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Phytochemicals and Biological Activities of *Adiantum* Species

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The present review deals with traditional uses of *Adiantum* species in the treatment of various ailments along with the studies of biological activity and phytochemistry of the plant species reporting up to 2002. Till date, not much of work has been done on these plant species. Hence the review anticipates to provoke keen interest of various of workers to undertake works on genus *Adiantum* the major portion of which remains unexplored.

Keywords: *Adiantum* species, Traditional uses, Biological activity, Phytochemical constituents

Introduction

Adiantum species are well-known for their significant medicinal efficacies and are being traditionally used in the treatment of various ailments for a long period[1,2]. *Adiantum* is a large and diverse genus of ferns of about 150 species[3]. It is evidently an old and morphologically isolated genus with relations to the *Pteridaceae*, but without clear alliance to any particular group within it. Much discussion regarding its taxonomical classification is available, previously the genus was regarded as under the family *Polypodiaceae*[4]; latter it was classified as under the family *Adiantaceae*[2,5]. But Tryon *et al.*[3] have taxonomically subdivided the family *Pteridaceae* into many subfamilies, where the single genus *Adiantum* constitutes the subfamily *Adiantoideae*. The genus exhibits both aneuploid and polyploid series as observed from many chromosome counts (e.g. $n = 29$, 30, 57, 58, 60, 90, 114, 116, 122, 150 and c.180)[3]. It is pantropical with extensions northward to Newfoundland, Alaska and northeastern Asia and southward to southern South America, southern Africa and New Zealand. In India about nine species are generally found, most of which are being used in the indigenous system of medicine[2,4]. It is evident from literature survey that out of about 150 species, only few of them have been considered so far for studying their biological activity and phytochemical investigation. Most of them are lying unexplored. The aim of the present review is to focus on the chemical studies of the *Adiantum* species reported so far along with detailed reporting on the biological activities shown by the *Adiantum* species as studied. Many interesting findings regarding their biological activity and structural variety of the isolated chemical components have appeared; the chemical components at hand may be much informative to the chemotaxonomists to solve the age-old confusion regarding exact taxonomical classification of this genus. Besides the review anticipates to draw keen attention of various workers to undertake further research works on the plant species of this genus, major portion of which remains unexplored.

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Plant Species Used As Traditional Medicine

Traditional uses of *Adiantum* species in indigenous system of medicine in the treatment of numerous ailments are noteworthy.

(i) Adiantum lunulatum Burm. Syn. A. philippense Linn.

In India the plant is traditionally used in the treatment of various diseases among the local and tribal people, mainly in blood diseases, epileptic fits, erysipelas, fever, dysentery, ulcers, febrile affections, atropy, emaciation or cachexy, muscular pain and rabies[2,6]. Rhizomes prescribed for strangury and also in fever due to elephantiasis[2]. Fronds are burnt in oil and applied to itches[4]. Hosagoudar and Henry[7] mentioned that the plant species is used in birth control among the tribal "Soliga" of Biligiri Rangana Betta in Mysore district of Karnataka, India. The authors have reported that a handful of root paste of *A. lunulatum* (locally known as Seniya or Sanya) mixed with the water dripped from hair while bathing, is being administered to women orally once during menstrual period for permanent sterility. To get fruitful result, these women are not supposed to mix with men for a period of two months.

(ii) A. caudatum Linn. syn. A. incisum Forsk

Fronds of this plant are used in the treatment of skin diseases, hemicrania, diabetes, cough and fever[2,4], and in other local uses[8]. The plant is also used as spasmolytic and anti-biotic[6].

(iii) A. capillus-veneris Linn.

The fern is used as a pectoral demulcent, expectorant, emmenagogue, diuretic and tonic[2]. It is used in cold imposthumes of uretus, hard swellings and in cases of hard tumours of spleen, liver, and other viscera[2,4,8]. Fronds with honey are also used in catarrh affections[6].

(iv) A. flabellulatum Linn.

The plant rhizomes are used as anthelmintic; also used against gripe. The herb is also used as medicine for cough[4].

(v) A. pedatum Linn.

The plant is employed in France and North America as a pectoral in chronic catarrh[4]. The herb is also used as stimulant, expectorant, demulcent, tonic, astringent, and emmenagogue[2,4].

(vi) A. venustum G. Don

Plant fronds are used as tonic, expectorant, diuretic, emmenagogue, astringent, ematic, and also used in scoopionsting[4]. The fern appears to constitute much of the drug Hansraj[2] in Punjab, India which is used as an anodyne in bronchitis; the herb is also used to treat biliousness affections, inflammatory disease of chest, ophthalmia, hydrophobia, cold, and headache[6,9].

(vii) A. aethiopicum Linn. Syn. A. emarginatum Bedd.

Leaves of the plant are used as emolument in coughs and diseases of chest[4].

(viii) A. tenerum Sw.

The plant is used as sudorific, expectorant and demulcent[4].

Biological Activity

Adiantum species possess immense traditional applications, as discussed earlier. So far, only a very few species have been screened for their biological activity and the experimental results show a wide spectrum of such effect. Hence, *adiantum* species demand an extensive study on their biological acitivity.

Hypoglycaemic Activity

Neef *et al.*[10] have shown that *A. capillus-veneris* could play a vital role in regulating blood glucose levels of diabetic patients. The authors exhaustively studied the effect of water and alcoholic extracts of the plant species using Oral Glucose Tolerance Test (OGTT), a well accepted and frequently used model to screen hypoglycaemic activity. It was observed that only the water extract of *A. capillus-veneris* shows hypoglycaemic effect, while the alcoholic extract increases the blood glucose levels in experimental models (mice). Though ultimate effect of the water extract becomes hypoglycaemic, it was found that it provokes an initial rise in glucose levels.

A. capillus-veneris when administered 60 min prior to dextrose load, it induced an initial rise of the glucose levels at $t0$ ($p < 0.001$, p = significance of difference between controls and treated groups evaluated using Mann-Whitney test[11]), but at $t + 60$ and +90 min, respectively, 20 per cent and 16 per cent decrease of the glycaemia were observed. Hydrosoluble chemical components of the water extract are probably responsible for the hypoglycaemic effect; cell cultures, intestinal fragments and commercial enzymes might be useful to control a large quantity of prepared fractions. Ethanolic (50 per cent) extract of another plant species *A. incisum* was also found to exhibit hypoglycaemic effect[12].

Antifungal Activity

Significant antifungal activity shown by the species *A. lunulatum* against *Microsporum nanum*, was reported by Rai[13]. *In vitro* study of the aqueous leaf-extract of the plant species was found to suppress the growth of *M. nanum* in 1 min after the application of the extract, while no growth was observed after 30 min.

Cardiovascular Activity

The Iraqi workers[14] have reported that Iraqi species of genus *Adiantum* possess cardiovascular activity. They used alcoholic extracts of leaves and roots in evaluating such activity of the plant materials. These extracts in concentrations of 1-10 mg/kg were found to produce dose-dependent vasodepressor effects in experimental rats. Hypotensive action of another plant species *A. capillus-veneris* was also reported by Twaij *et al.*[15] in experimental models.

Diuretic Activity

Diuretic activity of the species *A. capillus-veneris* was also observed[15]. It was found that total aqueous and/or alcoholic extract of the plant when administered orally or intraperitoneally to the test animals (rats, mice and guinea pigs), satisfactory results were obtained. The same activity exhibited by alcoholic extract of some Iraqi species under genus *Adiantum* was also reported[14].

Anti-microbial Activity

Mahmoud *et al.*[16] have reported that the methanolic extract of *A. capillus-veneris* (aerial parts) shows high degree of antimicrobial potency against Gram (+), Gram (-) bacteria and *Candida* species. The representative microbes screened were *Escherichia coli*, *Bacillus subtilis*, *Proteus vulgaris*, *Staphylocoous aureus*, *Pseudomonas aeruginosa*, *Candida lbicaus*, and *Candida pseutropicalis*. Concentrations between 2 - 0.1 mg/mL of the extract were tested against all the microbes, as mentioned above, and their anti-microbial activity was recorded. The extract of 2 mg/mL concentration exhibited a very promising result. The minimum inhibitory concentrations for *E. coli* and *S. aureus* as a representative Gram (-) and Gram (+) bacteria were determined, respectively, as 250 μg/mL and 300 μg/mL. The authors further reported that the flavonoid constituents of the methanolic extract are responsible for the effective anti-microbial activity.

Antiviral Activity

Crude extract of some *Adiantum* plants were also found to show antiviral activities. Significant antiviral activity of *A. capillus-veneris* was observed biologically on cellular cultures[17]. Leaf and fronds extract of another species *A. venustum* inhibit the formation of local lesions effectively on *Chenopodium amaranticolor* by cucumber mosaic virus, as reported by Pandey and Bhargava[17].

Reports of Chemical Constituents

The chemical constituents isolated so far from *Adiantum* species, along with their available physical data and various spectra used for their characterization are enlisted in Table 1. Their structures (**1-34**) are also given in Figure 1.

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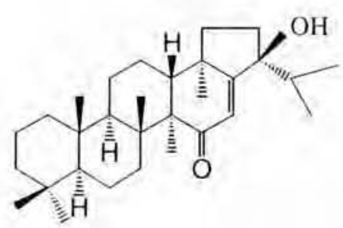
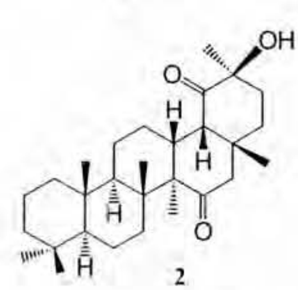
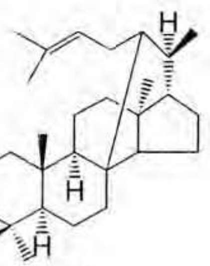
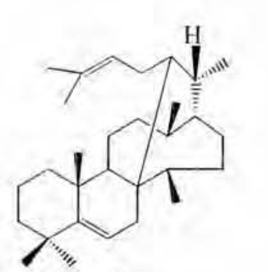
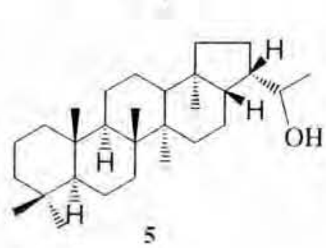
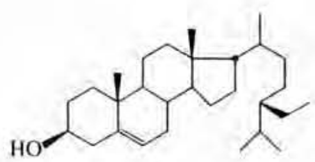
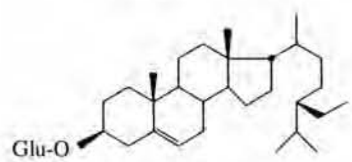
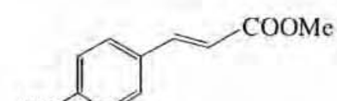
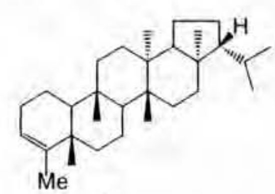
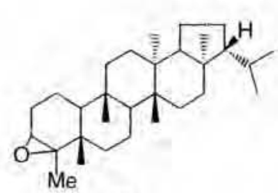
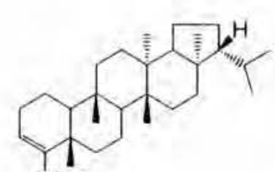
Table 1 — Phytochemical constituents of *Adiantum* species

Compound, molecular formula, mp (°C), $[\alpha]_D$	Spectra recorded	Structure	Source	Reference
1	2	3	4	5
Adininaneone (21β-hydroxy-15-oxo-hop-16-ene) $C_{30}H_{48}O_2$ 223° $[\alpha]_D25° - 40.2°$ ($CHCl_3$)	UV/vis, IR, ^{1}H- & ^{13}C-NMR, 2D-NMR (HMBC, HMQC), EIMS, HRMS	 I	*A. incisum* (Methanolic extract, ethylacetate fraction)	18
Adininaonol (20β-hydroxy-19-oxolean) $C_{29}H_{48}O_2$ 227° $[\alpha]_D25° - 29.4°$ ($CHCl_3$)	UV/vis, IR, ^{1}H- & ^{13}C-NMR, 2D-NMR (HMBC, HMQC), EIMS, HRMS	 2	*A. incisum* (Methanolic extract, ethylacetate fraction)	18
Adiantutirucallene B [tirucall-8,22-cyclo-24(25)-ene], $C_{30}H_{50}$ 183°- 84° $[\alpha]_D25° - 47°$ ($CHCl_3$)	IR, ^{1}H- & ^{13}C- NMR, ^{1}H-^{1}H & ^{1}H-^{13}C COSY, EIMS, HRMS	 3	*A. indicum* Ghatak (a member of *A. caudatum complex*) petrol extract of aerial parts	19
Adiantulanostene [13,14-seco-8,22-cyclolanost-5(6), 24(25)-diene], $C_{30}H_{50}$ 148°-50° $[\alpha]_D25° - 46°$ ($CHCl_3$)	IR, ^{1}H- & ^{13}C- NMR, ^{1}H-^{1}H & ^{1}H-^{13}C COSY, EIMS, HRMS	 4	*A. venustum* (ethylacetate fraction of ethanolic extract of aerial parts and roots)	19
29-Norhopan-22-ol, $C_{29}H_{50}O$, 242° – 45° $[\alpha]_D$ +3.04° ($CHCl_3$)	IR, ^{1}H & ^{13}C-NMR, EIMS	 5	*A. indicum* Ghatak (a member of *A. caudatum complex*) petrol extract of aerial parts	20

—Contd

Table 1 — Phytochemical constituents of *Adiantum* species — (Contd)

Compound, molecular formula, mp (°C), [α]D	Spectra recorded	Structure	Source	Reference
1	2	3	4	5
β-Sitosterol $C_{29}H_{50}O$, 139° [α]D −36° ($CHCl_3$)	IR, ¹H & ¹³C-NMR, EIMS	 6	*A. indicum* Ghatak (a member of *A. caudatum complex)* petrol extract of aerial parts	20
			A. thalictroides (chloroform extract)	21
β-Sitosterol glucoside, $C_{35}H_{61}O_6$, 283° – 86°	IR, ¹H & ¹³CNMR, EIMS	 7	*A. indicum* Ghatak (a member of *A. caudatum complex)* ethanolic extract of aerial parts	20
Methyl-*p*-coumarate, $C_{10}H_{10}O_3$, 136° – 38°	UV, IR, ¹H-NMR	 8	*A. thalictroides* (petrol extract)	21
Filicene $C_{30}H_{50}$, 225°	IR, ¹H-NMR, EIMS	 9	*A. indicum* Ghatak (a member of A. *caudatum complex)* petrol extract of aerial parts	20
			A. venustum (petrol extract)	22
			A. pedatum (hexane extract of leaves)	23
Adiantoxide (3α,4 α -epoxyfilicane) $C_{30}H_{50}O$ 229°- 31° [α]D30° + 46.8°	EIMS	 10	*A. capillus-veneris*	24, 25
Filicenal $C_{30}H_{48}O$ 272° [α]D25° + 74° ($CHCl_3$)	UV, IR, NMR, EIMS	 11	*A. pedatum* (hexane extract of dried leaves)	23

—Contd

Table 1 — Phytochemical constituents of *Adiantum* species — (Contd)

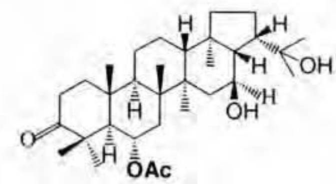
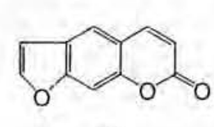
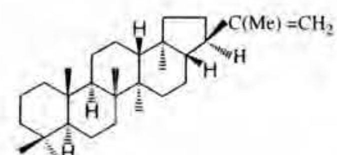
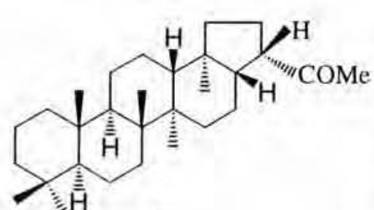
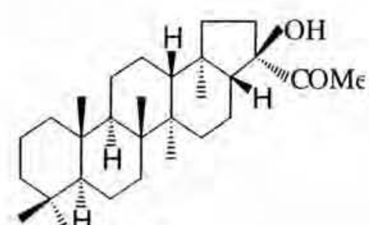
Compound, molecular formula, mp (°C), $[\alpha]_D$	Spectra recorded	Structure	Source	Reference
1	2	3	4	5
6α-Acetoxy-16β,22-dihydroxy-3-ketoiso-hopane $C_{32}H_{52}O_5$ 261°- 62°	IR, ^{1}H & ^{13}C-NMR, EIMS	 **12**	*A. lunulatum* (petrol extract of whole plants)	26
Psoralene $C_{11}H_6O_3$ 161°-63°	UV, IR, ^{1}H-NMR, EIMS	 **13**	*A. thalictroides* (petrol extract)	21
3β-Acetoxy-21α-H-hop-22(29)ene $C_{32}H_{52}O_2$ 283°- 84°	IR, ^{1}H & ^{13}C-NMR, EIMS	 **14**	*A. lunulatum (petrol extract of whole plants)*	27
Adiantone (22-oxo-21β-H-hopane) $C_{29}H_{48}O$ 222°- 24° $[\alpha]_D 20^0 + 80^0$	IR, ^{1}H-NMR, EIMS	 **15**	*A. indicum Ghatak* (a member of *A. caudatum complex)* petrol extract of aerial parts	20, 28
			A. capillus-veneris (petrol extract)	29
			A. thalictroides (petrol extract)	21
			A. pedatum (hexane extract of leaves)	23
			A. venustum (petrol extract)	22
			A. incisum	18
21-Hydroxy-adiantone $C_{29}H_{48}O_2$ 281°- 84° $[\alpha]_D + 18^0$ (dioxane) $+ 50^0$(py))	IR, ^{1}H-NMR, EIMS	 **16**	*A. venustum* (petrol extract) *A. capillus-veneris*	22

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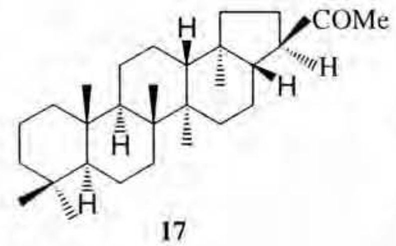
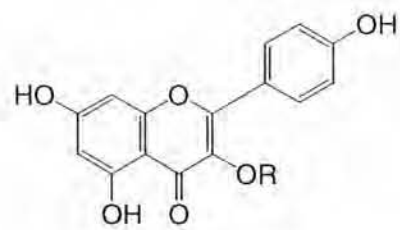
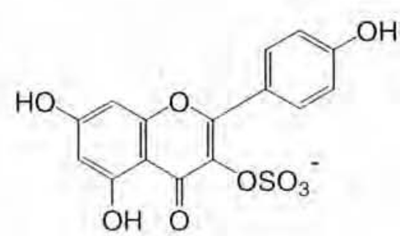
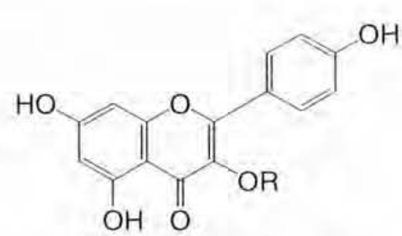
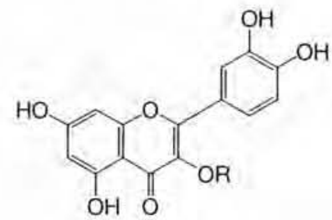
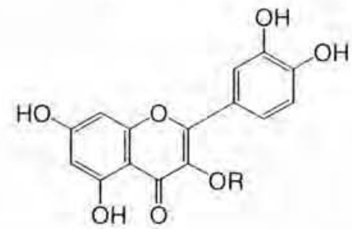
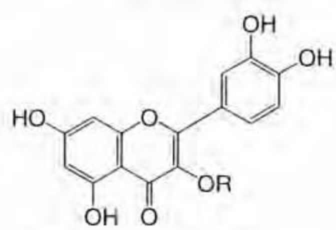
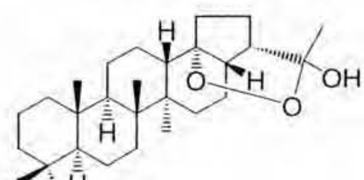
Table 1 — Phytochemical constituents of *Adiantum* species — (Contd)

Compound, molecular formula, mp (°C), $[\alpha]_D$	Spectra recorded	Structure	Source	Reference
1	2	3	4	5
Isoadiantone $C_{29}H_{48}O$, 230^0- 32^0 $[\alpha]_D 20^0 + 4^0$ ($CHCl_3$)	IR, ^{1}H-NMR, EIMS	 **17**	*A. capillus-veneris* (petrol extract)	29
			A. caudatum (petrol extract)	28
			A. thalictroides (petrol extract)	21
			A. incisum (methanol-extract, ethylacetate fraction)	18
Kaempferol-3-glucoside (Astragalin) $C_{21}H_{20}O_{11}$	—	 **18**. R : glucosyl	*A. aethiopicum*	6
Kaempferol-3-sulphate $[C_{15}H_9O_9S]^-$	Electrophoresis & UV(with and without various shift reagents) [confirmrd	 **19**	*A. capillus-veneris* (ethanolic extract of fresh fronds)	30
Kaempferol-3-rhamno-glucoside (Nicotiflorin)	—	 **20**. R : rhamnoglucosyl	*A. capillus-veneris*	6

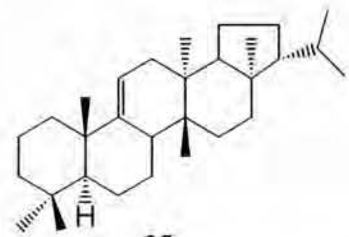
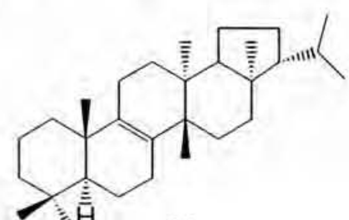
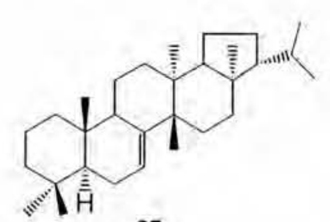
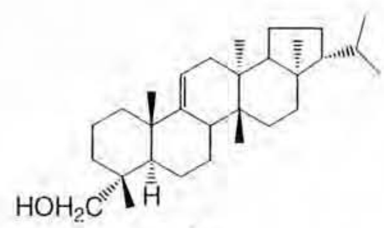
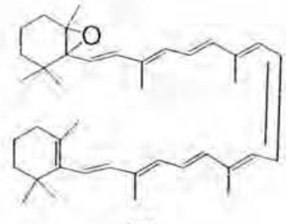
—Contd

Table 1 — Phytochemical constituents of *Adiantum* species — (Contd)

Compound, molecular formula, mp ($^{\circ}$C), $[\alpha]_D$	Spectra recorded	Structure	Source	Reference
1	2	3	4	5
Quercetin-3-O-glucoside $C_{21}H_{20}O_{12}$ 236°- 38°	UV, IR, ^{1}H & ^{13}C-NMR, EIMS	 **21**. R : glucosyl	*A. indicum Ghatak* (a member of *A. caudatum complex*) ethylacetate extract *A. venustum*	20 6
Querciturone $C_{21}H_{18}O_{13}$ 182° $[\alpha]_D$ –23°	—	 **22**. R : glucuronosyl	*A. capillus-veneris*	6
Rutin $C_{27}H_{30}O_{16}$ 191° $[\alpha]_D$ –36° (py)	—	 **23**. R : rutinosyl	*A. capillus-veneris*	6
Adipedataol $C_{29}H_{48}O_2$ 185°- 88° $[\alpha]_D$ + 88° ($CHCl_3$)	UV, IR, NMR, EIMS	 **24**	*A. pedatum* (hexane extract of leaves)	23
An ester $C_{28}H_{54}O_2$ 185°- 90°	—	—	*A. capillus-veneris* (petrol extract)	31
A ketone $C_{25}H_{40}O$ or $C_{26}H_{42}O$ 222°- 24° $[\alpha]_D$23° + 80.06° ($CHCl_3$)	—	—	*A. capillus-veneris* (petrol extract)	31

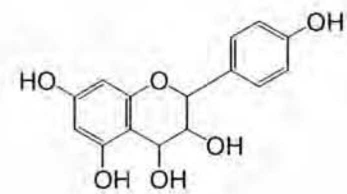
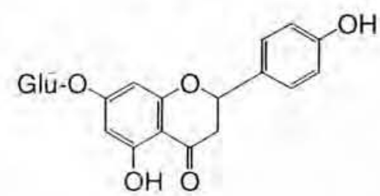
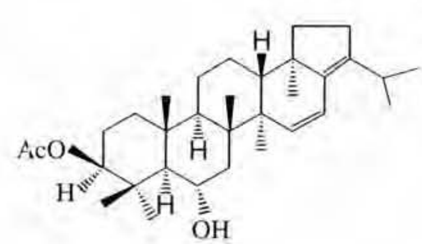
— Contd.

Table 1 — Phytochemical constituents of *Adiantum* species — (Contd)

Compound, molecular formula, mp (°C), $[\alpha]_D$	Spectra recorded	Structure	Source	Reference
1	2	3	4	5
Ferene $C_{30}H_{50}$, 171°-72°	IR, NMR	 **25**	*A. caudatum* (petrol extract)	28
8-fernene $C_{30}H_{50}$, 191°-92° $[\alpha]_D + 18°$ ($CHCl_3$)	UV, IR, NMR, EIMS	 **26**	*A. pedatum* (hexane extract of leaves)	23
7-fernene $C_{30}H_{50}$, 211°-13° $[\alpha]_D - 18°$ ($CHCl_3$)	UV, IR, NMR, EIMS	 **27**	*A. pedatum* (hexane extract of leaves)	23
23-hydroxyfernene $C_{30}H_{50}O$, 190° $[\alpha]_D - 12.4°$ ($CHCl_3$)	IR, NMR, EIMS, HRMS	 **28**	*A. incisum*	18
α-carotene monoepoxide $C_{40}H_{56}O$, 175°	—	 **29**	*A. venustum*	6

— Contd

Table 1 — Phytochemical constituents of *Adiantum* species — (Contd)

Compound, molecular formula, mp (°C), $[\alpha]_D$	Spectra recorded	Structure	Source	Reference
1	2	3	4	5
Leucopelargonidin $C_{15}H_{14}O_6$, 220° $[\alpha]_D$ +9°	—	 **30**	*A. venustum*	6
Prunin $C_{21}H_{22}O_{10}$, 225° $[\alpha]_D$ −42°	—	 **31**	*A. aethiopicum*	6
Hentriacontane $C_{31}H_{64}$, 68°	—	$Me(CH_2)_{29}Me$ **32**	*A. caudatum*	6
16-hentriacontanone (Palmitone) $C_{31}H_{62}O$ 82°	—	$Me(CH_2)_{14}CO(CH_2)_{14}Me$ **33**	*A. caudatum*	6
A diol $C_{30}H_{52}O_2$, 243°-44° $[\alpha]_D 20°$ + 14.84° ($CHCl_3$)	—	—	*A. capillus-veneris* (petrol extract)	31
3β-acetoxy-6α-hydroxy-hop-15,17(21)-diene $C_{32}H_{50}O_3$, 233°-35°	UV, IR, ^1H & ^{13}C-NMR, EIMS	 **34**	*A. lunulatum* (petrol extract of the whole plant)	32

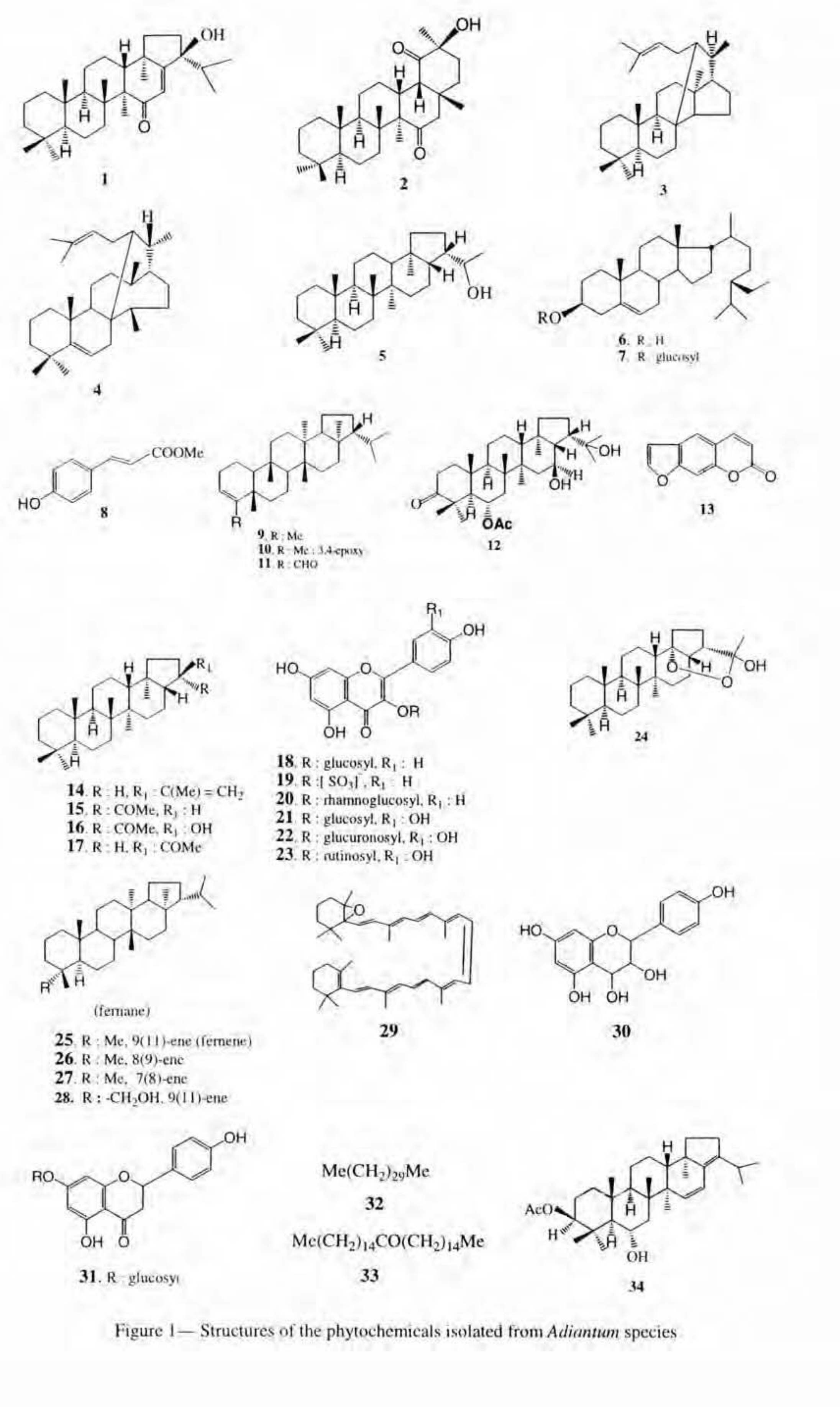


Figure 1— Structures of the phytochemicals isolated from *Adiantum* species

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