanidin A2 and A6, **57-58**) from the stem of *Acer rubrum*<sup>23</sup>.

**Isoflavone and chalone:** An isoflavone (isoluteolin, **59**) and a chalone (phloridzin, **60**) were isolated from *A. negundo*<sup>26</sup> and the stem of *Acer rubrum*<sup>23</sup>, respectively.

## Conclusion

The genus *Acer* (*Aceraceae*) contains ca. 200 species, which were widely distributed in Asia, North America and Europe regions. Many species of this genus have been used in traditional folk medicine. Extensive studies of the chemical components of *Acer* have led to the identification more than 200 chemical constituents from nearly 30 *Acer* species. However, there are still many other *Acer* species that have not been received or only little attention. Phytochemical and biological studies should focus on these plants from now on in order to fully exploit *Acer* species.

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