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< Review >

The Chemistry of Secondary Products from *Acanthopanax* Species and their Pharmacological Activities

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Abstract – The chemistry of secondary products from *Acanthopanax* species and their pharmacological activities were reviewed. A nitrogenous compound, a furan compound, a quinoid, benzoids, coumarins, phenylpropanoids, lignans, flavonoids, terpenoids, phytosterols, polyacetylenes, a pyrimidine, cyclitols, monosaccharides and an aliphatic alcohol have been isolated from *Acanthopanax* species and have been shown to have various levels of activities such as anti-bacterial, anti-cancer, anti-gout, anti-hepatitis, anti-hyperglycemic, anti-inflammatory, anti-leishmanicidic, anti-oxidant, anti-pyretic, anti-xanthine oxidase, choleretic, hemostatic, hypocholesterolemic, immunostimulatory and radioprotectant effects, etc.

Keywords – *Acanthopanax* species, Araliaceae, secondary products, pharmacological activities

Introduction

Acanthopanax species that belongs to the family Araliaceae is known to be native to Asia, the Malay peninsula, Polynesia, Europe, North Africa and the Americas (Wielgorskaya and Takhtajan, 1995), and about 15 species of *Acanthopanax* are found in eastern Asia. Among *Acanthopanax* species growing in the Korean peninsula, *A. senticosus*, *A. chiisanensis* and *A. sessiliflorus* are most abundant species.

Acanthopanax species have traditionally been used as a tonic and a sedative as well as in the treatment of rheumatism and diabetes. Regular use was said to restore vigor, appetite, memory, impotence and increase longevity.

A nitrogenous compound, a furan compound, a quinoid, benzoids, coumarins, phenylpropanoids, lignans, flavonoids, terpenoids, phytosterols, polyacetylenes, a pyrimidine, cyclitols, monosaccharides and an aliphatic alcohol have been isolated from *Acanthopanax* species and have been shown to have various levels of activities such as anti-bacterial, anti-cancer, anti-gout, anti-hepatitis, anti-hyperglycemic, anti-inflammatory, anti-leishmanicidic, anti-oxidant, anti-pyretic, anti-xanthine oxidase, choleretic, hemostatic, hypocholesterolemic, immunostimulatory and radioprotectant effects, etc.

This paper reviewed the chemistry of secondary products from *Acanthopanax* species and their pharmacological activities.

A nitrogenous compound – Sessiline [**1**], a new nitrogenous compound, was isolated from the fruits of *A. sessiliflorus* (Lee *et al.*, 2002a). There has been no previous report on the isolation of a nitrogenous compound from *Acanthopanax* species. To our knowledge, this is the first report on a nitrogenous compound from *Acanthopanax* species.

A furan compound – 5-Hydroxymethylfurfural (HMF) [**2**] was isolated from the fruits of *A. sessiliflorus* (Lee *et al.*, 2002b). There has been no previous report on a furan compound from *Acanthopanax* species. To our knowledge, this is the first report on a furan compound from *Acanthopanax* species. Shimizu *et al.* (1993) reported the isolation of HMF having aldose reductase inhibitory activity from Hachimi-jio-gan (Kampo medicine). HMF, occurs in many foods, does not pose a serious health risk, even though the highest concentrations in specific foods approach the biologically effective concentration range in cell systems (Janzowski *et al.*, 2000), and the physiological effects of HMF on *Saccharomyces cerevisiae* CBS 8066 has been studied. Addition of HMF caused a decrease in the carbon dioxide evolution rate (Taherzadeh *et al.*, 2000). HMF from the roasted fruits of *Prunus mume* had been demonstrated anthelmintic activity against *Clonorchis sinensis* (Kwak *et al.*, 1985).

A quinoid – 2,6-Dimethoxy-*p*-benzoquinone [**3**] was isolated from the stem barks of *A. senticosus* (Nishibe *et al.*, 1990).

Benzoids – Protocatechuic acid (3,4-dihydroxybenzoic acid, DBA) [**4**] was isolated from the roots and the stem barks of *A. senticosus* (Yun-Choi *et al.*, 1986) and from the fruits of *A. sessiliflorus* (Lee *et al.*, 2002b). DBA from the stem barks of *A. senticosus* had an anti-platelet aggregatory

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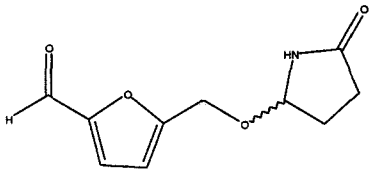

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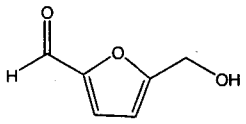

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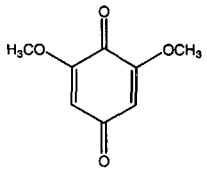

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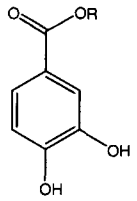
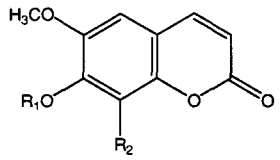


4 R: H
5 R: CH_2CH_3

activity (Yun-Choi *et al.*, 1986; Yun-Choi *et al.*, 1987). DBA from the flowers of *Hibiscus sabdariffa* L. (Malvaceae) exhibited a protection against *tert*-butylhydroperoxide-induced hepatotoxicity by its anti-oxidant and anti-inflammatory characteristics accompanied by blocking of stress signal transduction (Liu *et al.*, 2002). Overdoses of DBA, a naturally occurring simple phenolic anti-oxidant in dietary plant foodstuff, can disturb the detoxication of other electrophilic toxicants including ultimate carcinogens (Nakamura *et al.*, 2001). DBA from the BuOH fraction of *Polygonum bistorta* (Polygonaceae) showed an anti-inflammatory activity, its IC_{50} value, being 165.27 μg/ml (Ahn *et al.*, 1999).

Ethyl 3,4-dihydroxybenzoate [**5**] was isolated from the roots of *A. senticosus* (Yun-Choi *et al.*, 1986). It has been demonstrated to possess an anti-platelet aggregatory activity (Yun-Choi *et al.*, 1986).

Coumarins – Isofraxidin [**6**] was isolated from *A. senticosus* (Wagner *et al.*, 1982; Bladt *et al.*, 1990) and from the stem barks of *A. senticosus* (Nishibe *et al.*, 1990). It showed cytotoxicity in lymphocytic leukemia in mice and stimulated bile as well (Borris *et al.*, 1980), and exhibited a choleretic effect when administered orally at 25 mg/kg



6 R_1: H, R_2: OCH_3
7 R_1: Glc, R_2: OCH_3
8 R_1: CH_3, R_2: H

(Danielak *et al.*, 1973).

Isofraxidin-7-*O*-β-D-glucoside (eleutheroside B_1) [**7**] was isolated from *A. senticosus* (Wagner *et al.*, 1982; Bladt *et al.*, 1990; Wagner and Wurmböck, 1977), from the roots of *A. senticosus* (Slacanin *et al.*, 1991) and from the stem barks of *A. senticosus* (Nishibe *et al.*, 1990).

Scoparone [**8**] was isolated from the fruits of *A. sessiliflorus* (Lee *et al.*, 2002b). Overdoses of this compound can disturb the detoxification of other electrophilic toxicants including ultimate carcinogens (Nakamura *et al.*, 2001). After the treatment with this compound, hepatic microsomal UDP glucuronyltransferase activity (Huh *et al.*, 1987) and hepatic cytosolic sulfotransferase activity (Huh *et al.*, 1990) were increased in dose-dependent manner. This compound from *Artemisia capillaris* caused a reduction of cold ischemic injury in liver transplantation (Cho *et al.*, 2000). Differential oxidation of scoparone can be used as a sensitive indicator for distinguishing between different cytochrome P_{450} isoforms (Meyer *et al.*, 2001).

Phenylpropanoids – Caffeic acid [**9**] was isolated from *A. senticosus* (Bladt *et al.*, 1990). Caffeic acid showed an inhibition of xanthine oxidase activity and a nitric oxide production in C_6 astrocyte cells (Soliman and Mazzio, 1998), inhibited the toxic action of aflatoxin from *Aspergillus parasiticus* (Aziz *et al.*, 1998), showed an anti-gout and an anti-hepatitis activity (Chan *et al.*, 1995) and inhibited tumor promotion *in vivo* and *in vitro* in murine peritoneal macrophages treated with tumor promoters, and it also produced superoxide anions (Kaul and Khanduja, 1998).

Caffeic acid ethylester [**10**] was isolated from *A. senticosus* (Wagner *et al.*, 1982; Bladt *et al.*, 1990). It showed a protectant activity against single stranded DNA breaks caused by hydrogen peroxide in Chinese hamster (V79 cells) (Nakayama *et al.*, 1996).

Coniferin [**11**] was isolated from the root barks of *A. koreanum* (Kim *et al.*, 1988) and from the roots of *A. sesnticosus* (Slacanin *et al.*, 1991). Coniferin exhibited dual inhibitory effects, since it produced reduction in the generation of both cyclooxygenase and 5-lipoxygenase metabolites (Díaz Lanza *et al.*, 2001). Coniferin produced concentration-dependent contractions in rat aortic rings

(Deliorman *et al.*, 2000).

Coniferylaldehyde [**12**] was isolated from the *A. sesnticosus* (Wagner *et al.*, 1982). Coniferylaldehyde showed a protectant activity against DNA breaks caused by UV light-derived hydroxyl radicals (Taira *et al.*, 1992).

Coniferylaldehyde glucoside [**13**] was isolated from *A. sesnticosus* (Slacanin *et al.*, 1991).

p-Coumaric acid [**14**] and *p*-coumaric acid methylester [**15**] were isolated from the leaves of *A. sciadophylloides* (Kitajima *et al.*, 1989). *p*-Coumaric acid showed synergistic properties in reinforcing the anti-oxidant activity of lactoferrin in lipid systems containing iron (Medina *et al.*, 2002).

Sinapaldehyde glucoside [**16**] was isolated from the roots of *A. senticosus* (Slacanin *et al.*, 1991).

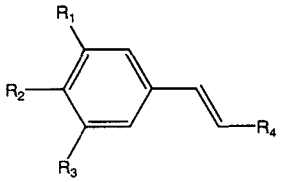
Sinapylalcohol [**17**] was isolated from *A. senticosus* (Wagner *et al.*, 1982; Bladt *et al.*, 1990).

Syringin (eleutheroside B) [**18**] was isolated from *A. koreanum* (Hahn *et al.*, 1985; Wagner *et al.*, 1982; Wagner and Wurmböck, 1977), from the root bark of *A. koreanum* (Chung and Kim, 1986), from the roots of *A. senticosus* (Li *et al.*, 2001; Slacanin *et al.*, 1991), from the roots and rhizomes of *A. sesnticosus* (Yat *et al.*, 1998) and from the stem barks of *A. koreanum* (Nishibe *et al.*, 1990) as one of main constituents. Syringin isolated from the roots of *A. senticosus* protected the animals from the stress-induced decreases in sex behaviors and in rectal temperature (Nishiyama *et al.*, 1985). Syringin functioned to prevent the stress-induced decreases in grip tone and exploratory movement, and to accelerate recovery from the decreases in grip tone, exploratory movement and spontaneous movement (Takasugi *et al.*, 1985). Syringin showed a protectant activity against damage from radiation. Fewer deaths occurred in mice after X-ray irradiation (400 rads). This compound decreased leucopoenia, and improved white blood cell count and thrombocyte level in human workers after exposure to unspecified radioactive substances (Ruijun *et al.*, 1990), and inhibited immunohaemolysis of antibody-coated sheep erythrocytes by guinea pig serum (Kapil and Sharma, 1997).

Eugenyl β-rutinoside [**19**] and sasanquin [**20**] were isolated for the first time from the stem barks of *A. setchuenensis* (Zhao *et al.*, 1999).

Chlorogenic acid [**21**] was isolated from the leaves of *A. divaricatus* forma *nambunensis* (Cho *et al.*, 1999), from the roots of *A. sesnticosus* (Slacanin *et al.*, 1991), from the root barks of *A. sesnticosus* (Fujikawa *et al.*, 1996), from the stem barks of *A. sesnticosus* (Nishibe *et al.*, 1990) and from the leaves of *A. trichodon* (Miyakoshi *et al.*, 1997b). Chlorogenic acid showed a significant inhibitory effect on gastric ulcer by 21.4% (Fujikawa *et al.*, 1996).

1,5-Di-*O*-caffeoylquinic acid [**22**] was isolated from the roots of *A. senticosus* (Slacanin *et al.*, 1991).



9 R_1: OH, R_2: OH, R_3: H, R_4: COOH

10 R_1: OH, R_2: OH, R_3: H, R_4: $COOCH_2CH_3$

11 R_1: OCH_3, R_2: O-Glc, R_3: H, R_4: CH_2OH

12 R_1: OCH_3, R_2: OH, R_3: H, R_4: CHO

13 R_1: OCH_3, R_2: O-Glc, R_3: H, R_4: CHO

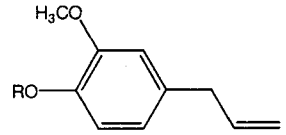
14 R_1: H, R_2: OH, R_3: H, R_4: COOH

15 R_1: H, R_2: OH, R_3: H, R_4: $COOCH_3$

16 R_1: OCH_3, R_2: O-Glc, R_3: OCH_3, R_4: CHO

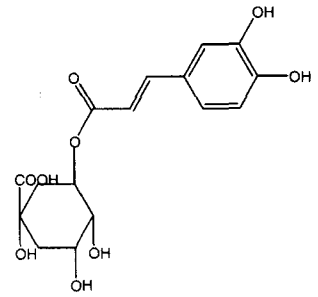
17 R_1: OCH_3, R_2: OH, R_3: OCH_3, R_4: CH_2OH

18 R_1: OCH_3, R_2: O-Glc, R_3: OCH_3, R_4: CH_2OH



19 R: Rha-Glc

20 R: Xyl-Glc



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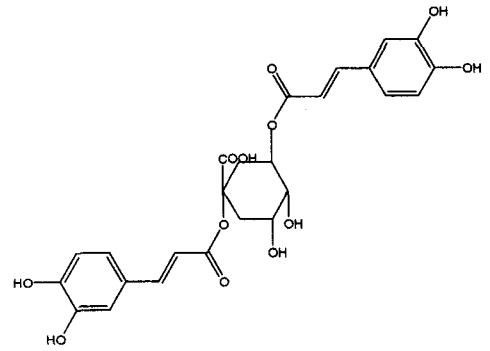

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Lignans – Acanthoside B [(+)-syringaresinol-*O*-β-D-glucoside, eleutheroside E_1] [**23**] was isolated from the root barks of *A. setchuenensis* (Zhao *et al.*, 1999) and from the

roots of *A. senticosus* (Li *et al.*, 2001).

Acanthoside D [(+)-syringaresinol-*O*-β-D-diglucoside, eleutheroside E] [**24**] was isolated from the stem barks of *A. senticosus* (Nishibe *et al.*, 1990), from the root cortex of *A. chiisanensis* (Kim and Hahn, 1981), from the fruits of *A. chiisanensis* (Shin *et al.*, 1992), from the root barks of *A. divaricatus* (Yook *et al.*, 1996), from the roots of *A. koreanum* (Hahn *et al.*, 1985; Kim *et al.*, 1985; Chung and Kim, 1986), from the root barks of *A. setchuenensis* (Zhao *et al.*, 1999), from the barks of *A. senticosus* forma *inermis* (Yook *et al.*, 1991), from the root barks of *A. senticosus* (Fujikawa *et al.*, 1996), from the roots and rhizomes of *A. senticosus* (Yat *et al.*, 1998) and from the roots of *A. sesnticosus* (Slacanin *et al.*, 1991; Li *et al.*, 2001). Acanthoside D isolated from the root barks of *A. koreanum* has been found to have *s*-GPT and *s*-GOT lowering effect, BSP-retention rate and survival rate in the toxic state through the bio-pharmacological experiments (Hahn *et al.*, 1985) were significantly increased. Among eleutherosides B_1, C and E in stress, eleutheroside E exhibited the most pronounced protective effect against stress (Brekhman and Dardymov, 1969). Acanthoside D isolated from the stem barks of *A. senticosus* had the pharmacological effect in chronic swimming stressed rats (Nishibe *et al.*, 1990). Acanthoside D from the root barks of *A. senticosus* showed a significant inhibition against gastric ulcer by 51.3% (Fujikawa *et al.*, 1996). Acanthoside D isolated from *A. senticosus* protected the animals from the stress-induced decreases in sex behaviors and in rectal temperature, from the stress-induced failure of retrieval of memory and from the stress-induced enlargement of adrenal gland (Nishiyama *et al.*, 1985). Acanthoside D also functioned to prevent the stress-induced decreases in spontaneous movements and to accelerate recovery from the decreases in grip tone, exploratory movement and spontaneous movement (Takasugi *et al.*, 1985).

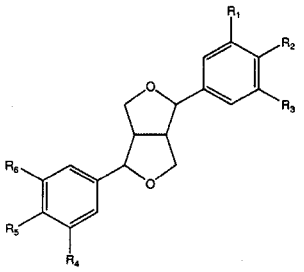
Eleutheroside E octaacetate [**25**] was isolated from *A. koreanum* (Chung and Kim, 1986).

Liriodendrin [**26**] was isolated from the cortex of *A. sessiliflorus* forma *chungbunensis*. Liriodendrin stimulated the incorporation of ^{14}C-leucine into mouse liver protein (Ro *et al.*, 1977).

(+)-Medioresinol-*O*-β-D-diglucoside [**27**], (+)-pinoresinol-*O*-β-D-glucoside [**28**] and (+)-pinoresinol-*O*-β-D-diglucoside [**29**] were isolated from the stem bark of *A. senticosus* (Nishibe *et al.*, 1990).

Syringaresinol [**30**] was isolated from the root barks of *A. setchuenensis* (Zhao *et al.*, 1999).

Sesamin (eleutheroside B_4) [**31**] was isolated from the roots and the stem barks of *A. chiisanensis* (Jang, 1970),



23 R_1: OCH_3, R_2: O-Glc, R_3: OCH_3, R_4: OCH_3, R_5: OH, R_6:OCH_3

24 R_1: OCH_3, R_2: O-Glc, R_3: OCH_3, R_4: OCH_3, R_5: O-Glc, R_6: OCH_3

25 R_1: OCH_3, R_2: O-Glc_{Ac}, R_3: OCH_3, R_4: OCH_3, R_5: O-Glc_{Ac}, R_6: OCH_3

26 R_1: OCH_3, R_2: O-Glc, R_3: OCH_3, R_4: OCH_3, R_5: O-Glc, R_6: OCH_3

27 R_1: OCH_3, R_2: O-Glc, R_3: OCH_3, R_4: H, R_5: O-Glc, R_6: OCH_3

28 R_1: OCH_3, R_2: O-Glc, R_3: H, R_4: H, R_5: OH, R_6: OCH_3

29 R_1: OCH_3, R_2: O-Glc, R_3: H, R_4: H, R_5: O-Glc, R_6: OCH_3

30 R_1: OCH_3, R_2: OH, R_3: OCH_3, R_4: OCH_3, R_5: OH, R_6: OCH_3

31 R_1,R_2: OCH_2O, R_3: H, R_4,R_5: OCH_2O, R_6: H

from the roots of *A. chiisanensis* (Lee *et al.*, 2002c), from the stem barks of *A. divaricatus* (Yook *et al.*, 1996), from the roots of *A. divaricatus* (Miyakoshi *et al.*, 1995; Yook *et al.*, 1996), from the root barks of *A. divaricatus* var. *albeofructus* (Oh *et al.*, 2000), from the fruits of *A. sessiliflorus* (Lee *et al.*, 2002b), from the root barks of *A. senticosus* (Bo *et al.*, 1998), from the barks of *A. senticosus* forma *inermis* (Yook *et al.*, 1991) and from the root barks of *A. sessiliflorum* (Yook *et al.*, 1977). Sesamin induced hypocholesterolemia especially low-density lipoproteins and cholesterol, which are risk factors for human atherosclerosis (Hirata *et al.*, 1996), showed 36% reduction in 7,12-dimethylbenz[a]anthracene-induced mammary cancer in female rats when measured at 12 weeks after uptake (Hirose *et al.*, 1992), decreased liver enlargement caused by excessive alcohol intake and increased the concentration of immunoglobulin G (Nonaka *et al.*, 1997), and improved impaired liver function in rodents caused by 1% EtOH or CCl_4 (100 mg/kg) (Akimoto *et al.*, 1993). Sesamin is one of the most abundant lignans in sesame seeds. The dietary sesamin-dependent decrease in lipogenic enzyme gene expression is due to the suppression of the gene expression of the sterol regulatory element binding protein-1 as well as the proteolysis of the membrane-bound precursor form of this transcriptional factor to generate the mature form (Ide *et al.*, 2001). The chronic ingestion of sesamin from sesame oil attenuated each of elevation in blood pressure, oxidative stress and thrombotic tendency, suggesting that these treatments might be beneficial in the prevention of hypertension and stroke (Noguchi *et al.*, 2001). Dietary sesamin significantly increased the

activities of hepatic mitochodrial and peroxisomal fatty acid oxidation enzymes such as mitochondrial carnitine acyltransferase, acyl-CoA dehydrogenase and peroxisomal acyl-CoA oxidase (Umeda-Sawada *et al.*, 2001). A consumption of sesamin rich in lignans resulted in physiological activity to alter lipid metabolism in a potentially beneficial manner (Sirato-Yasumoto *et al.*, 2001). Sesamin exhibited significant anti-feedant activity and moderate growth inhibition towards 4th instar larvae of *Spilarctia oblique* (Srivastava *et al.*, 2001). Sesamin suppressed the growth and induced apoptosis in the cells (Hibasami *et al.*, 2000).

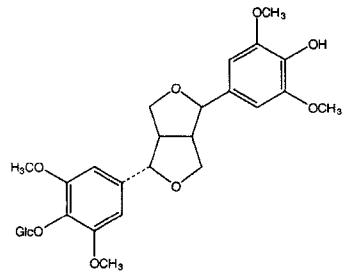
Eleutheroside E_2 [**32**] was isolated for the first time from the roots of *A. senticosus* (Li *et al.*, 2001).

Ariensin [**33**] was isolated from the root barks of *A. koreanum* (Chung and Kim, 1986; Kim *et al.*, 1988).

Helioxanthin [**34**] were isolated from the roots of *A. chiisanensis* (Lee *et al.*, 2002c) and from the roots of *A. divaricatus* (Miyakoshi *et al.*, 1995).

Taiwanin C [**35**] was isolated from the roots of *A. chiisanensis* (Lee *et al.*, 2002c). Taiwanin C from the roots of *A. chiisanensis* has anti-inflammatory activity (Ban *et al.*, 2002; Lee *et al.*, 2002c).

3-(3,4-Dimethoxybenzyl)-2-(3,4-methylenedioxybenzyl)



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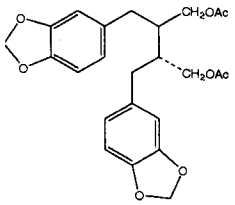

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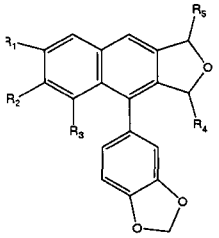
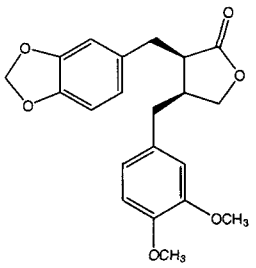


34 R_1: H, R_2,R_3: OCH_2O, R_4: H, R_5: =O

35 R_1,R_2: OCH_2O, R_3: H, R_4: =O, R_5: H



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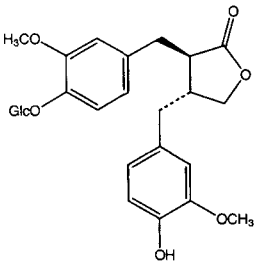

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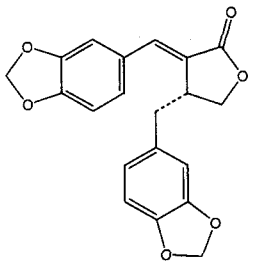

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butyrolactone [**36**] was isolated from the roots of *A. chiisanensis* (Lee *et al.*, 2002c).

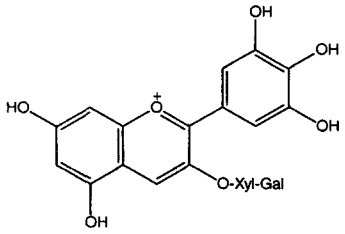
Matairesinoside [**37**] was isolated from the roots of *A. sieboldianus* (Miyakoshi *et al.*, 1995).

Savinin (taiwanin B) [**38**] was isolated from the roots of *A. chiisanensis* (Lee *et al.*, 2002c), from the root barks of *A. divaricatus* var. *albeofructus* (Oh *et al.*, 2000), from the fruits of *A. chiisanensis* (Shin *et al.*, 1992), from the root barks of *A. senticosus* (Bo *et al.*, 1998) and from the barks of *A. senticosus* forma *inermis* (Yook *et al.*, 1991). Savinin exhibited potent spermicidal and significant insecticidal activities (Nissanka *et al.*, 2001).

Flavonoids – Delphinidin 3-lathyroside (delphinidin 3-xylosylgalactoside) [**39**] was isolated from the fruits of *A. divaricatus* (Ishikura, 1975).

Afzelin (kaempferol 3-*O*-rhamnoside) [**40**] was isolated from the leaves of *A. sciadophylloides* (Kitajima *et al.*, 1989).

Antoside [**41**] was isolated from the leaves of *A. sciadophylloides* (Yasue *et al.*, 1968).



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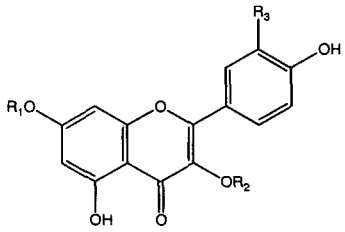


40 R_1: H, R_2: Rha, R_3: H

41 R_1: Rha, R_2: Glc, R_3: OH

42 R_1: Rha, R_2: Gal, R_3: H

43 R_1: H, R_2: Glc, R_3: OH

44 R_1: H, R_2: Gal, R_3: OH

45 R_1: Rha, R_2: Rha, R_3: OH

46 R_1: H, R_2: H, R_3: H

47 R_1: H, R_2: Glc-Rha, R_3: H

48 R_1: Rha, R_2: H, R_3: H

49 R_1: Rha, R_2: H, R_3: OH

50 R_1: Rha, R_2: Rha, R_3: OH

51 R_1: H, R_2: Rha, R_3: OH

52 R_1: H, R_2: Glc-Rha, R_3: OH

3-*O*-β-D-Galactopyranosyl-kaempferol 7-rhamnoside [**42**] was isolated from the leaves of *A. sciadophylloides* (Kitajima *et al.*, 1989).

Isoquercitrin (hirsutrin) [**43**] was isolated from the leaves of *A. sciadophylloides* (Yasue *et al.*, 1969; Kitajima *et al.*, 1989).

Hyperin [**44**] was isolated from the leaves of *A. divaricatus* (Matsumoto *et al.*, 1987; Shirasuna *et al.*, 1997), from the leaves of *A. divaricatus* forma *nambunensis* (Cho *et al.*, 1999) and for the first time from the fruits of *A. sessiliflorus* (Lee *et al.*, 2002b). Hyperin had no significant effects on the resting Ca^{2+}, markedly inhibited the increase of Ca^{2+} evoked by K^+ in a concentration-dependent manner and inhibited the increase of Ca^{2+} induced by norepinephrine. Also hyperin markedly attenuated 5-hydroxytryptamine and L-glutamic acid-induced increase of Ca^{2+}. As a result, hyperin possessed an inhibitory effect on influx of Ca^{2+} in the neonatal rat brain cells (Chen and Ma, 1999).

Kaempferitrin (lespedin) [**45**] was isolated from the leaves of *A. sciadophylloides* (Yasue *et al.*, 1968; Kitajima *et al.*, 1989), from the leaves of *A. senticosus* var. *subinermis* (Chang, 1990), and from the leaves of *A. sessiliflorum* (Kim, 1985).

Kaempferol [**46**] was isolated from the leaves of *A. sciadophylloides* (Kitajima *et al.*, 1989).

Kaempferol 3-*O*-rutinoside [**47**] was isolated from the leaves of *A. sieboldianus* (Sawada *et al.*, 1993).

Kaempferol 7-*O*-rhamnoside [**48**] was isolated from the leaves of *A. sciadophylloides* (Yasue *et al.*, 1969; Kitajima *et al.*, 1989; Sawada *et al.*, 1993).

Quercetin 7-*O*-rhamnoside (vincetoxicoside B) [**49**] was isolated from the leaves of *A. sciadophylloides* (Yasue *et al.*, 1969).

Quercetin 3,7-*O-bis*-α-L-rhamnopyranoside [**50**] was isolated from the leaves of *A. sciadophylloides* (Kitajima *et al.*, 1989).

Quercitrin [**51**] was isolated from the leaves of *A. divaricatus* (Shirasuna *et al.*, 1997).

Rutin [**52**] was isolated from the leaves of *A. koreanum* (Chung and Hahn, 1991).

Hesperidin [**53**] was isolated from the root barks of *A. setchuenensis* (Zhao *et al.*, 1999).

Sesquiterpenoids – β-Caryophyllene [**54**] was isolated from the leaves of *A. sciadophylloides* (Kitajima *et al.*, 1989). It markedly inhibited the growth of tested Gram-(+) and Gram-(−) bacteria except for *Pseudomonas aeruginosa* (Haznedaroglu *et al.*, 2001).

Farnesol [**55**] was isolated from the roots of *A. divaricatus* (Miyakoshi *et al.*, 1995).

β-Farnesene [**56**] was isolated from the leaves of *A. sciadophylloides* (Kitajima *et al.*, 1989).

Diterpenoids – Phytol [**57**] was isolated from the leaves of *A. sciadophylloides* (Kitajima *et al.*, 1989).

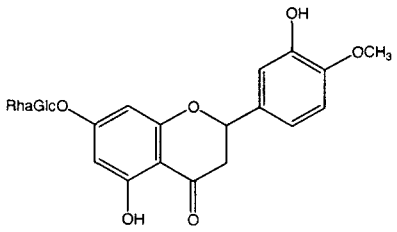
Acanthoic acid [(-)-pimara-9(11),15-dien-19-oic acid] [**58**] was isolated from the root barks of *A. koreanum* (Yook *et al.*, 1996; Kang *et al.*, 1996; Kim and Chung, 1988). Acanthoic acid has a potent anti-inflammatory and anti-fibrosis effect by reducing IL-1 and TNF-α production (Kang *et al.*, 1996).

(−)-Pimara-9(11),15-dien-19-ol [**59**] and *iso*-pimara-9(11), 15-dien-19-ol [**60**] were isolated for the first time from the root barks of *A. koreanum*. (−)-Pimara-9(11),15-dien-19-ol 19-acetate [**61**] and (-)-pimara-9(11),15-diene [**62**] were isolated from the root barks of *A. koreanum* (Kim and Chung, 1988).

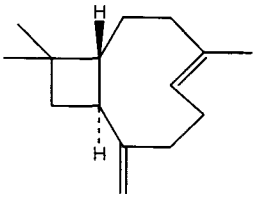
Sumogaside [**63**] was isolated from the root barks of *A. koreanum* (Kim *et al.*, 1990)

ent-Kaur-16-en-19-oic acid [**64**] was isolated from the root barks of *A. koreanum* (Kim and Chung, 1988) and from the leaves of *A. trichodon* (Miyakoshi *et al.*, 1997b).

ent-16β,17-Dihydroxy-(−)-kauran-19-oic acid [**65**] was isolated from the root barks of *A. koreanum* (Kim and



53



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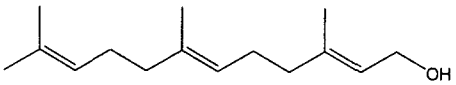

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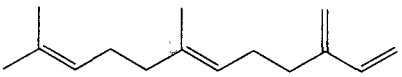

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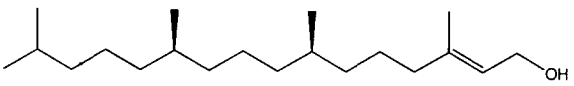

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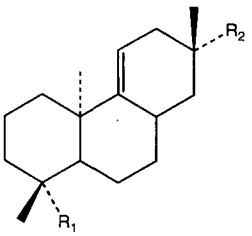


58 R_1: COOH, R_2: $CHCH_2$

59 R_1: CH_2OH, R_2: $CHCH_2$

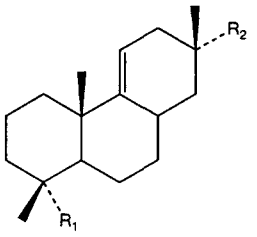
61 R_1: CH_2OAc, R_2: $CHCH_2$

62 R_1: CH_3, R_2: $CHCH_2$

63 R_1: COO-Glc, R_2: $CHOHCH_2OH$

Chung, 1988)

ent-16b,17-*iso*-Valerate-kauran-19-oic acid [**66**] and *ent*-16βH,17-methyl butanoate-kauran-19-oic acid [**67**] were isolated for the first time from the stem bark of *A. koreanum* (Kim *et al.*, 1995).



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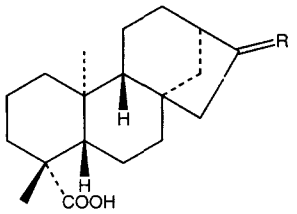
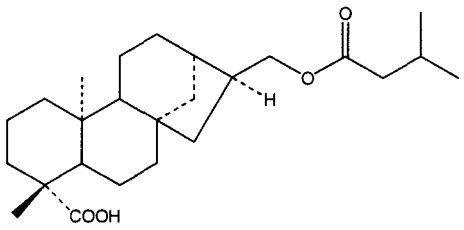


64 R: O

65 R: α-OH, β-CH_2OH



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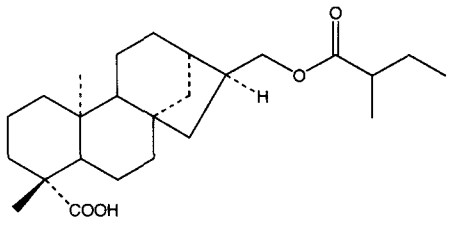


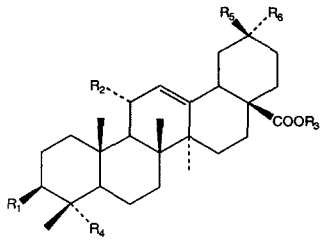
67

Oleane triterpenoids – Ciwujianoside D_1 [**68**] was isolated from the aerial parts of *A. senticosus* (Umeyama *et al.*, 1992). It strongly inhibited histamine release in a concentration-dependent manner in rat peritoneal mast cells induced by anti-immunoglobulin E (Umeyama *et al.*, 1992).

Eleutherosides I [**69**], K [**70**], L [**71**] and M (hederasaponin B) [**72**] were isolated from *A. senticosus* (Wagner and Wurmböck, 1977). Hederasaponin B [eleutheroside M] showed antileishmanicidic effect but could not be confirmed (Majester-Savornin *et al.*, 1991).

Hederagenin [**73**] was isolated from leaves of *A. hypoleucus* (Kohda *et al.*, 1990).

Hypoleucosides A [**74**] and B [**75**] were isolated for the first time from the leaves of *A. hypoleucus* (Kohda *et al.*, 1990).



68 R_1: O-Ara, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_3, R_5: CH_3, R_6: CH_3

69 R_1: O-Rha(1→4)-Ara, R_2: H, R_3: H, R_4: CH_3, R_5: CH_3, R_6: CH_3

70 R_1: O-Rha(1→2)-Ara, R_2: H, R_3: H, R_4: CH_3, R_5: CH_3, R_6: CH_3

71 R_1: O-Rha(1→4)-Ara, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_3, R_5: CH_3, R_6: CH_3

72 R_1: O-Rha(1→2)-Ara, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_3, R_5: CH_3, R_6: CH_3

73 R_1: H, R_2: H, R_3: H, R_4: CH_2OH, R_5: CH_3, R_6: CH_3

74 R_1: O-Glc, R_2: OCH_3, R_3: Glc, R_4: CH_3, R_5: CH_3, R_6: CH_3

75 R_1: O-Glc-Ara-Glc, R_2: H, R_3: Glc-Glc, R_4: CH_3, R_5: CH_3, R_6: CH_3

76 R_1: =O, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_2OH, R_5: CH_3, R_6: CH_3

77 R_1: β-O-Glc, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_3, R_5: CH_3, R_6: CH_3

78 R_1: β-O-Glc, R_2: H, R_3: Glc-Glc-Rha, R_4: CHO, R_5: CH_3, R_6: CH_3

79 R_1: β-OH, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_2OH, R_5: CH_3, R_6: CH_2OH

80 R_1: β-OH, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_2OH, R_5: CH_3, R_6: OH

81 R_1: β-OH, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_2OH, R_5: CH_3, R_6: CH_3

82 R_1: O-Ara-Rha, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_2OH, R_5: CH_3, R_6: CH_3

83 R_1: O-Ara-Rha, R_2: H, R_3: H, R_4: CH_2OH, R_5: CH_3, R_6: CH_3

84 R_1: O-Ara-Rha-Ara, R_2: H, R_3: H, R_4: CH_2OH, R_5: CH_3, R_6: CH_3

85 R_1: O-Ara-Rha-Xyl, R_2: H, R_3: H, R_4: CH_2OH, R_5: CH_3, R_6: CH_3

86 R_1: O-Ara-Rha-Xyl, R_2: H, R_3: H, R_4: CH_3, R_5: CH_3, R_6: CH_3

87 R_1: O-Ara-Rha-Xyl, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_2OH, R_5: CH_3, R_6: CH_3

88 R_1: O-Ara-Rha-Xyl, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_3, R_5: CH_3, R_6: CH_3

89 R_1: OH, R_2: H, R_3: H, R_4: CH_3, R_5: CH_3, R_6: CH_3

90 R_1: OH, R_2: H, R_3: Glc-Glc-Rha, R_4: CHO, R_5: CH_3, R_6: OH

91 R_1: O-Ara-Glc, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_3, R_5: CH_3, R_6: CH_3

92 R_1: O-Ara-Rha, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_3, R_5: CH_3, R_6: CH_2OH

93 R_1: O-Ara, R_2: H, R_3: Glc-Glc_{Ac}-Rha, R_4: CH_3, R_5: CH_3, R_6: CH_2OH

94 R_1: O-Ara-Glc, R_2: H, R_3: Glc-Glc_{Ac}-Rha, R_4: CH_3, R_5: CH_3, R_6: CH_2OH

95 R_1: O-Ara, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_3, R_5: CH_3, R_6: CH_3

96 R_1: O-Ara-Rha, R_2: H, R_3: Glc-Glc_{Ac}-Rha, R_4: CH_3, R_5: CH_3, R_6: CH_3

97 R_1: O-Ara, R_2: H, R_3: Glc-Glc_{Ac}-Rha, R_4: CH_3, R_5: CH_3, R_6: CH_3

Nipponosides A [**76**], B [**77**], C [**78**], D [**79**] and E [**80**] were isolated for the first time from the leaves of *A. nipponicus* (Miyakoshi *et al.*, 1999). Niponoside E was isolated from the leaves of *A. japonicus* (Park *et al.*, 2002).

Kalopanax saponin G [**81**] was isolated from the leaves of *A. nipponicus* (Miyakoshi *et al.*, 1999).

Kalopanax saponins A [**82**], B [**83**], saponin A [**84**], sapindoside B [**85**] and CP_3 [**86**] were isolated from the leaves of *A. sieboldianus* (Sawada *et al.*, 1993).

Sieboldianosides A [**87**] and B [**88**] were isolated for the first time from the leaves of *A. sieboldianus* (Sawada *et al.*, 1993).

Oleanolic acid [**89**] was isolated from the barks of *A. senticosus* forma *inermis* (Yook *et al.*, 1991), and from *A. divaricatus* (Yook *et al.*, 1996; Kohda *et al.*, 1990; Bladt *et al.*, 1990). This compound from *Fabiana patagonica* showed diuretic activity (Alvarez *et al.*, 2002).

Acanjaposide C [**90**] was isolated for the first time from the leaves of *A. japonicus* (Park *et al.*, 2002).

Ciwujianosides A_1 [**91**], A_3 [**92**], D_3 [**93**] and A_4 [**94**] were isolated for the first time from the leaves of *A. senticosus* (Shao *et al.*, 1989). Ciwujianosides C_3 [**95**], C_4 [**96**] and D_1 [**97**] were isolated for the first time from the leaves of *A. senticosus* (Shao *et al.*, 1988).

Spinosides D_1 [**98**], D_2 [**99**], D_3 [**100**] C_1 [**101**], C_4 [**102**] and C_5 [**103**] were isolated for the first time from the leaves of *A. spinosus* (Miyakoshi *et al.*, 1993a; Miyakoshi *et al.*, 1993b). Spinosides C_2 [**104**], C_3 [**105**], C_6 [**106**] and C_7 [**107**] were isolated from the leaves of *A. spinosus* (Miyakoshi *et al.*, 1997a).

Ciwujianoside C_1 [**108**] was isolated from the aerial parts of *A. senticosus* (Umeyama *et al.*, 1992). It strongly inhibited histamine release in a concentration-dependent manner in rat peritoneal mast cells induced by anti-immunoglobulin E (Umeyama *et al.*, 1992).

Acanjaposides A [**109**] and B [**110**] were isolated for the first time from the leaves of *A. japonicus* (Park *et al.*, 2002).

Ciwujianoside A_2 [**111**] was isolated for the first time from the leaves of *A. senticosus* (Shao *et al.*, 1989). Ciwujianosides B [**112**], C_1 [**113**], C_2 [**114**], D_2 [**115**] and E [**116**] were isolated for the first time from the leaves of *A. senticosus* (Shao *et al.*, 1988).

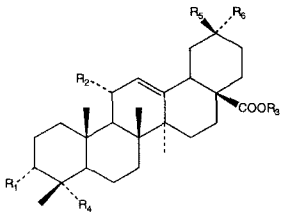
3b-{*O*-β-D-Glucopyranosyl-(1→3)-*O*-β-D-galactopyranosyl-(1→4)-[*O*-α-L-rhamnopyranosyl-(1→2)]-*O*-β-D-glucuronopyranosyl}-16α-hydroxy-13β,28-epoxyoleanane [**117**] and 3β-{*O*-α-L-rhamnopyranosyl-(1→4)-*O*-α-L-rhamnopyranosyl-(1→4)-[*O*-α-L-rhamnopyranosyl-(1→2)]-*O*-b-D-glucopyranosyl-(1→x)-*O*-β-D-glucuronopyranosyl}-16α-hydroxy-13β,28-epoxyoleanane [**118**] were isolated for the first time from the roots of *A. senticosus* (Segiet-Kujawa and Kaloga, 1991).

Taraxane triterpenoids – Taraxerol [**119**] was isolated from the leaves of *A. sciadophylloides* (Yasue *et al.*, 1969; Kitajima *et al.*, 1989; Yasue *et al.*, 1970; Chen *et al.*, 1972a).

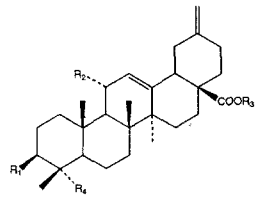
Taraxeryl acetate [**120**] was isolated from the leaves of *A. sciadophylloides* (Chen *et al.*, 1972a).

Ursane triterpenoids – Bauerenyl acetate [**121**] was isolated from the leaves of *A. trichodon* (Miyakoshi *et al.*, 1997b).

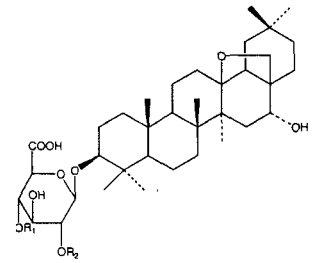
Ursolic acid (UA) [**122**] was isolated from the fruits of *A. sessiliflorus* (Lee *et al.*, 2002b). There have been no previous reports of an ursane triterpenoid from *Acanthopanax* species. To our knowledge, this is the first report of an ursane triterpenoid from *Acanthopanax* species. UA showed anti-



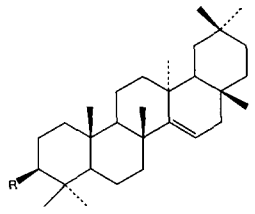
98 R_1: OH, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_3, R_5: CH_3, R_6: COOH
99 R_1: OH, R_2: H, R_3: Glc-Glc-Rha, R_4: CHO, R_5: CH_3, R_6: COOH
100 R_1: OH, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_2OH, R_5: CH_3, R_6: COOH
101 R_1: OH, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_3, R_5: CH_3, R_6: CH_2OH
102 R_1: OH, R_2: H, R_3: Glc-Glc-Rha, R_4: CHO, R_5: CH_3, R_6: CH_2OH
103 R_1: OH, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_2OH, R_5: CH_3, R_6: CH_2OH
104 R_1: OH, R_2: H, R_3: Rha-Glc-Glc, R_4: CHO, R_5: CH_2OH, R_6: CH_3
105 R_1: OH, R_2: H, R_3: Rha-Glc-Glc, R_4: CH_3, R_5: CH_3 R_6: OH
106 R_1: OH, R_2: H, R_3: Rha-Glc-Glc, R_4: CH_2OH, R_5: CH_3, R_6: OH
107 R_1: OH, R_2: H, R_3: Rha-Glc-Glc, R_4: CHO, R_5: CH_3, R_6: OH



108 R_1: O-Ara, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_3
109 R_1: OH, R_2: H, R_3: Glc-Glc-Rha, R_4: COOH
110 R_1: OH, R_2: H, R_3: Glc-Glc-Rha, R_4: CHO
111 R_1: O-Ara-Glc, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_3
112 R_1: O-Ara-Rha, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_3
113 R_1: O-Ara, R_2: H, R_3: Glc-Glc-Rha, R_4: CH_3
114 R_1: O-Ara-Rha, R_2: H, R_3: Glc-Glc$_{Ac}$-Rha, R_4: CH_3
115 R_1: O-Ara, R_2: H, R_3: Glc-Glc$_{Ac}$-Rha, R_4: CH_3
116 R_1: O-Ara-Rha, R_2: H, R_3: H, R_4: CH_3

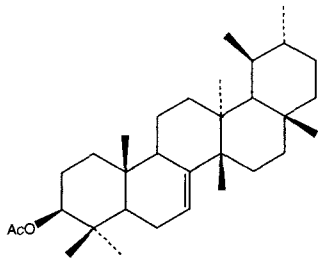


117 R_1: *O*-β-D-Glc-(1→3)-β-D-Gal, R_2: α-L-Rha
118 R_1: *O*-α-L-Rha-(1→4)-*O*-α-L-Rha-(1→4)-[*O*-α-L-Rha-(1→2)]-β-D-Glc, R_2: H



119 R: OH
120 R: OAc

tumor effects and chemopreventive properties in normal cells (Novotný *et al.*, 2001) and changes in tumor growth,



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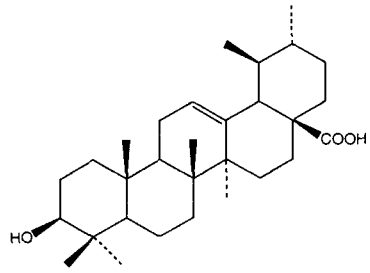


122

O_2 consumption, and tumor interstitial fluid pressure (Lee *et al.*, 2001). UA stimulates NO and TNF-α release and is able to up regulate iNOS and TNF-α expression through NF-κB transactivation in the resting macrophages (You *et al.*, 2001). The treatment of UA from *Origanum majorana* L. inhibited the Abeta-induced neurotoxic effect (Heo *et al.*, 2002).

Lupane triterpenoids – Acantrifoside A [**123**] was isolated for the first time from the leaves of *A. koreanum* (Chung and Hahn, 1991) and from the leaves of *A. trifoliatus* and *A. koreanum* (Yook *et al.*, 1998).

Acankoreosides A [**124**], B [**125**], C [**126**] and D [**127**] were isolated from the leaves of *A. koreanum* (Chang *et al.*, 1998; Chang *et al.*, 1999).

3α,11α-Dihydroxylup-20(29)-en-28-oic acid (impressic acid) [**128**], 3α,11α,23-trihydroxylup-20(29)-en-28-oic acid [**129**] and 3α,11α-dihydroxy-23-oxo-lup-20(29)-en-28-oic acid [**130**] were isolated for the first time from the leaves of *A. trifoliatus* (Ty *et al.*, 1984a; Ty *et al.*, 1984b).

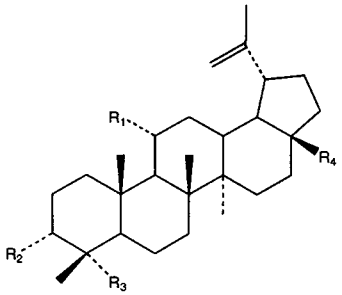
Acanthodiol [**131**] was isolated from the leaves of *A. koreanum* (Chung and Hahn, 1991; Kim, 1988).

Acanthodiol glycoside [**132**] was isolated from the leaves of *A. koreanum* (Chung and Hahn, 1991) and from the leaves of *A. trifoliatus* forma *tristigmatis* (Yook *et al.*, 1999).

Methyl betulin [**133**] was isolated from the fruits of *A. chiisanensis* (Shin *et al.*, 1992).

Protochiisanoside [**134**] was isolated from the leaves of *A. divaricatus* (Shirasuna *et al.*, 1997).

24-*nor*-3α,11α-Dihydroxylup-20(29)-en-28-oic acid [**135**] was isolated for the first time from the leaves of *A.*



123 R_1: OH, R_2: OH, R_3: CH_3, R_4: COO-Glc-Glc-Rha

124 R_1: H, R_2: OH, R_3: COOH, R_4: COO-Glc-Glc-Rha

125 R_1: OH, R_2: OH, R_3: CH_2OH, R_4: COO-Glc-Glc-Rha

126 R_1: OH, R_2: O-Glc, R_3: CH_3, R_4: COO-Glc-Glc-Rha

127 R_1: OH, R_2: OH, R_3: CHO, R_4: COO-Glc-Glc-Rha

128 R_1: OH, R_2: OH, R_3: CH_3, R_4: COOH

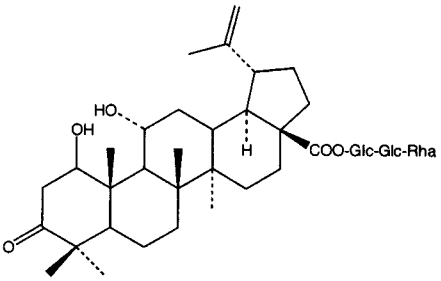
129 R_1: OH, R_2: OH, R_3: CH_2OH, R_4: COOH

130 R_1: OH, R_2: OH, R_3: CHO, R_4: COOH

131 R_1: OH, R_2: β-OH, R_3: CH_3, R_4: COOH

132 R_1: OH, R_2: β-OH, R_3: CH_3, R_4: COO-Glc-Glc-Rha

133 R_1: H, R_2: β-OCH_3, R_3: CH_3, R_4: CH_2OH



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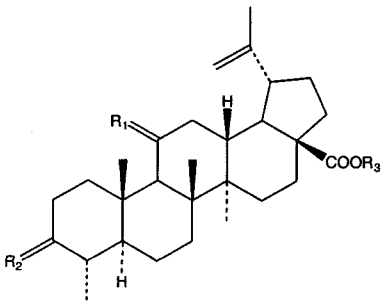
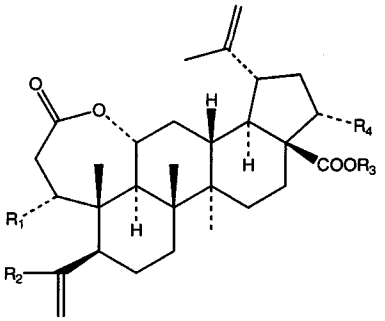


135 R_1: α-OH, β-H, R_2: α-OH, β-H, R_3: H

136 R_1: α-OH, β-H, R_2: O, R_3: H

trifoliatus (Lischewski *et al.*, 1985; Kutschabsky *et al.*, 1985). 24-*nor*-11α-Hydroxy-3-oxo-lup-20(29)-en-28-oic acid [**136**] was isolated for the first time from the leaves of *A. trifoliatus* (Lischewski *et al.*, 1985).

Seco-lupane triterpenoids – Chiisanogenin [**137**] was isolated from the root barks of *A. divaricatus* var. *albeofrutus*



137 R_1: OH, R_2: CH_3, R_3: H, R_4: H

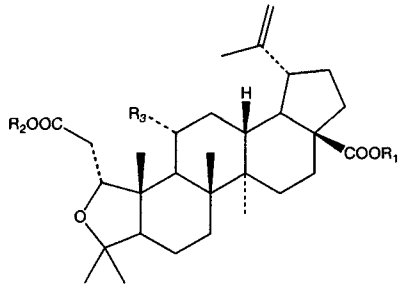
138 R_1: OH, R_2: CH_3, R_3: Glc-Glc-Rha, R_4: H

139 R_1: H, R_2: CH_3, R_3: Glc-Glc-Rha, R_4: H

141 R_1: OH, R_2: CH_2OH, R_3: Glc-Glc-Rha, R_4: H

143 R_1: OH, R_2: CH_3, R_3: Glc-Glc-Rha, R_4: OH

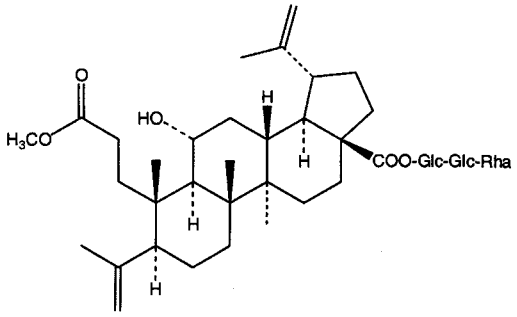
144 R_1: OH, R_2: CH_3, R_3: Glc-Glc, R_4: H



140 R_1: Glc-Glc-Rha, R_2: H, R_3: H

145 R_1: Glc-Glc-Rha, R_2: H, R_3: OH

146 R_1: Glc-Glc-Rha, R_2: CH_3, R_3: OH



142

(Oh *et al.*, 2000).

Chiisanoside [**138**] was isolated for the first time from the leaves of *A. chiisanensis* (Kim and Hahn, 1980). Chiisanoside was isolated from the barks of *A. senticosus* forma *inermis* (Yook *et al.*, 1991), from the leaves of *A. senticosus* forma *inermis* (Park *et al.*, 2000b), from the leaves and stem barks of *A. chiisanensis* (Hahn *et al.*, 1984; Kasai *et al.*, 1986), from the fruits of *A. chiisanensis* (Shin *et al.*, 1992), from the leaves of *A. divaricatus* (Matsumoto *et al.*, 1987; Yook *et al.*, 1996; Shirasuna *et al.*, 1997), from the root barks of *A.*

divaricatus var. *albeofrutus* (Oh *et al.*, 2000) and from the leaves of *A. divaricatus* forma *nambunensis* (Cho *et al.*, 1999). Chiisanoside exhibited non-toxic effects and significant anti-histaminic activities. It was found that it showed the anti-diabetic activities against epinephrine- and alloxan-induced diabetes, decreased the toxicities by ephedrine hydrochloride and promoted the elimination of chloramphenicol from blood. It also increased the survival rate in rats intoxicated by carbon tetrachloride and led to the re-establishment of normal enzymatic function. In the histopathological studies, it improved fatty degeneration and parenchymal cell necrosis of the liver induced by carbon tetrachloride in rats (Kim and Hahn, 1980). An anti-cancer activity and an anti-nephrotoxicity were tested by MTT assay. An anti-cancer effect of chiisanoside from *A. divaricatus* was much lower than that of cisplatin (Yook *et al.*, 1996). Chiisanoside decrease the clearance rate of carbon (Lee *et al.*, 1987).

1-Deoxychiisanoside [**139**], 11-deoxyisochiisanoside [**140**], 24-hydroxychiisanoside [**141**] and inermoside [**142**] were isolated for the first time from the leaves of *A. senticosus* forma *inermis* (Park *et al.*, 2000a). 22a-Hydroxychiisanoside [**143**] was isolated from the leaves of *A. divaricatus* (Shirasuna *et al.*, 1997) and the leaves of *A. senticosus* forma *inermis* (Park *et al.*, 2000b).

Divaroside [**144**] was isolated from the leaves of *A. divaricatus* (Matsumoto *et al.*, 1987) and the leaves of *A. senticosus* forma *inermis* (Park *et al.*, 2000b).

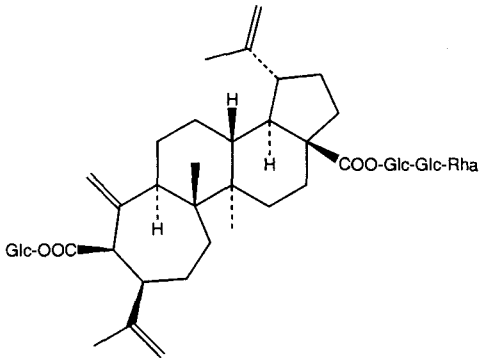
iso-Chiisanoside [**145**] was isolated from the leaves and stem barks of *A. chiisanensis* (Kasai *et al.*, 1986), from the leaves of *A. senticosus* forma *inermis* (Park *et al.*, 2000b) and from the leaves of *A. divaricatus* (Matsumoto *et al.*, 1987; Shirasuna *et al.*, 1997).

iso-Chiisanoside methylester [**146**] was isolated from the leaves and stem barks of *A. divaricatus* (Kasai *et al.*, 1986) and the leaves of *A. senticosus* forma *inermis* (Park *et al.*, 2000b).

Sachunoside [**147**] was isolated from the leaves of *A. divaricatus* var. *sachunensis* (Park *et al.*, 2001).

Phytosterols – Campesterol [**148**] was isolated from the root barks of *A. divaricatus* (Yook *et al.*, 1996) and the root barks of *A. sessiliflorus* (Yook *et al.*, 1977).

β-Sitosterol [**149**] was isolated from the barks of *A. senticosus* forma *inermis* (Yook *et al.*, 1991), from the root barks of *A. divaricatus* (Yook *et al.*, 1996), from the root barks of *A. sessiliflorus* (Yook *et al.*, 1977), from the leaves of *A. trifoliatus* (Chen *et al.*, 1972a; Chen *et al.*, 1972b; Chen *et al.*, 1973) and from the root barks of *A. setchuenensis* (Zhao *et al.*, 1999). β-Sitosterol inhibited growth of human colon cancer (ht-29) by activating sphingomyelin cycle (Awad *et al.*, 1998), showed anti-inflammatory and anti-



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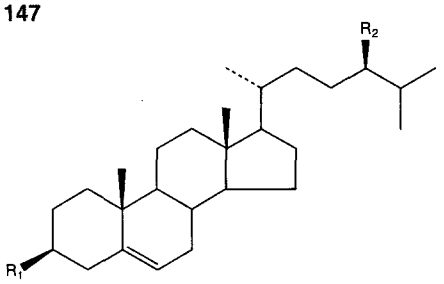
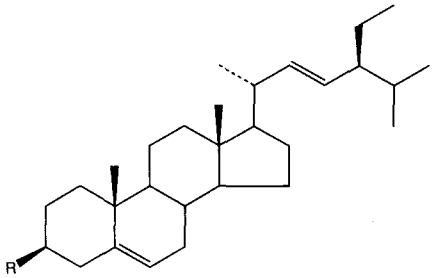


148 R_1: OH, R_2: CH_3

149 R_1: OH, R_2: CH_2CH_3

150 R_1: O-Glc, R_2: CH_2CH_3



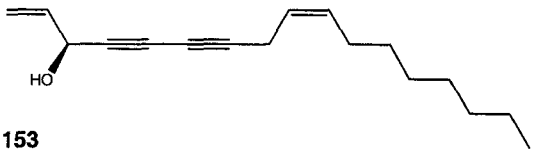
151 R: OH

152 R: O-Glc

pyretic effect (Gupta *et al.*, 1980), reduced dietary cholesterol absorption in humans (Heinemann *et al.*, 1993) and reduced levels of insulin (Ivorra *et al.*, 1988).

Daucosterol (β-sitosterol glucoside, eleutheroside A) [**150**] was isolated from the leaves of *A. trifoliatus* (Chen *et al.*, 1972b; Chen *et al.*, 1973) and from the root barks of *A. setchuenensis* (Zhao *et al.*, 1999). Daucosterol decreased vascular permeability and showed hemostatic effect (Sugiyama and Seki, 1991).

Stigmasterol [**151**] was isolated from the root barks of *A. divaricatus* (Yook *et al.*, 1996), from the root barks of *A. sessiliflorus* (Kim, 1985; Yook *et al.*, 1977), from the leaves of *A. trifoliatus* (Chen *et al.*, 1972b; Chen *et al.*, 1973) and from the barks of *A. senticosus* forma *inermis* (Yook *et al.*, 1991).



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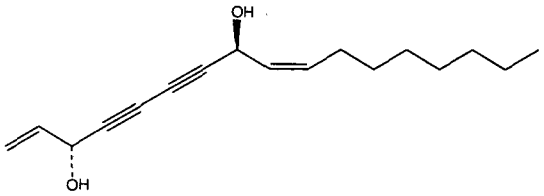

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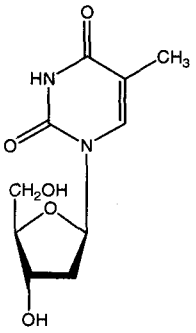

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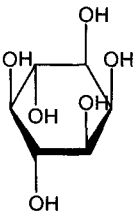


156

Stigmasterol glucoside [**152**] was isolated from the leaves of *A. trifoliatus* (Chen *et al.*, 1972b; Chen *et al.*, 1973).

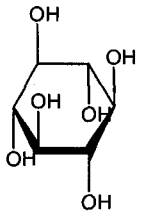
Polyacetylenes – Falcarinol [**153**] and falcarindiol [**154**] were isolated from the root barks of *A. koreanum* (Kim *et al.*, 1988) and from the roots of *A. divaricatus* (Miyakoshi *et al.*, 1995). Falcarindiol was isolated from the root barks of *A. koreanum* (Chung and Kim, 1986).

A pyrimidine – Thymidine [**155**] was isolated from the roots of *A. senticosus* (Li *et al.*, 2001).

Cyclitols – Myo-inositol [**156**] and scyllo-inositol [**157**] were isolated from the leaves of *A. sciadophylloides* (Yasue *et al.*, 1968) and from the leaves of *A. trifoliatus* (Chung *et al.*, 1972a).

Monosaccharides – Isomaltol 3-*O*-α-glucoside [**158**] was isolated for the first time from the roots of *A. senticosus* (Li *et al.*, 2001).

Eleutheroside C [**159**] was isolated from the roots of *A. senticosus* (Brekhman and Dardymov, 1969).



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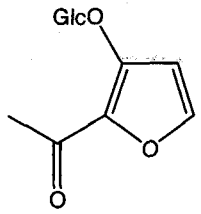

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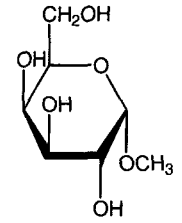

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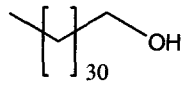

160

An aliphatic alcohol – 1-Dotriacontanol [**160**] was isolated from the leaves of *A. sciadophylloides* (Kitajima *et al.*, 1989).

References

Ahn, J. S., Kwon, Y. S. and Kim, C. M., Anti-inflammatory constituents of *Polygonum bistorta*. *Kor. J. Pharmacogn.* **30**, 345-349 (1999).

Akimoto, K., Kitagawa, Y., Akamatsu, T., Hirose, N., Sugano, M., Shimazu, S. and Yamada, H., Protective effect of sesamin against liver damage caused by alcohol or carbon tetrachloride in rodents. *Ann. Nutr. Metabol.* **37**, 218-224 (1993).

Alvarez, M. A., María, A. O. M. and Saad, J. R., Diuretic activity of *Fabiana patagonica* in rats. *Phytother. Res.* **16**, 71-73 (2002).

Awad, A. B., Von Holtz, R., Cone, J. P., Fink, C. S. and Chen, Y. C., β-Sitosterol inhibits growth of HT-29 human cancer cells by activating the sphingomyelin cyclA. *Anticancer Res.* **18**, 471-479 (1998).

Aziz, N. H., Farag, S. A., Mousa, L. A. and Abo-Zaid, M. A., Comparative anti-bacterial and anti-fungal effects of some phenolic compounds. *Microbios* **93**, 43-54 (1998).

Ban, H. S., Lee, S. Kim, Y. P., Yamaki, K., Shin, K. H. and

Ohuchi, K., Inhibition of prostaglandin E_2 production by taiwanin C isolated from the root of *Acanthopanax chiisanensis* and the mechanism of action. *Biochem. Pharmacol.* **64**, 1345-1354 (2002).

Bladt, S., Wagner, H., Woo, W. S. and Taiga-Wurzel., DC- und HPLC-Analyse von *Eleutherococcus*- bzw. *Acanthopanax*-Extrkten und diese enthaltenden Phytopräparaten. *DAZ* **130**, 1499-1508 (1990).

Bo, F., Matsumaru, Y., Okada, Y., Qin, M., Xu, J-D. and Okuyama, T., Studies on constituents of *Acanthopanax senticosus* in China. *Nat. Med.* **52**, 287 (1998).

Borris, R. P., Cordell, G. A. and Farnsworth, N. R., Isofraxidin, a cytotoxic coumarin from *Micrandra elata* (Euphorbiaceae). *J. Nat. Prod.* **43**, 641-643 (1980).

Brekhman, I. I. and Dardymov, I. V., Pharmacological investigation of glycosides from *Ginseng* and *Eleutherococcus*. *J. Nat. Prod.* **32**, 46-51 (1969).

Chan, W. S., Wen, P. C. and Chiang, H. C., Structure-activity relationship of caffeic acid analogues on xanthine oxidase inhibition. *Anticancer Res.* **15**, 703-707 (1995).

Chang, S. Y., Yook, C. S. and Nohara, T., Lupane-triterpene glycosides from leaves of *Acanthopanax koreanum*. *Phytochemistry* **50**, 1369-1374 (1999).

Chang, S. Y., Yook, C. S. and Nohara, T., Two new lupane-triterpene glycosides from leaves of *Acanthopanax koreanum*. *Chem. Pharm. Bull.* **46**, 163-165 (1998).

Chen, F. C., Lin, Y. M. and Lin, S., Constituents of three-leaved *Acanthopanax*. *Phytochemistry* **11**, 1496-1497 (1972a).

Chen, F. C., Lin, Y. M. and Yu, P. L., Constituents of *Acanthopanax trifoliatus*. *J. Am. Chem. Soc.* **94**, 4367 (1972b).

Chen, F. C., Lin, Y. M. and Yu, P. L., Constituents of *Acanthopanax trifoliatus*. *Phytochemistry* **12**, 467 (1973).

Chen, Z. W. and Ma, C. G., Effects of hyperin on free intracellular calcium in dissociated neonatal rat brain cells. *Acta Pharmac. Sin.* **20**, 27-30 (1999).

Cho, H. K., Ham, I. and Whang, W. K., Constituents and quantitative analysis from the leaves of *Acanthopanax divaricatus* forma *nambunensis*. *Yakhak Hoeji* **43**, 294-299 (1999).

Cho, H. R., Choi, D. H., Ko, B. K., Nam, C. W., Park, K. M., Lee, Y. J., Lee, S. G., Lee, J. S., Lee, K. A., Lee, A. A., Ju, S. A. and Kim, B. S., Cold preservation of rat cultured hepatocytes: the scoparone effect. *Transplantation Proceedings* **32**, 2325-2327 (2000).

Chung, B. S. and Kim, Y. H., Studies on the constituents of *Acanthopanax koreanum*. *Kor. J. Pharmacogn.* **17**, 62-66 (1986).

Chung, J. Y. and Hahn, D. R., Constituents of *Acanthopanax koreanum* leaves. *Yakhak Hoeji* **35**, 240-244 (1991).

Danielak, R., Popowska, A. and Borkowski, B., The preparation of vegetable products containing isofraxidin, silibin and Glaucium alkaloids and evaluation of their choleretic action. *Polish J. Pharmacol. Pharm.* **25**, 271-283 (1973).

Deliorman, D., Caliş, I., Ergun, F., Doğăn, B. S., Buharalioglu, C. K. and Kanzik, I., Studies on the vascular effects of the fractions and phenolic compounds isolated from *Viscum album* ssp. *album*. *J. Ethnopharmacol.* **72**, 323-329 (2000).

Díaz Lanza, A. M., Abad Martínez, M. J., Fernández Matellano, L., Recuero Carretero, C., Villaescusa Castillo, L., Silván Sen, A. M. and Bermejo Benito, P., Lignan and phenylpropanoid glycosides from *Phillyrea latifolia* and their *in vitro* anti-inflammatory activity. *Planta Med.* **67**, 219-223 (2001).

Fujikawa, T., Yamaguchi, A., Morita, I., Takeda, H. and Nishibe, S., Protective effects of *Acanthopanax senticosus* Harms from Hokkaido and its components on gastric ulcer in restrained cold water stressed rats. *Biol. Pharm. Bull.* **19**, 1227-1230 (1996).

Gupta, M. B., Nath, R., Srivastava, N., Kishor, K. and Bhargava, K. P., Anti-inflammatory and anti-pyretic activities of β-sitosterol. *Planta Med.* **39**, 157-163 (1980).

Hahn, D. R., Kasai, R., Kim, J. H., Taniyasu, S. and Tanaka, O., A new glycosyl ester of 3,4-seco-triterpene from a Korean medicinal plant, *Acanthopanax chiisanensis* (Araliaceae). *Chem. Pharm. Bull.* **32**, 1244-1247 (1984).

Hahn, D. R., Kim, C. J. and Kim, J. H., A study on the chemical constituents of *Acanthopanax koreanum* Nakai and its pharmaco-biological activities. *Yakhak Hoeji* **29**, 357-361 (1985).

Haznedaroglu, M. Z., Karabay, N. U. and Zeybek, U., Anti-bacterial activity of *Salvia tomentosa* essential oil. *Fitoterapia* **72**, 829-831 (2001).

Heinemann, T., Axtmann, G. and Von Bergmann, K., Comparison of intestinal absorption of cholesterol with different plant sterols in man. *Eur. J. Clin. Invest.* **23**, 827-831 (1993).

Heo, H-J., Cho, H-Y., Hong, B., Kim, H-K., Heo, T-R., Kim, E-K., Kim, S-K., Kim, C-J. and Shin, D-H., Ursolic acid of *Origanum majorana* L. reduces Abeta-induced oxidative injury. *Molecules and Cells* **13**, 5-11 (2002).

Hibasami, H., Fujikawa, T., Takeda, H., Nishibe, S., Satoh, T., Fujisawa, T. and Nakashima, K., Induction of apoptosis by *Acanthopanax senticosus* HARMS and its component, sesamin in human stomach cancer KATO cells. *Oncology Reports* **7**, 1213-1216 (2000).

Hirata, F., Fujita, K., Ishikura, Y., Hosoda, K. and Ishikawa, H., Hypocholesterolemic effect of sesamin lignan in humans. *Atherosclerosis* **122**, 135-136 (1996).

Hirose, N., Doi, F., Ueki, T., Akazawa, K., Chijiiwa, K., Sugano, M., Akimoto, K., Shimizu, S. and Yamada, H., Suppressive effect of sesamin against 7,12-dimethylbenz[a]anthracene-induced rat mammary carcinogenesis. *Anticancer Res.* **12**, 1259-1265 (1992).

Huh, K., Lee, S-I. and Park, J-M., Effect of scoparone on the hepatic microsomal UDP glucuronyltransferase activity in mice. *Arch. Pharm. Res.* **10**, 165-168 (1987).

Huh, K., Park, J-M., Shin, U-S. and Lee, S-I., Effect of scoparone on the hepatic sulfotransferase activity in mice. *Arch. Pharm. Res.* **13**, 51-54 (1990).

Ide, T., Ashakumary, L, Takahashi, Y., Kushiro, M., Fukuda, N. and Sugano, M., Sesamin, a sesame lignan, decreases fatty acid synthesis in rat liver accompanying the down-regulation of sterol

regulatory element binding protein-1, *Biochim. Biophys. Acta* **1534**, 1-13 (2001).

Ishikura, N., Anthocyanin of *Acanthopanax divaricatus*. *Phytochemistry* **14**, 1439 (1975).

Ivorra, M. D., D'Ocan, M. P., Paya, M. and Villar, A., Anti-hyperglycemic and insulin-releasing effect of b-sitosterol 3-β-D-glucoside and its aglycone, β-sitosterol. *Arch. Int. Pharmacodyn.* **296**, 224-231 (1988).

Jang, S. H., A study on the chemical constituent of *Acanthopanax chiisanensis*. *Daehan Hwahak Hwoejee* **14**, 277-279 (1970).

Janzowski, C., Glaab, V., Samimi, A., Schlatter, J. and Eisenbrand, G., 5-Hydroxymethylfurfural: assessment of mutagenicity, DNA-damaging potential and reactivity towards cellular glutathione. *Food Chem. Toxicol.* **38**, 801-809 (2000).

Kang, H. S., Kim, Y. H., Lee, C. S., Lee, J. J., Choi, I. and Pyun, K. H., Suppression of interleukin-1 and tumor necrosis factor-α production by acanthoic acid, (-)-pimara-9(11),15-diene-19-oic acid, and its anti-fibrotic effects *in vivo*. *Cell. Immunol.* **170**, 212-221 (1996).

Kapil, A. and Sharma, S., Immunopotentiating compounds from *Tinospora cordifolia*. *J. Ethnopharmacol.* **58**, 89-95 (1997).

Kasai, R., Matsumoto, K., Taniyasu, S., Tanaka, O., Kim, J. H. and Hahn, D. R., 3,4-Seco-lupane triterpene glycosyl esters from a Korean medicinal plant, *Acanthopanax chiisanensis* (Araliaceae). *Chem. Pharm. Bull.* **34**, 3284-3289 (1986).

Kaul, A. and Khanduja, K. L., Polyphenols inhibit promotional phase of tumorigenesis: relevance of superoxide radicals. *Nutr. Cancer* **32**, 81-85 (1998).

Kim, C. J. and Hahn, D. R., The biological activity of a new glycoside, chiisanoside from *Acanthopanax chiisanensis* Nakai leaves. *Yakhak Hoeji* **24**, 123-34 (1980).

Kim, J. H. and Hahn, D. R., Studies on the chemical constituents of *Acanthopanax chiisanensis* Nakai roots. *Arch. Pharm. Res.* **4**, 59-62 (1981).

Kim, Y. H. and Chung, B. S., Pimaradiene diterpenes from *Acanthopanax koreanum*. *J. Nat. Prod.* **51**, 1080-1083 (1988).

Kim, Y. H., Chung, B. S. and Kim, H. J., Studies on the constituents of *Acanthopanax koreanum* Nakai. *Kor. J. Pharmacogn.* **16**, 151-154 (1985).

Kim, Y. H., Chung, B. S., Ko, Y. S. and Han, H. J., Studies on the chemical constituents of *Acanthopanax koreanum*. *Arch. Pharm. Res.* **11**, 159-162 (1988).

Kim, Y. H., Kim, H. S., Lee, S. W., Uramoto, M. and Lee, J. J., Kaurane derivatives from *Acanthopanax koreanum*. *Phytochemistry* **39**, 449-451 (1995).

Kim, Y. H., Ryu, J. H. and Chung, B. S., Diterpene glycoside from *Acanthopanax koreanum*. *Kor. J. Pharmacogn.* **21**, 49-51 (1990).

Kitajima, J., Takamori, Y. and Tanaka, Y., Studies on the constituents of *Acanthopanax sciadophylloides* Fr. et Sav. leaves. *Yakugaku Zasshi* **109**, 188-191 (1989).

Kohda, H., Tanaka, S. and Yamaoka, Y., Saponins from leaves of *Acanthopanax hypoleucus* Makino. *Chem. Pharm. Bull.* **38**, 3380-3383 (1990).

Kutschabsky, L., Pfeiffer, D., Lischewski, M., Ty, P. D. and Adam, G., Molecular and crystal structure of a new 24-nor-triterpenoid carboxylic acid from *Acanthopanax trifoliatus*. *Croatica Chemica Acta* **58**, 427-434 (1985).

Kwak, Y-S., Ryu, S-H., Baek, B-K., Lee, J-T. and Ahn, B-Z., The anthelmintic principle of "O-Mae", the roasted fruits of *Prunus mume*, against *Clonorchis sinensis*. *Yakhak Hoeji* **29**, 32-38 (1985).

Lee, I., Lee, J., Lee, Y. H., and Leonard, J., Ursolic acid-induced changes in tumor growth, O_2 consumption, and tumor interstitial fluid pressure. *Anticancer Res.* **21**, 2827-2833 (2001).

Lee, M. W., Chung, J. Y., Kim, Y. C. and Hahn, D. R., The primary investigation on physiological activity from Araliaceous glycoside. *Chung Ang J. Pharm. Sci.* **1**, 1-3 (1987).

Lee, S., Ji, J., Shin, K. H. and Kim, B-K., Sessiline, a new nitrogenous compound from the fruits of *Acanthopanax sessiliflorus*. *Planta Med.* **68**, 936-939 (2002a).

Lee, S., Kim, B-K., Cho, S. H. and Shin, K. H., Phytochemical constituents from the fruits of *Acanthopanax sessiliflorus*. *Arch. Pharm. Res.* **25**, 280-284 (2002b).

Lee, S., Ban, H. S., Kim, Y. P., Kim, B-K., Cho, S. H., Ohuchi, K. and Shin, K. H., Lignans from the roots of *Acanthopanax chiisanensis* having inhibitory activity on prostaglandin E_2 production. *Phytother. Res* (Accepted for publication, 2002c).

Li, X-C., Barnes, D. L. and Khan, I. A., A new lignan glycoside from *Eleutherococcus senticosus*. *Planta Med.* **67**, 776-778 (2001).

Lischewski, M., Ty, P. D., Kutschabsky, L., Pfeiffer, D., Phiet, H. V., Preiss, A., Sung, T. V. and Adam, G., Two 24-*nor*-triterpenoid carboxylic acids from *Acanthopanax trifoliatus*. *Phytochemistry* **24**, 2355-2357 (1985).

Liu, C-L., Wang, J-M., Chu, C-Y., Cheng, M-T., and Tseng, T-H., *In vivo* protective effect of protocatechuic acid on *tert*-butyl hydroperoxide-induced rat hepatotoxicity. *Food Chem. Toxicol.* **41**, 635-641 (2002).

Majester-Savornin, B., Elias, R., Diaz-Lanza, A. M., Balansard, G., Gasquet, M. and Delmas, F., Saponins of the ivy plant, *Hedera helix*, and their Leishmanicidic activity. *Planta Med.* **57**, 260-262 (1991).

Matsumoto, K., Kasai, R., Kanamaru, F., Kohda, H. and Tanaka, O., 3,4-Seco-lupane-type triterpene glycosyl esters from leaves of *Acanthopanax divaricatus* Seem. *Chem. Pharm. Bull.* **35**, 413-415 (1987).

Medina, I., Tombo, I., Satué-Gracia, M. T., German, J. B. and Frankel, A. N., Effects of natural phenolic compounds on the anti-oxidant activity of lactoferrin in liposomes and oil-in-water emulsions. *J. Agric. Food Chem.* **50**, 2392-2399 (2002).

Meyer, R. P., Hagemeyer, C. E., Knoth, R., Kurz, G. and Volk, B., Oxidative hydrolysis of scoparone by cytochrome P_{450} CYP_2C_{29} reveals a novel metabolite. *Biochem. Biophys. Res. Comm.* **285**, 32-39 (2001).

Miyakoshi, M., Ida, Y., Isoda, S. and Shoji, J., 3-*epi*-Oleanene type

triterpene glycosyl esters from leaves of *Acanthopanax spinosus*. *Phytochemistry* **33**, 891-895 (1993a).

Miyakoshi, M., Ida, Y., Isoda, S. and Shoji, J., 3α-Hydroxy-oleanene type triterpene glycosyl esters from leaves of *Acanthopanax spinosus*. *Phytochemistry* **34**, 1599-1602 (1993b).

Miyakoshi, M., Isoda, S., Sato, H., Hira,i Y., Shoji, J. and Ida, Y., 3α-Hydroxy-oleanene type triterpene glycosyl esters from leaves of *Acanthopanax spinosus*. *Phytochemistry* **46**, 1255-1259 (1997a).

Miyakoshi, M., Shirasuna, K., Hirai, Y., Shingu, K., Isoda, S., Shoji, J., Ida, Y. and Shimizu, T., Triterpenoid saponins of *Acanthopanax nipponicus* leaves. *J. Nat. Prod.* **62**, 445-448 (1999).

Miyakoshi, M., Shirasuna, K., Sawada, H., Isoda, S., Ida, Y. and Shoji, J., Constituents of *Acanthopanax divaricatus* and *A. sieboldianus* roots. *Nat. Med.* **49**, 218 (1995).

Miyakoshi, M., Terajima, Y., Isoda, S., Hirai, Y. and Ida, Y., Constituents of leaves of *Acanthopanax trichodon*. *Nat. Med.* **51**, 494 (1997b).

Nakamura, Y., Torikai, K., and Ohigashi, H., Toxic dose of a simple phenolic anti-oxidant, protocatechuic acid, attenuates the glutathione level in ICR mouse liver and kidney. *J. Agric. Food Chem.* **49**, 5674-5678 (2001).

Nakayama, T., Yamada, M., Osawa, T. and Kawakishi, S., Inhibitory effect of caffeic acid ethyl ester on H_2O_2-induced cytotoxicity and DNA single-stranded breaks in Chinese hamsters V79 cells. *Biosci. Biotechnol. Biochem.* **60**, 316-318 (1996).

Nishibe, S., Kinoshita, H., Takeda, H. and Okano, G., Phenolic compounds from stem bark of *Acanthopanax senticosus* and their pharmacological effect in chronic swimming stressed rats. *Chem. Pharm. Bull.* **38**, 1763-1765 (1990).

Nishiyama, N., Kamegaya, T., Iwai, A., Saito, H., Sanada, S., Ida, Y. and Shoji, J., Effect of *Eleutherococcus senticosus* and its components on sex- and learning-behaviour and tyrosine hydroxylase activities of adrenal gland and hypothalamic regions in chronic stressed mice. *Shoyakugaku Zasshi* **39**, 238-242 (1985).

Nissanka, A. P., Karunaratne, V., Bandara, B. M., Kumar, V., Nakanishi, T., Nishi, M., Inada, A., Tillekeratne, L. M., Wijesundara, D. S. and Gunatilaka, A. A., Anti-microbial alkaloids from *Zanthoxylum tetraspermum* and *caudatum*. *Phytochemistry* **56**, 857-861 (2001).

Noguchi, T., Ikeda, K., Sasaki, Y., Yamamoto, J., Seki, J., Yamagata, K., Nara, Y., Hara, H., Kakuta, H. and Yamori, Y., Effects of vitamin E and sesamin on hypertension and cerebral thrombogenesis in stroke-prone spontaneously hypertensive rats. *Hypertension Research: Official Journal of the Japanese Society of Hypertension* **24**, 735-742 (2001).

Nonaka, M., Yamashita, K., Iizuka, Y., Namiki, M. and Sugano, M., Effects of dietary sesaminol and sesamin on eicosanoid production and immunoglobulin level in rats given ethanol. *Biosci. Biotechnol. Biochem.* **61**, 836-839 (1997).

Novotný, L., Vachálková, A., and Biggs, D., Ursolic acid: an anti-tumorigenic and chemopreventive activity, minireview. *Neoplasma* **48**, 241-246 (2001).

Oh, O. J., Chang, S. Y., Kim, T. H., Yang, K. S., Yook, C. S., Park, S. Y. and Nohara, T., Constituents of *Acanthopanax divaricatus* var. *albeofructus*. *Nat. Med.* **54**, 29-32 (2000).

Park, S. Y., Chang, S. Y., Oh, O. J., Yook, C. S. and Nohara, T., *nor*-Oleanene type triterpene glycosides from the leaves of *Acanthopanax japonicus*. *Phytochemistry* **59**, 379-384 (2002).

Park, S. Y., Chang, S. Y., Yook, C. S. and Nohara, T., New 3,4-seco-lupane-type triterpene glycosides from *Acanthopanax senticosus* forma *inermis*. *J. Nat. Prod.* **63**, 1630-1633 (2000a).

Park, S. Y., Chang, S. Y., Yook, C. S. and Nohara, T., Triterpene glycosides from leaves of *Acanthopanax senticosus* forma *inermis*. *Nat. Med.* **54**, 43 (2000b).

Park, S. Y., Yook, C. S. and Nohara, T., A novel 3,4-*seco*-migrated-lupane glycoside with a seven-membered B-ring from *Acanthopanax divaricatus* var. *sachunensis*. *Tetrahedron Lett.* **42**, 2825-2828 (2001).

Ro, H. S., Lee, S. Y. and Han, B. H., Studies on the lignan glycoside of *Acanthopanax* Cortex. *J. Pharm. Soc. Kor.* **21**, 81-86 (1977).

Ruijun, Z., Jinkang, Q., Gnanghua, Y., Baozhen, W. and Xiulan, W., Medicinal protection with Chinese herb-compound against radiation damage. *Avaition Space Environ. Med.* **61**, 729-731 (1990).

Sawada, H., Miyakoshi, M., Isoda, S., Ida, Y. and Shoji, J., Saponins from leaves of *Acanthopanax sieboldianus*. *Phytochemistry* **34**, 1117-1121 (1993).

Segiet-Kujawa, E. and Kaloga, M., Triterpenoid saponins of *Eleutherococcus senticosus* roots. *J. Nat. Prod.* **54**, 1044-1048 (1991).

Shimizu, M., Zenko, Y., Tanaka, R., Matsuzawa, T., and Morita, N., Studies on aldose reductase inhibitors from natural products. V. Active components of Hachimi-jio-gan (Kampo medicine). *Chem. Pharm. Bull.* **41**, 1469-1471 (1993).

Shao, C-J., Kasai, R., Xu, J-D. and Tanaka, O., Saponins from leaves of *Acanthopanax senticosus* HARMS., Ciwujia: Structures of Ciwujianosides B, C_1, C_2, C_3, C_4, D_1, D_2 and E. *Chem. Pharm. Bull.* **36**, 601-608 (1988).

Shao, C-J., Kasai, R., Xu, J-D. and Tanaka, O., Saponins from leaves of *Acanthopanax senticosus* HARMS., Ciwujia. II. Structures of Ciwujianosides A_1, A_2, A_3, A_4 and D_3. *Chem. Pharm. Bull.* **37**, 42-45 (1989).

Shin, A. T., Kim, C. J. and Yook, C. S., Studies on the chemical constituents of *Acanthopanax* fruits. *Bull. K. H. Pharm. Sci.* **20**, 63-73 (1992).

Shirasuna, K., Miyakoshi, M., Mimoto, S., Isoda, S., Satoh, Y., Hirai, Y., Ida, Y. and Shoji, J., Lupane triterpenoid glycosyl esters from leaves of *Acanthopanax divaricatus*. *Phytochemistry* **45**, 579-584 (1997).

Sirato-Yasumoto, S., Katsuta, M., Okuyama, Y., Takahashi, Y. and Ide, T., Effect of sesame seeds rich in sesamin and sesamolin on fatty acid oxidation in rat liver. *J. Agric. Food Chem.* **49**, 2647-2651 (2001).

Slacanin, I., Marston, A., Hostettmann, K., Guédon, D. and Abbe, P., The isolation of *Eleutherococcus senticosus* constituents by centrifugal partition chromatography and their quantitative determination by high performance liquid chromatography. *Phytochem. Anal.* **2**, 137-142 (1991).

Soliman, K. F. A. and Mazzio, A. A., *In vitro* attenuation of nitric acid production in C_6 astrocyte cell culture by various dietary compounds. *Proc. Soc. Exp. Biol. Med.* **218**, 390-397 (1998).

Srivastava, S., Gupta, M. M., Prajapati, V., Tripathi, A. K., and Kumar, S., Sesamin a potent anti-feedant principle from *Piper mullesua*. *Phytother. Res.* **15**, 70-72 (2001).

Sugiyama, M. and Seki, J., *In vivo* application of lipoproteins as drug carriers: pharmacological evaluation of sterylglucoside-lipoprotein complexes. *Targ. Diagn. Ther.* **5**, 315-350 (1991).

Taherzadeh, M. J., Gustafsson, L., Niklasson, C. and Lidén, G., Physiological effects of 5-hydroxymethylfurfural on *Saccharomyces cerevisiae*. *Appl. Microbiol. Biotechnol.* **53**, 701-708 (2000).

Taira, J., Ikemoto, T., Yoneya, T., Hagi, A., Murakami, A. and Makino, K., Essential oil phenyl propanoids: useful as OH scavengers? *Free Rad. Res. Commun.* **16**, 197-204 (1992).

Takasugi, N., Moriguchi, T., Fuwa, T., Sanada, S., Ida, Y., Shoji, J. and Saito, H., Effect of *Eleutherococcus senticosus* and its components on rectal temperature, body and grip tones, motor coordination, and exploratory and spontaneous movements in acute stressed mice. *Shoyakugaku Zasshi* **39**, 232-237 (1985).

Ty, P. D., Lischewski, M., Phiet, H. V., Preiss, A., Nguyen, P. V. and Adam, G., 3α,11α-Dihydroxy-23-oxo-lup-20(29)-en-28-oic acid from *Acanthopanax trifoliatus*. *Phytochemistry* **24**, 867-869 (1985).

Ty, P. D., Lischewski, M., Phiet, H. V., Preiss, A., Sung, T. V., Schmidt, J. and Adam, G., Two triterpenoid carboxylic acids from *Acanthopanax trifoliatus*. *Phytochemistry* **23**, 2889-2891 (1984).

Umeda-Sawada, R., Ogawa, M., Nakamura, M. and Igarashi, O., Effect of sesamin on mitochodrial and peroxisomal β-oxidation of arachidonic and eicosapentaenoic acids in rat liver. *Lipids* **36**, 483-489 (2001).

Umeyama, A., Shoji, N., Takei, M., Endo, K. and Arihara, S., Ciwujianosides C_1 and D_1: Powerful inhibitors of histamine release induced by anti-immunoglobulin E from rat peritoneal mast dells. *J. Pharm. Sci.* **81**, 661-662 (1992).

Wagner, H., Heur, Y. H., Obermeier, A., Tittel, G. and Bladt, S., Die DC- und HPLC-Analyse der *Eleutherococcus* Droge. *Planta Med.* **44**, 193-8 (1982)

Wagner, H. and Wurmböck, A., Chemie, Pharmakologie und Dünnschichtchromatographie der *Ginseng*und *Eleutherococcus*-Droge. *DAZ* **117**, 743-748 (1977).

Wielgorskaya, T. and Takhtajan, A., Dictionary of generic names of seed plants. Columbia University Press, NY (1995).

Yasue, M., Kato, Y., Lin, Y. M. and Sakakibara, J., Studies on the constituents of *Acanthopanax sciadophylloides* Franch. et Sav. I. Isolation of cyclitols and flavonoid glycosides. Structure of antoside. *Yakugaku Zasshi* **88**, 738-741 (1968).

Yasue, M., Kato, Y., Lin, Y. M. and Sakakibara, J., Studies on the constituents of *Acanthopanax sciadophylloides* Franch. et Sav. 2. On the flavonoid and terpenoid constituents. Coincidence of hirsutrin and isoquercitrin. *Yakugaku Zasshi* **89**, 872-876 (1969).

Yasue, M., Lin, Y. M. and Sakakibara, J., Studies on the constituents of *Acanthopanax sciadophylloides* Franch. et Sav. III. *Yakugaku Zasshi* **90**, 341-343 (1970).

Yat, P. N., Arnason, J. T. and Awang, D. V. C., An improved extraction procedure for the rapid, quantitative high-performance liquid chromatographic estimation of the main eleutherosides (B and E) in *Eleutherococcus senticosus* (Eleuthero). *Phytochem. Anal.* **9**, 291-295 (1998).

Yook, C. S., Chang, S. Y., Lai, J. H., Ko, S. K., Jeong, J. H. and Nohara, T., Lupane-glycoside of *Acanthopanax trifoliatus* forma *tristigmatis* leaves. *Arch. Pharm. Res.* **22**, 629-632 (1999).

Yook, C. S., Kim, I. H., Hahn, D. R., Nohara, T. and Chang, S. Y., A lupane-triterpene glycoside from leaves of two *Acanthopanax*. *Phytochemistry* **49**, 839-843 (1998).

Yook, C. S., Kim, S. C., Kim, C. J. and Han, D. R., Phytochemical studies on the barks of *Acanthopanax senticosus* forma *inermis*. *Yakhak Hoeji* **35**, 147-153 (1991).

Yook, C. S., Lee, D. H., Seo, Y. K. and Ryu, K. S., Study on the constituents in the root bark of *Acanthopanax sessiliflorum* Seemann (II). *Kor. J. Pharmacogn.* **8**, 31-34 (1977).

Yook, C. S., Rho, Y. S., Seo, S. H., Leem, J. Y. and Han, D. R., Chemical components of *Acanthopanax divaricatus* and anti-cancer effect in leaves. *Yakhak Hoeji* **40**, 251-261 (1996).

You, H. J., Choi, C. Y., Kim, J. Y., Park, S. J., Hahm, K. S., and Jeong, H. G., Ursolic acid enhances nitric oxide and tumor necrosis factor-α production *via* nuclear factor-κB activation in the resting macrophages. *FEBS Lett.* **509**, 156-160 (2001).

Yun-Choi, H. S., Kim, J. H,, Kim, S. O. and Lee, J. R., Platelet anti-aggregating plant materials. *Kor. J. Pharmacogn.* **17**, 161-167 (1986).

Yun-Choi, H. S., Kim, J. H. and Lee, J. R., Potential inhibitors of platelet aggregation from plant sources, . *J. Nat. Prod.* **50**, 1059-1064 (1987).

Zhao, W. M., Qin, G. W., Xu, R. S., Li, X. Y., Liu, J. S., Wang, Y. and Feng, M., Constituents from the roots of *Acanthopanax setchuenensis*. *Fitoterapia* **70**, 529-531 (1999).

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