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Review

Chemical constituents and biological activities of genus Hosta (Liliaceae)

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Genus *Hosta* is comprised of about forty species, with a world-wide distribution. The plants of genus *Hosta* are the rich resources of steroidal saponins and amaryllidaceae alkaloids, and some species are important medical plants and traditionally used to treat various diseases, including mastitis, otitis media, pharyngolaryngitis, urethritis, dysmenorrhea and snake bites etc. However, the studies on *Hosta* were mostly focused on their ornamental values. In the present review, an attempt has been made to compile all the available information regarding the chemical constituents (mainly steroidal saponins, amaryllidaceae alkaloids and flavonoids) and biological activities of genus *Hosta*, and provides new insights for future study on genus *Hosta*.

Key words: *Hosta,* chemical constituents, biological activities, review.

INTRODUCTION

The genus *Hosta*, belonging to the tribe *Hemerocallis* in *Liliaceae*, encompasses about 40 species and is widely distributed in temperate and subtropical regions and is cultivated in Europe as a garden plant. Their young leaves and buds are edible, meanwhile the leaves and rhizome have been used as an important folk medicine in China and Japan. *Hosta* species are used to treat various conditions such as mastitis, otitis media, folliculitis, pharyngolaryngitis, urethritis, dysmenorrhea and snake bites. For example, *Hosta ventricosa*, a perennial herb mainly used as ornamental plants, has been used to treat the stomach pain, bruises, meanwhile with the external application of bloated boils and snake bites (Nanjing University of TCM, 2006).

The studies on *Hosta* were mostly focused on their ornamental value and garden exploitation. The horticultural cultivars named *Hosta* were more than 4,000 cultivars over the world and about 2,000 varieties were registered (Mark, 2001). Meanwhile lots of new varieties were brought out and applied for registration every year. However, their various bioactivities, including anti-tumor, anti-inflammatory, anti-viral, antifungal and anti-acetylcholinesterase activity have been discovered. The medical value of genus *Hosta* deserves further notice. This review is intended to collect all the possible information regarding the chemical constituents and pharmacological actions of genus *Hosta* and thus provide the basis for future research on the application of medical plants from genus *Hosta*.

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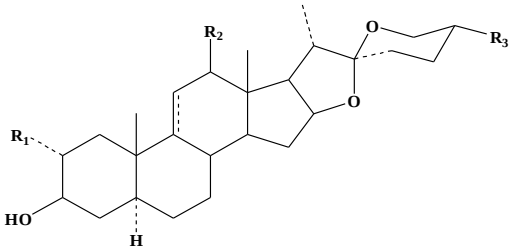
CHEMICAL RESEARCH

According to the literatures, 82 compounds have been isolated from *Hosta*, including steroidal saponins, sapogenins, alkaloids, flavonoids etc. Their structures are shown subsequently in the scheme and their names, classes and corresponding plant sources are listed in Table 2.

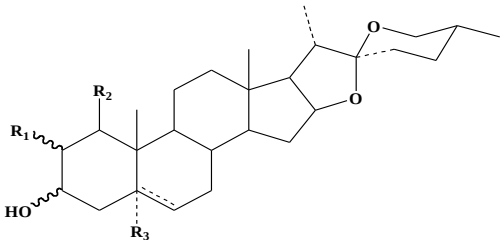
Steroidal saponins

Saponins are the main and common chemical constituents of the genus *Hosta*. Most of the isolated compounds have been confirmed to be steroidal saponins with aglycone as diosgenin, gitogenin, hecogenin, 9-dehydromanogenin etc., and glucose, rhamnose, xylose, galactose as sugar units. $\triangle^{25\,(27)}$-sapogenins which once were considered as artifacts were isolated and

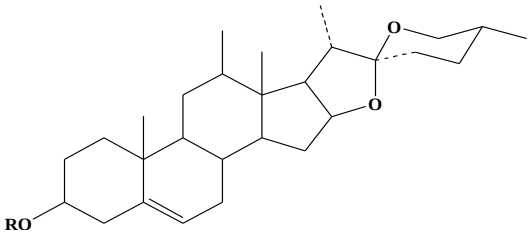
Table 1. Steroidal saponins.



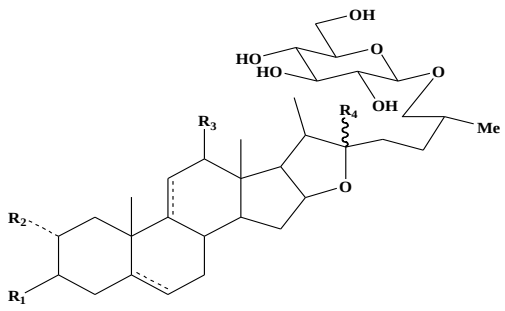
	R_1	R_2	R_3	
1	OH	—	$=CH_2$	
2	OH	=O	$=CH_2$	
3	OH	=O	$=CH_2$	$\triangle^9$
4	—	—	$=CH_2$	
5	—	—	CH_3	
6	—	=O	CH_3	
7	—	=O	CH_3	$\triangle^9$
8	OH	—	CH_3	25R
9	OH	—	CH_3	25S
10	OH	=O	CH_3	
11	OH	=O	CH_3	$\triangle^9$



	R_1	R_2	R_3	
12	—	—	H	3β,$\triangle^5$
13	OH	OH	OH	2β,3α
14	—	OH	H	3β,$\triangle^5$
15	OH	OH	H	2β,3α



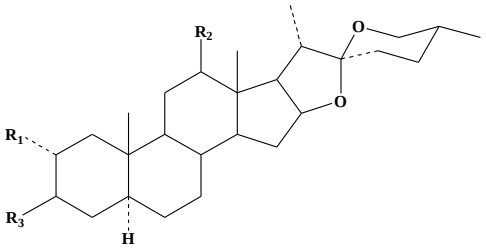
	R
16	-Glcp
17	-Glcp-(1-4)-galp
18	-Glcp-(1-2)-glcp(1-4)-galp
19	-Rhap-(1-4)-glcp(1-2)-glcp(1-4)-galp
20	-Rhap-(1-4)-glcp-(1-2)-[xylp-(1-3)]-glcp-(1-4)-galp



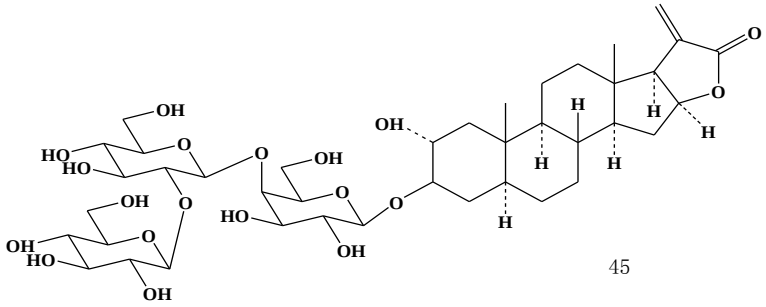
	R_1	R_2	R_3	R_4	
21	β-OH	—	—	α-OH	$\triangle^5$
22	-Rhap-(1-2)-Galp	α-OH	—	OMe	—
23	-Rhap-(1-2)-[Glcp-(1-4)]-Galp	α-OH	—	OMe	—
24	β-OH	α-OH	—	OMe	—
25	-Glcp-(1-2)-[Xylp-(1-3)]-Glcp-(1-4)-Galp	α-OH	=O	OMe	—
26	-Glcp-(1-2)-[Xylp-(1-3)]-Glcp-(1-4)-Galp	α-OH	=O	OMe	$\triangle^9$

	R_1	R_2	R_3

Table 1. Contd.



27	OH	—	-Glcp-(1-2)-[xylp-(1-3)]-glcp-(1-4)-galp
28	H	=O	-Glcp-(1-2)-[xylp-(1-3)]-glcp-(1-4)-galp
29	OH	—	-Glcp-(1-2)-[glcp-(1-3)]-glcp-(1-4)-galp
30	OH	—	-Rhap-(1-2)-galp
31	OH	—	-Rhap-(1-2)-[glcp-(1-4)]-galp
32	H	—	-Rhap-(1-2)-[glcp-(1-4)]-galp
33	OH	—	-Glcp-(1-2)-glcp-(1-4)-galp
34	OH	—	-Glcp-(1-2)-[rhap-(1-4)-xylp-(1-3)]-glcp-(1-4)-galp
35	OH	—	-Rhap-(1-4)-glcp-(1-3)-[glcp-(1-2)]-glcp-(1-4)-galp
36	OH	—	-Galp
37	OH	=O	-Glcp-(1-2)-[xylp-(1-3)]-glcp-(1-4)-galp
38	OH	=O	-Glcp-(1-2)-[rhap-(1-4)-xylp-(1-3)]-glcp-(1-4)-galp
39	OH	=O	-Glcp-(1-2)-glcp-(1-4)-galp
40	OH	OH	-Rhap-(1-2)-galp
41	H	—	-Glcp-(1-4)-galp
42	OH	—	-Glcp-(1-4)-[rhap-(1-2)]-galp
43	H	—	-Glcp-(1-4)-[rhap-(1-2)]-galp
44	OH	—	-Xylp-(1-4)-glcp-(1-2)-[xylp-(1-3)]-glcp-(1-4)-galp



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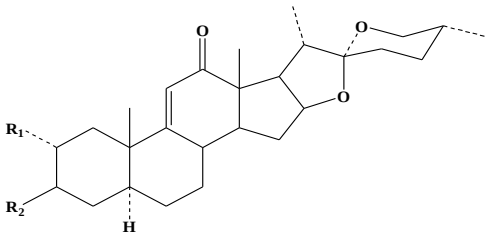

	R_1	R_2
46	OH	-Glcp-(1-2)-[rhap-(1-4)-glcp-(1-3)]-glcp-(1-4)-galp
47	OH	-Glcp-(1-2)-[glcp-(1-3)]-glcp-(1-4)-galp
48	OH	-Glcp-(1-2)-[xylp-(1-3)]-glcp-(1-4)-galp
49	—	-Glcp-(1-2)-[xylp-(1-3)]-glcp-(1-4)-galp
50	OH	-Glcp-(1-2)-glcp-(1-4)-galp
51	OH	-Glcp-(1-2)-[rhap-(1-4)-xylp-(1-3)]-glcp-(1-4)-galp

the research indicated the interconversion between the unsaturated and the saturated sapogenins occurring by the action of the plant enzyme: $\triangle^{25\ (27)}$-gitogenin transforms into gitogenin and/or neogitogenin. So the naturally occurring spirostans should be divided into 25D- or R-sapogenin (iso), 25L- or S-sapogenin (neo), and 25, 27-unsturated sapogenin (Takeda et al., 1967, 1968) (Table 1).

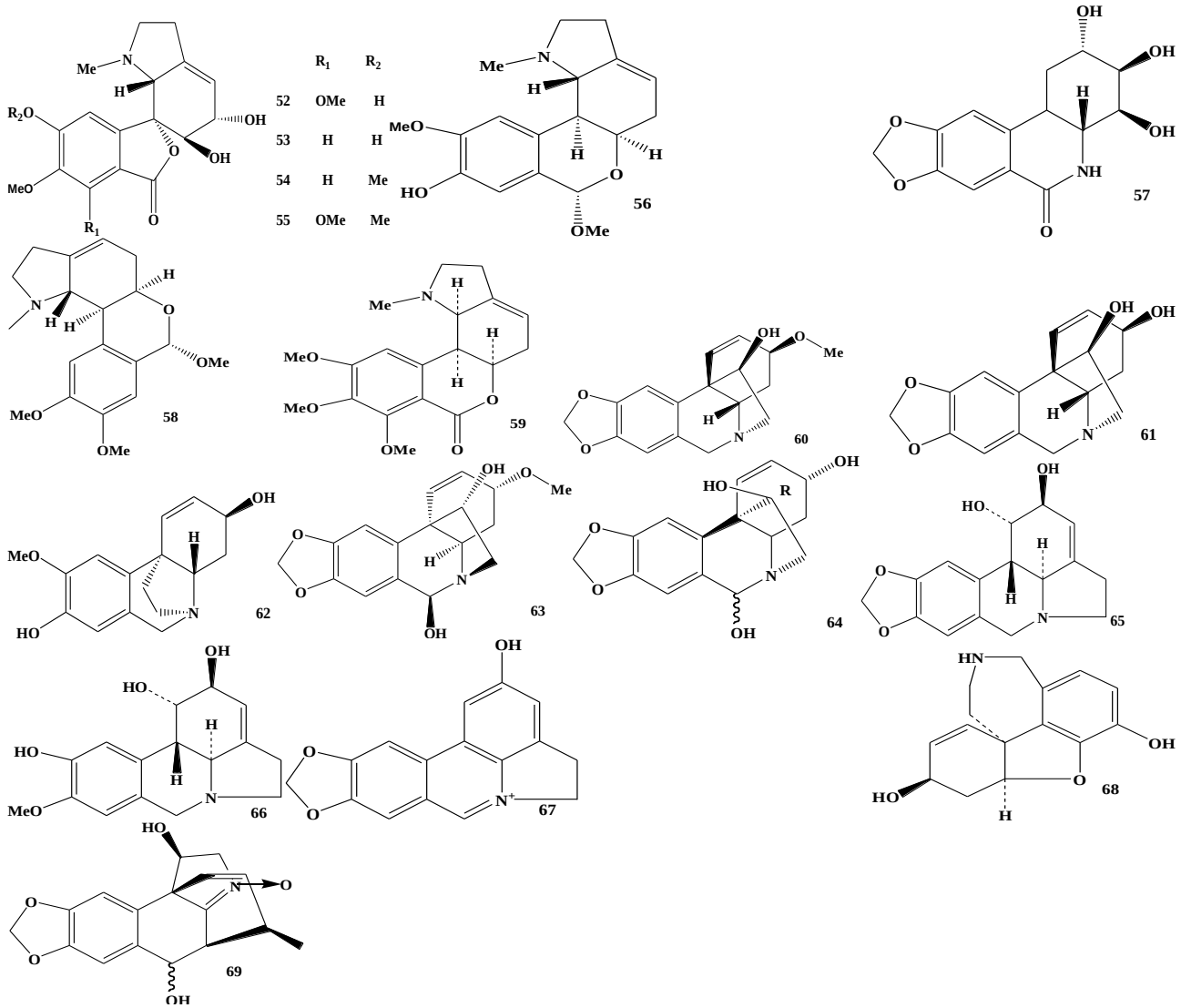

Figure 1. Alkaloids.

Alkaloids

All the 18 alkaloids (52 to 69) isolated from *Hosta plantaginea* (Lam.) Aschers are benzylphenethylamine alkaloids, which are widely distributed in the plants of the Amaryllidaceae family and called amaryllidaceae alkaloids, with unique skeletons and remarkable biological activities (Wang et al., 2007a). It is worth mentioning that among the isolated alkaloid Hostasinine A (69), possessing a new skeleton of C_4-C_6 linkage and a nitrone moiety (Wang et al., 2007b) (Figure 1).

Flavonoids

Ten kaempferol glycosides are isolated from genus *Hosta*. The further surveys of flavonoids aglycones in Liliaceae suggest that kaempferol is characteristic of tribe *Hemerocallis* (subfamily Asphodeloideae) (Table 2).

Others

Some article mentioned that long-chain fatty acids and esters also existed (Xie et al., 2009) (Figure 2).

PHARMACOLOGICAL RESEARCH

The whole plant and the compounds isolated from *Hosta* genus showed the broad pharmacological actions such as anti-tumor, anti-inflammatory, anti-acetylcholinesterase, anti-viral, antifungal, and insecticidal activity, with a wide application prospect.

Table 2. Chemical constituents from the Genus *Hosta*.

S/N	Compound class and name	Plant	Reference
	Steroidal Sapogenins		
1	$^{\triangle 25\,(27)}$-gitogenin	*H. kiyosumiensis*	Takeda et al. (1965)
2	$^{\triangle 25\,(27)}$-manogenin	*H. kiyosumiensis*	Takeda et al. (1965)
3	$^{\triangle 25\,(27)}$-9-dehydromanogenin	*H. kiyosumiensis*	Takeda et al. (1965)
4	$^{\triangle 25\,(27)}$-tigogenin	*H. kiyosumiensis*	Takeda et al. (1965)
5	Tigogenin	*H. montana*	Takeda et al. (1964)
6	Hecogenin	*H. montana*	Takeda et al. (1964)
7	9-Dehydrohecogenin	*H. montana*	Takeda et al. (1964)
8	Gitogenin	*H. montana* *H. caerulea* *H. plantaginea*	Takeda et al. (1964) Takeda et al. (1965) Liu et al. (2010)
9	Neogitogenin	*H. montana*	Takeda et al. (1964)
10	Manogenin	*H. montana*	Takeda et al. (1964)
11	9-Dehydromanogenin	*H. montana*	Takeda et al. (1964)
12	Diosgenin	*H. caerulea*	Kintya et al. (1977)
13	Kogagenin	*H. caerulea*	Kintya et al. (1977)
14	Ruscogenin	*H. caerulea*	Kintya et al. (1977)
15	Tokorogenin	*H. caerulea*	Kintya et al. (1977)
	Steroidal Saponins		
16	Funkioside A	*H. caerulea*	Kintya et al. (1976)
17	Funkioside C	*H. caerulea*	Mashchenko et al. (1977)
18	Funkioside D	*H. caerulea*	Mashchenko et al. (1977)
19	Funkioside E	*H. caerulea*	Kintya et al. (1977)
20	Funkioside G	*H. caerulea*	Kintya et al. (1977)
21	Funkioside B	*H. caerulea*	Kintya et al. (1976)
22	26-*O*-glcp-22-*O*-methyl-25(R)-5α-furostane-2α,3β,22ξ,26-tetrol 3-*O*-{rhap-(12)-galp}	*H. longipes* *H. sieboldii*	Mimaki et al. (1996) Mimaki et al. (1998)
23	26-*O*-glcp-22-*O*-methyl-25(R)-5α-furostane-2α,3β,22ξ,26-tetrol 3-*O*-{rhap-(1-2)-[glcp- (1-4)]-galp}	*H. longipes* *H. sieboldii*	Mimaki et al. (1996) Mimaki et al. (1998)
24	25(R)-22-*O*-methyl-5α-furostane-2α,3β,22ξ,26-tetrol 26-*O*-glcp	*H. plantaginea*	Mimaki et al. (1997)
25	(25R)-2α,3β-dihydroxy-26-glcp-22-methoxy-5α-furostan-12-one 3-*O*-{glcp-(1-2)-[xylp- (1-3)]-glcp-(1-4)-galp}	*H. sieboldii*	Mimaki et al. (1998)
26	(25R)-2α,3β-dihydroxy-26-glcp-22-methoxy-5α-furostan-9-en-12-one 3-*O*-{glcp-(1-2)-[xylp-(1-3)]-glcp-(1-4)-galp}	*H. sieboldii*	Mimaki et al. (1998)
27	F-gitonin	*H. longipes* *H. plantaginea* *H. sieboldii*	Mimaki et al. (1995, 1997,1998) and Liu et al. (2010) Yada et al. (2010)

Table 2. Contd.

28	Hecogenin 3-*O*-{glcp-(1-2)-[xylp-(1-3)]-glcp -(1-4)-galp}	*H. longipes* *H. sieboldii*	Mimaki et al. (1995) Mimaki et al. (1998)
29	Gitogenin 3-*O*-{glcp-(1-2)-[glcp-(1-3)]-glcp -(1-4)-galp}	*H. longipes*	Mimaki et al. (1995)
30	Gitogenin 3-*O*-{rhap-(1-2)-galp}	*H. longipes* *H. plantaginea* *H. sieboldii*	Mimaki et al. 1996 Liu et al. (2010) Mimaki et al. (1998)
31	Gitogenin 3-*O*-{rhap-(1-2)-[glcp-(1-4)]-galp}	*H. longipes* *H. sieboldii*	Mimaki et al. (1996) Mimaki et al. (1998)
32	Tigogenin 3-*O*-{rhap-(1-2)-[glcp-(1-4)]-galp}	*H. longipes* *H. sieboldii*	Mimaki et al. (1996) Mimaki et al. (1998)
33	Gitogenin 3-*O*-{glcp-(1-2)- glcp-(1-4)-galp}	*H. plantaginea*	Mimaki et al. (1997) and Liu et al. (2010)
34	Gitogenin 3-*O*-{glcp-(1-2)-[rhap-(1-4)-xylp- (1-3)]-glcp-(1-4)-galp}	*H.plantaginea* *H. sieboldii*	Liu et al. (2010) Mimaki et al. (1997,1998)
35	25(R)-3β-{rhap-(1-4)-glcp-(1-3)-[glcp-(1-2)]-glcp-(1-4)-galp}-5α-spirostan-2α-ol	*H. sieboldii*	Yada et al. (2010)
36	Gitogenin 3-*O*-galp	*H. sieboldii*	Mimaki et al. (1998) and Liu et al. (2010)
37	Manogenin 3-*O*-{glcp-(1-2)-[xylp-(1-3)]-glcp -(1-4)-galp}	*H. sieboldii*	Mimaki et al. (1998)
38	Manogenin 3-*O*-{glcp-(1-2)-[rhap-(1-4)-xylp -(1-3)]-glcp-(1-4)-galp}	*H. sieboldii*	Mimaki et al. (1998)
39	Manogenin 3-*O*-{glcp-(1-2)- glcp-(1-4)-galp}	*H. sieboldii*	Mimaki et al. (1998)
40	(25R)-5α-spirostan-2α,3β,12β-triol 3-*O*-{rhap-(1-2)-galp}	*H. sieboldii*	Mimaki et al. (1998)
41	Gitogenin 3-*O*-glcp-(1-4)-galp	*H. plantaginea*	Liu et al. (2010)
42	Gitogenin 3-*O*-glcp-(1-4)-[rhap-(1-2)]-galp	*H. plantaginea*	Liu et al. 2010)
43	Tigogenin 3-*O*-glcp-(1-4)-[rhap-(1-2)]-galp	*H. plantaginea*	Liu et al. 2010)
44	Gitogenin 3-*O*-{xylp-(1-4)-glcp-(1-2)-[xylp-(1-3)]-glcp-(1-4)-galp}	*H. plantaginea*	Liu et al. (2010)
45	2α,3β,16β-trihydroxy-5α-pregn-20(21)-ene- carboxylic acid γ-lactone 3-*O*-{glcp-(1-2)- glcp-(1-4)-galp}	*H.plantaginea*	Mimaki et al. (1997)

Table 2. Contd

46	9-Dehydromanogenin 3-*O*-{glcp-(1-2)-[rhap- (1-4)-glcp-(1-3)]-glcp-(1-4)-galp}	*H. longipes*	Mimaki et al. (1995)
47	9-Dehydromanogenin 3-*O*-{glcp-(1-2)-[glcp- (1-3)]-glcp-(1-4)-galp}	*H. longipes*	Mimaki et al. (1995)
48	9-Dehydromanogenin 3-*O*-{glcp-(1-2)-[xylp- (1-3)]-glcp-(1-4)-galp}	*H. longipes* *H. sieboldii*	Mimaki et al. (1995) Mimaki et al. (1998)
49	9-Dehydrohecogenin 3-*O*-{glcp-(1-2)-[xylp- (1-3)]-glcp-(1-4)-galp}	*H. longipes*	Mimaki et al. (1995)
50	9-Dehydromanogenin 3-*O*-{glcp-(1-2)-glcp-(1-4)-galp}	*H. sieboldii*	Mimaki et al. (1998)
51	9-Dehydromanogenin 3-*O*-{glcp-(1-2)-[rhap-(1-4)-xylp-(1-3)]-glcp-(1-4)-galp}	*H. sieboldii*	Mimaki et al. (1998)
	Alkaloids		
52	Hostasine	*H. plantaginea*	Wang et al. (2007a)
53	8-demethoxyhostasine	*H. plantaginea*	Wang et al. (2007a)
54	8-demethoxy-10-*O*-methylhostasine	*H. plantaginea*	Wang et al. (2007a)
55	10-*O*-methylhostasine	*H. plantaginea*	Wang et al. (2007a)
56	9-*O*-demethyl-7-*O*-methyllycorenine	*H. plantaginea*	Wang et al. (2007a)
57	7-deoxytrans-dihydronarciclasine	*H. plantaginea*	Wang et al. (2007a)
58	*O*-methyllycorenine	*H. plantaginea*	Wang et al. (2007a)
59	Albomaculine	*H. plantaginea*	Wang et al. (2007a)
60	(+)-haemanthamine	*H. plantaginea*	Wang et al. (2007a)
61	*O*-demethylhaemanthamine	*H. plantaginea*	Wang et al. (2007a)
62	8-*O*-demethylmaritidine	*H. plantaginea*	Wang et al. (2007a)
63	Haemanthidine	*H. plantaginea*	Wang et al. (2007a)
64	Yemenine C	*H. plantaginea*	Wang et al. (2007a)
65	Lycorine	*H. plantaginea*	Wang et al. (2007a)
66	Pseudolycorine	*H. plantaginea*	Wang et al. (2007a)
67	Ungeremine	*H. plantaginea*	Wang et al. (2007a)
68	Norsanguinine	*H. plantaginea*	Wang et al. (2007a)
69	Hostasinine A	*H. plantaginea*	Wang et al. (2007b)
	Flavonoids		
70	Kaempferol	*H. plantaginea*	Xie et al. (2009)
71	Kaempferol 3-*O*-(2^G-glucosylrutinoside)-7-*O*- glucoside	*H. ventricosa*	Budzianowski (1990)
72	Kaempferol 3-*O*-sophoroside-7-*O*-glucoside	*H. ventricosa*	Budzianowski (1990)
73	Kaempferol 3-*O*-(2^G-xylosylrutinoside)-7-*O*- glucoside	*H. ventricosa*	Budzianowski (1990)
74	Kaempferol 3-*O*-rutinoside-7-*O*-glucoside	*H. ventricosa*	Budzianowski (1990)
75	Kaempferol 3-*O*-(2^G-glucosylrutinoside)	*H. ventricosa*	Budzianowski (1990)
76	Kaempferol 3-*O*-(2^G-xylosylrutinoside)	*H. ventricosa*	Budzianowski (1990)
77	Kaempferol 3-*O*-sophoroside	*H. ventricosa*	Budzianowski (1990)
78	Kaempferol 3-*O*-rutinoside	*H. plantaginea*	Xie et al. (2009)
79	Kaempferol 7-*O*-glucoside	*H. ventricosa* *H. plantaginea*	Xie et al. (2009) He et al. (2010)
80	Quercertin	*H. plantaginea*	Xie et al. (2009)

Table 2. Contd.

	Others		
81	Eicosan acid	*H. plantaginea*	Xie et al. (2009)
82	Hexadecanoic acid 2,3-dihydroxypropylester	*H. plantaginea*	Xie et al. (2009)

Glcp = *β*-D-glucopyranosyl, Xylp = *β*-D-xylopyranosyl. Galp = *β*-D-galactopyranosyl, Rhap = *α*-L-rhamnopyranosyl.

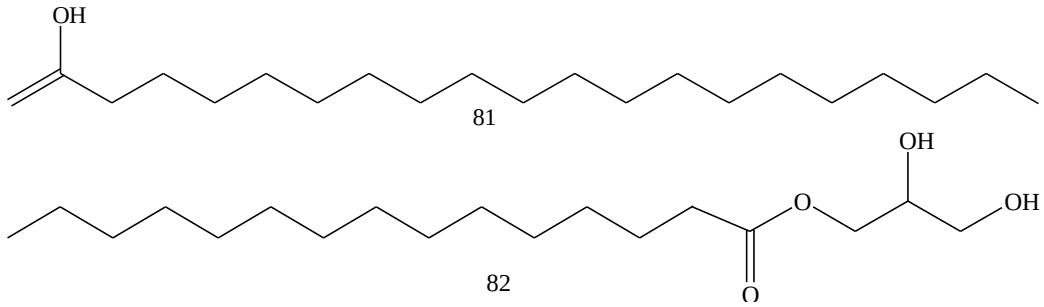

Figure 2. Long-chain fatty acids and esters.

Anti-tumor activity

The isolated compounds were examined for their inhibitory activity on 12-O-tetradecanoylphorbol-13-acetate (TPA)-stimulated ^{32}P-incorporation into phospholipids of HeLa cells to identify new anti-tumor-promoter compounds. The results showed compound 28, 29, 47, 48 and 49 were cytotoxic towards HeLa cells at a sample concentration of 50 μg/ml; when the concentration changed to 5 μg/ml, compound 28 still exhibited the obvious cytotoxicity (Mimaki et al., 1995). Compound 6, 11, 30 and 32 showed the high inhibition at 50 μg/ml (the inhibition ratios were 78.3, 57.8, 77.8, 45.6%, respectively) (Mimaki et al., 1996). Compound 27, 24, 33, 34 and 45 were examined for their cytostatic activity on human promyelocytic leukaemia HL-60 cells by MTT method. The IC_{50} values ranging between 1 and 3 μg/ml indicated that compound 27, 33, 34 with the potent cytostatic activity in a dose-dependent manner (Mimaki et al., 1997).

The cytostatic activities of the 18 saponins isolated from *Hosta sieboldii* on HL-60 cells were evaluated by the MTT method. The following structure-activity relationships were disclosed: modification on the aglycone moiety with a C-12 carbonyl or a conjugated C-12 carbonyl group, and glycosyl formation at the C-4 xylosyl moiety with a rhamnosyl group will decreased the activity significantly (Mimaki et al., 1998; Yoshihiro and Mimaki, 2009). The results of screening the anti-tumor activity of the 10 compounds isolated from *H. plantaginea* by MTT method revealed that compound 27, 33, 34, 42 and 44 showed the favorable activity towards hepatic carcinoma HepG2, human breast adenocarcinoma pleural effusion MCF7 and gastric carcinoma SGC7901 cell lines (Liu et al., 2010). Compound 18 (Funkioside D) exhibited significant cytotoxicity against K562 *in vitro* with an IC_{50} value of 2.93 μg /mL (Yang et al., 2009).

In the pharmacological evaluation of the root extract of *H. plantaginea in vivo*, researchers found that the aqueous fraction have a high degree of anti-tumor activity towards Enrlich ascite carcinoma (ED_{50} = 10.7 mg/kg/d). Further study disclosed a high-molecular compound (molecular weight > 5×10^4) with a prominent activity (ED_{50}=0.67 mg/kg/d). Oral or intraperitoneal administration 0.26 g/kg of the ethanol extract exerted a certain inhibition of the mouse leukemia cell lines L615 (Yokata et al., 1986).

Anti-inflammatory activity

Researchers screened 86 plant extracts for their stimulating activities of retinoic acid-induced (RA-induced) HL-60 cells, and found the methanol extracts of *Hosta sieboldiana* possessed the marked activity of stimulating neutrophils. Further study indicated compound F-gitonin (27) with significant stimulating activity, could stimulate cells to promote active oxygen at a concentration of 0.5 to 5 μM. At a concentration of 2.5 μM, the active oxygen generated is 70 times as that of the blank (Hata et al., 2002).

It is also worth mentioning that the different extracts of *H. ventricosa* roots displayed highly anti-inflammatory activity towards early inflammation. When the dose is reduced to 1.1 g/kg, only the aqueous fraction showed inhibitory activity ($P<0.05$). The further study suggested that this fraction could remarkably reduce the volume of pleural effusion in pleurisy rat induced by carrageenin

(P<0.05) and inhibit the leukocyte migration into the pleural effusion (P<0.01) (Zhong et al., 2003; Cui et al., 2003).

Anti-acetylcholinesterase (Anti-AChE) activity

Ten alkaloids were isolated from the *H. plantaginea* and their inhibitions of acetylcholinesterase activity were studied. The results showed compound 54 (IC_{50}=2.32 μM), 67 (IC_{50}=3.85 μM), 68 (IC_{50} = 1.43 μM) with a strong activity (Wang et al., 2007a). Compound lycorine (65), the first isolated amaryllidaceous alkaloids have been confirmed for its weak Anti-AChE activity with IC_{50} = 450 μM, compared with positive control physostigmine which gave IC_{50} of 0.25 μM. Cholinesterase activity appears to be associated with the presence of two free hydroxy groups in this structural type of amaryllidaceae alkaloid (Houghton et al., 2004).

Lycorine, with a wide pharmacological activity, has attracted great interest as challenge targets for synthesis and structural modification. After a series of chemical transformations 5, 6-secolycorines possessing a 5, 6-dihydrophenanthridine skeleton were facilely prepared from lycorine. Several secolycorine derivatives showed potent inhibitory activity against acetylcholinesterase with the IC_{50} value at micromolar range and are more potent than galanthamine (Lee et al., 2007).

The structure-activity relationships of lycorine and its derivatives showed that the modification of C-8 may produce higher inhibitor; and the incompleteness D-ring and the presence of an aromatic C-ring may enhance the activity (Elgorashi et al., 2004, 2006).

Anti-viral and antifungal activity

In the screening for anti-viral activities against severe acute respiratory syndrome associated corona virus (SARS-CoV) based on a MTS assay, 200 Chinese medicinal herb extracts were tested, and compound lycorine (65) was isolated and purified from the active extracts, with an EC_{50} value of 15.7 nM. This compound has a CC_{50} value of 14980.0 nM in cytotoxicity assay and a selective index (SI) greater than 900. The results showed that lycorine was a candidate for the development of new anti-SARS-CoV drugs in the treatment of SARS (Li et al., 2005).

Tobacco mosaic virus (TMV), a plant virus which result in the mosaic symptoms appeared on leaves, growth trapped in bad state, leaves deformity. Tracking the active ingredient from *H. plantaginea* to screening for its anti-TMV ingredient by half leaf method. The ethyl acetate fraction and the fraction eluted by methanol from water-soluble part with D101 macroporous resin showed a strong activity.

Further study was focused on seven compounds isolated from *H. plantaginea*. The results revealed the compound 7-deoxy-trans-dihydronarciclasine (57) with a notable anti-TMV activity (IC_{50} = 1.80 μM) stronger than the postive drug Ribavirin (Wang et al., 2007a). Other research inspected 50% aqueous acetone extracts of 97 plants ranging from *Euphorbiaceae, Leguminosae, Malvaceae, Cucurbitaceae, Liliaceae Chenopodiaceae, Caryophyllaceae* etc., *H. ventricosa* was indentified with a 32.6% inhibition which showed certain anti-TMV activity (Fan et al., 2005).

The study found that Compound lycorine (65) with an inhibitory activity towards Japanese encephalitis virus, yellow fever virus, dengue virus and other virus *in vitro*. Meanwhile, it also shows inhibitory activity on the polio virus, herpes virus, coxsackievirus B2 in a dose-dependent manner. The mechanism of delayed virus growth and reduce the total viral was due to its blocking the formation of proteinsynthesis (Bjarne et al., 1992).

The antifungal activities of collected flavonoids and steriods were screened by the method of agar diffusion test. Compound Funkioside C (17) showed the growth inhibition of both *Fusarium oxysporum* and *Canida albicans* with the values of minimal inhibitory concentration 0.217 and 0.310 g/L, respectively (Zhang et al., 1997).

Insecticidal activity

Methanol extracts of 56 plants collected in Jiangxi Province were tested for their activities against larvae of aedes albopictus. The results showed *H. plantaginea* extracts, with a significant insecticidal activity, bring in a mortality rate of 74.97%. It is the first report about insecticidal activity of *H. plantaginea* (Ping et al., 2007).

OUTLOOKS

Most of researches focused on the ornamental values of genus *Hosta,* meanwhile its medicinal value is open to people gradually. The past investigations have revealed many active components in genus *Hosta*, especially the steroids and amaryllidaceae alkaloids with the broad prospects to develop potential new drugs such as anti-inflammatory and anti- Alzheimer's dementia agents. The high content steroid sapogenins in *Hosta* can be utilized to synthesize many steroid hormone drugs also. Much more attention should be focused on the exploitation and utilization of medical plants from genus *Hosta*.

Our comprehensive literature search also indicates that only a very few of *Hosta* species have been undergone the chemical and pharmacological investigation so far. So the research of the other species of genus *Hosta* should be carried out.

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REFERENCES

Bjarne G, Monath TP, Huggins JW, Kefauver DF (1992). Antiviral (RNA) activity of selected amaryllidaceae isoquinoline constituents and systhesis of related substances. J. Nat. Prod., 55: 1596-1581.

Budzianowski J (1990). Kaempferol glycosides from *Hosta ventricosa*. Phytochem., 29: 3643-3646.

Cui LJ, Huang Y, Zhao SF (2003). Study the anti-nonspecific inflammation of *Hosta ventricosa*. J. Hebei Tradit. Chin Med. Pharmacol., 18: 28-30.

Elgorashi EE, Malan SF, Stafford GI, Van SJ (2006). Quantitative structure–activity relationship studies on acetylcholinesterase enzyme inhibitory effects of amaryllidaceae alkaloids. S Afr. J. Bot. 72: 224-231.

Elgorashi EE, Stafford GI, Van SJ (2004). Acetylcholinesterase enzyme inhibitory effects of amaryllidaceae alkaloids. Planta Med., 70: 260-262.

Fan B, Wu YF, Yuan HF (2005). Primarily screening of antiviral substances from plants. J. Northwest Sci-Tech Univ. A&F. (Nat. Sci. Ed.) 33: 167-169.

Hata K, Hori K, Takahashi S (2002). Stimulating activity of F-gitonin, a steroidal saponin from *Hosta siebolaiana* on human neutrophils-like cells. Nat. Med., 56: 153-156.

Houghton PJ, Agbedahunsi JM, Adegbulugbe A (2004). Choline esterase inhibitory properties of alkaloids from two Nigerian *crinum* species. Phytochem., 65: 2893-2896

Kintya PK, Mashchenko NE, Konovova NI, Lazur'evskii GV (1976). Preliminary characterization of steroid glycosides from *Funkia ovata*. Khim. Prir.Soedin, 11: 241-242.

Kintya PK, Mashchenko NE, Lazur'evskii GV (1977). A chemical study of funkiosides E and G from the leaves of *Funkia ovata*. Khim. Prir. Soedin, 5: 58-61.

Lee SS, Venkatesham U, Rao CP, Lam SH, Lin JH (2007). Preparation of secolycorines against acetylcholinesterase. Bioorg. Med. Chem., 15: 1034-1043.

Li S Y, Chen C, Zhang HQ, Guo HY, Wang H, Wang L, Zhang X, Hua SN, Yu J, Xiao PG, Li RS, Tan XH (2005). Identification of natural compounds with antiviral activities against SARS-associated coronavirus. Antiviral Res., 67: 18-23.

Liu JQ, Wang CF, Qiu MH, Hu WX (2010). Steroidal saponins from flowers of *Hosta plantaginea* and their antitumor activities. Chin. Tradit. Herb Drugs, 41: 521-526.

Mark RZ (2001). The Hosta Handbook, 3rd ed., Illinois, pp 34-46

Mashchenko NE, Lazur'evskii GV, Kintya PK (1977). The structure of funkiosides C and D from the leaves of *Funkia ovata* (*Hosta caerulea*) Khim. Prir. Soedin., 18: 114-115.

Mimaki Y, Kameyama A, Kuroda M, Sashida Y, Hirano T, Oka K，Koike K，Nikaido T (1997). Steroidal glycosides from the underground parts of *Hosta plantaginea* var. *japonica* and their cytostatic activity on leukaemia HL-60 cells. Phytochemistry 44: 305-310.

Mimaki Y, Kanmoto T, Kuroda M, Sashida Y, Nishino A, Satomi Y, Nishino H (1995). Steroidal saponins from the underground parts of *Hosta longipes* and their inhibitory activity on tumor promoter-induced phospholipid metabolism. Chem. Pharm. Bull. 43: 1190-1196.

Mimaki Y, Kanmoto T, Kuroda M, Sashida Y, Satomi Y, Nishino A, Nishino H (1996). Steroidal saponins from *Hosta longipes* and their inhibitory activity on tumor promoter-induced phospholipid metabolism of Hela cells. Phytochemistry 42: 1065-1070.

Mimaki Y, Kuroda M, Kameyama A, Yokosuka A, Sashida Y (1998). Steroidal saponins from the rhizomes of *Hosta sieboldii* and their cytostatic activity on HL-60 cells. Phytochem., 48：1361-1369.

Nanjing University of TCM (2006). The Dictionary of Traditional Medicine. 3rd ed., Shanghai Scientific & Technical Press, China. p. 3283, 3304

Ping XL, Li BT, Zeng XN, Xiong ZH, Li XH (2007). Bioactivity of the Methanol Extracts from 56 Species of Plants against Aedes albopictus. Acta Agric. Univ. Jiangxiensis, 29: 31-33.

Takeda K, Minato H, Shimaoka A (1967). Studies on biochemical transformation of plant steroids. Part Ⅰ. Biochemical interconversion of the $\Delta^{25\,(27)}$- and the saturated 25D- or 25L-sapogenins. J. Chem. Soc., (C): 876-882.

Takeda K, Minato H, Shimaoka A (1968). Studies on biochemical transformation of plant steroids. Part Ⅱ. Biochemical conversion of Gitongenin into 12-oxygenated sapogenins in *Hosta kiyosumiensis* F. Maek. Chem. Pharm. Bull. 16: 275-279.

Takeda K, Okanisih T, Minato H, Shimaoka A (1964). Studies on the steroidal components of domestic plants-XLV. Constituents of Hosta species. Chem. Pharm. Bull. 12: 779-783.

Takeda K, Okanisih T, Minato H, Shimaoka A (1965). Studies on the steroidal components of domestic plants-XLVI. Tetrahedron, 21: 2089-2093.

Wang YH, Gao S, Yang FM, Sun QY, Wang JS, Liu HY, Li CS, Di YT, Li SL, Hao XJ (2007b). Structure elucidation and biomimetic synthesis of Hostasinine A, a new benzylphenethylamine alkaloid from *Hosta plantaginea*. Org. Lett. 9: 5279-5281.

Wang YH, Zhang ZK, Yang FM, Sun QY, He HP, Di YT, Mu SZ, Lu Y, Chang Y, Zheng QT, Ding M, Dong JH, Hao XJ (2007a). Benzylphenethylamine alkaloids from *Hosta plantaginea* with inhibitory activity against tobacco mosaic virus and acetylcholinesterase. J. Nat. Prod., 70: 1458-1461.

Xie HX, Zhang JH, Zhang HG, Xue PF (2009). Studies on Chemical Constituents from *Hosta plantaginea* (Lam.) Aschers, a Mongolia Medicine. Chin. Pharm. J., 44: 733-735.

Yada H, Kimura T, Suzuki M, Ohnishi-Kameyama M, Shinmoto H (2010). New steroidal saponin from *Hosta sieboldiana*. Biosci. Biotechnol. Biochem., 74: 861-864.

Yang SL, Liu XK, Wu H, Wang HB, Qing C (2009). Steroidal saponins and cytoxicity of the wild edible vegetable—*Smilacina atropurpurea*. Steroids, 74: 7-12.

Yokata M, Sugiyama K, Yamamoto T, Ni MY, Yan SC, Kosuge T (1986). Studies on Chinese medicines used for cancer.IV. Antitumor constituents in rhizoma zedoariae, periostracum cicadae, galla wisteriae, and radix Hostae. Yakugaku Zasshi, 106: 425-426.

Yoshihiro A, Mimaki Y (2009). Steroidal saponins from the whole plants of *Agave utahensis* and their cytotoxic activity. Phytochem., 70: 807-815.

Zhang LG, Zhang YY, Cai Y, Liu YQ, Wang JL, Wang JJ, Yang CR (1997). Antifungal activities *in vitro* of flavonoids and steroids from medicinal plants. Nat. Prod. Res. Develop, 9: 25-29.

Zhong GY, Zhou HR, Yu ZL, Xu LS (2003). Study the anti-nonspecific inflammation of folk medicine "*Hosta plantaginea*". China J. Chin. Mat. Med., 28: 979-980.