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Saponins of *Chlorophytum* species

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Abstract

The genus *Chlorophytum* (Liliaceae) owing to the presence of pharmacologically important saponins has attracted interest of the scientific community to investigate the chemistry of the saponins and study their cytotoxicity. Chloromaloside-A having cytotoxicity against cancer cell lines has been isolated from *C. malayense*, while saponins from *C. borivilianum* are gaining popularity as substitute for viagra. The paper presents a review of different saponins isolated from the *Chlorophytum* species and their pharmacological importance.

Introduction

The genus *Chlorophytum* (Liliaceae), widely distributed in the pantropical regions, is represented by more than 215 species (Li et al., 1990). They are perennial rhizomatous herbs. Rhizomes are often short and inconspicuous while roots are usually thicker or slightly fleshy. They are mainly cultivated for their ornamental flowers. Traditionally, roots of these species are reputed to posses various pharmacological utilities having saponins as one of the important phytochemical constituents. Saponins consist of a sugar moiety, usually containing glucose, galactose, glucuronic acid, xylose, rhamnose or methylpentose, glycosidically linked to a hydrophobic aglycone (sapogenin) which may be triterpenoid or steroid in nature. The oligosaccharide chain is normally attached at C_3 position (monodesmosidic) but many saponins have an additional sugar moiety at the C_{26} or C_{28} positions (bidesmosidic).

Several reviews have been published in recent years on various aspects of plant saponins (Kensil, 1996; Barr et al., 1998; Sen et al., 1998; Yoshiki et al., 1998). More recently Francis et al. (2002) have reviewed the biological action of saponins in animal systems and accordingly saponins exhibit diverse biological actions in animals which include membrane-permeabilising, immunostimulant, hypocholesterolaemic and anticarcinogenic properties. They have also been found to significantly affect growth, feed intake and reproduction in animals. These structurally diverse compounds have also been observed to kill protozoans and molluscs, to be antioxidants, to impair the digestion of protein and the uptake of vitamins and minerals in the gut, to cause hypoglycaemia, and to act as antifungal and antiviral agents. Demonstration of the physiological, immunological and pharmacological properties of saponins have incited considerable interest in these substances among the scientific community. This review summarizes the work done so far on chemical investigations of various *Chlorophytum* species with specific reference to saponins and their pharmacological importance.

Saponins of *C. malayense*

C. malayense Ridley is indigenous to south-east Asia and south-west of Yunnan province of China. Li et al. (1990) isolated four steroidal saponins (1–4) from *C. malayense* rhizome by methanolic

extraction followed by *n*-butanol partitioning to get crude saponin and subsequent separation on silicagel column chromatography with $CHCl_3$–MeOH–H_2O (50:10:1) to (10:10:1) gradient. These four saponins, termed as chloromaloside A, B, C and D (1–4, Figure 1) have neo-hecogenin and neotigogenin as the aglycone moiety with various substitutions of sugar moiety. Chloromaloside – A, C and D belong to 25 (S) spirostane series, while Chloromaloside-B (4) is found to be furostane type. Chloromaloiside A (1), isolated as colorless needles, is also the major saponin of *C. malayense* with 0.49% yield while yield of compound 2, 3, and 4 was 0.025, 0.074, and 0.018%, respectively. In a bioassay guided fractionation, Compound 1 also showed broad cytotoxicity against various human cancer cell lines (Qiu et al., 2000). The ED_{50} values varied from 1.4 to 5.00 μg/ml to different cell lines (Table 1) indicating moderate toxicity when compared to posi-

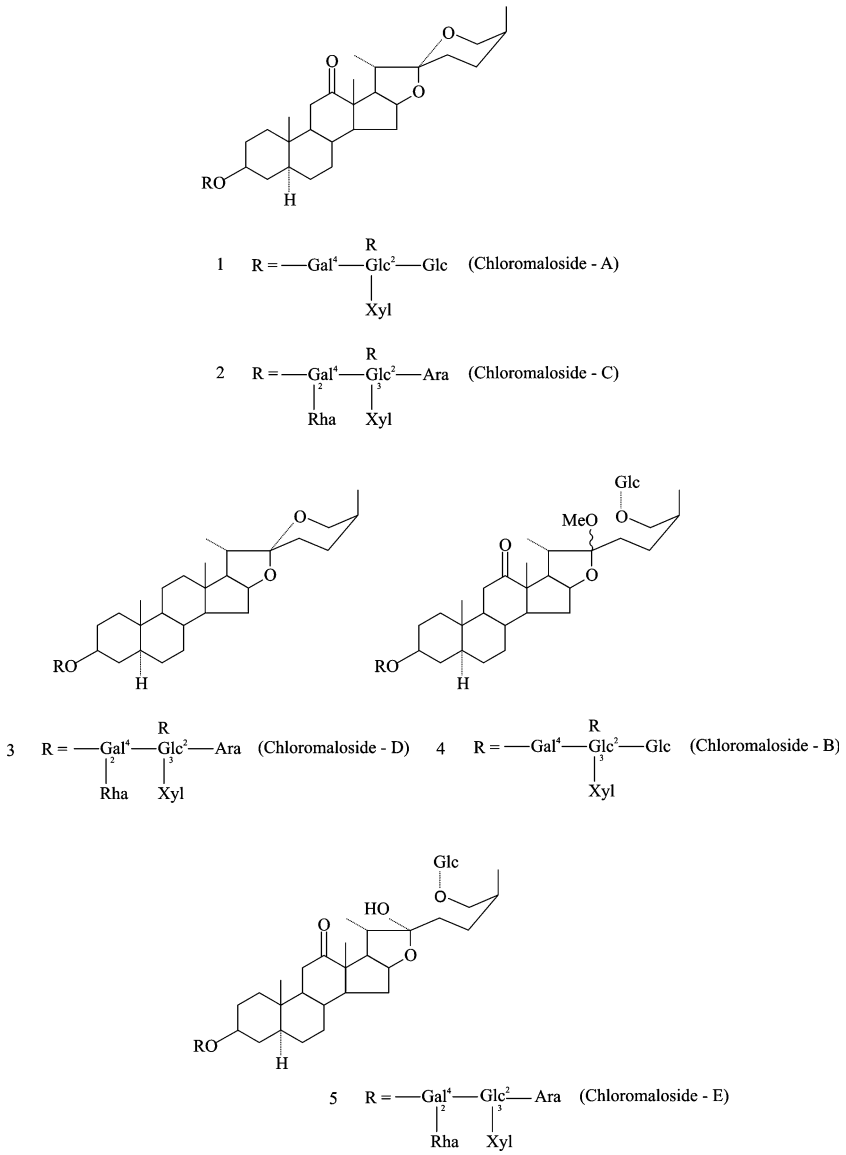


Figure 1. Saponins isolated from *C. malayense*.

Table 1. Cytotoxic activity of chloromaloside A.

Compound	ED_{50} values (μg/ml)							
	Cell Line[b] Lu-1	KB	KB-V (+VLB)	KB-V (–VLB)	LNCaP	BC1	Col2	ASK
Chloromaloside A	1.9	2.3	5.0	5.0	1.4	4.8	3.8	–

Key to cell lines used: Lu-1 = human lung cancer; KB = human oral epidermoid carcinoma; KB-V = vinblastine-resistant KB test in the presence (+VLB) or absence (–VLB) of 1 μg/ml vinblastine; LNCaP = hormone-dependent human prostate cancer; BC1 = human breast cancer; Col 2 = Human colon cancer; ASK = rat glioma.
Test compound that reverse astrocyte formation is scored as (+) and non-reverse astrocyte formation is scored as (–) in the ASK test at the concentration of 100 mg/ml.
Source: Qiu et al. (2000).

tive control colchicine and ellipticine. While, other compounds are still to be investigated for their pharmacological activity.

A new steroid saponin named as chloromaloside E (5) has been isolated recently by the same group (Yang and Yang, 2000) having neohecogenin as aglycone. So far, activity of this compound has not been tested.

Saponins of *C. comosum*

Chlorophytum comosum is native to South Africa and is used for the treatment of bronchitis, fracture, and burns as part of traditional medicine in China. It is commonly known as spider plant. Seven anti-tumour promoter steroidal saponins (6–12, Figure 2) have been isolated by silicagel, reverse phase RP18, and Diaion HP-20 chromatography of crude saponin obtained by partitioning of methanol extract with n-butanol from this species (Mikami et al., 1996).

Compound 6–9 are known spirostanol saponins while compound 10, 11 and 12 are new spirostanol pentaglycosides embracing β-D-apiofuranose. The saponins of *C. comosum* are different from saponins of *C. malayense* having aglycone based on (25R)-Spirostan series as tigogenin, gitogenin and hecogenin, while saponins of *C. malayense* are based on (25S) spirostan series as neotigogenin and neo-hecogenin. The isolated saponins have been evaluated for *in vitro* anti tumor promoter activity

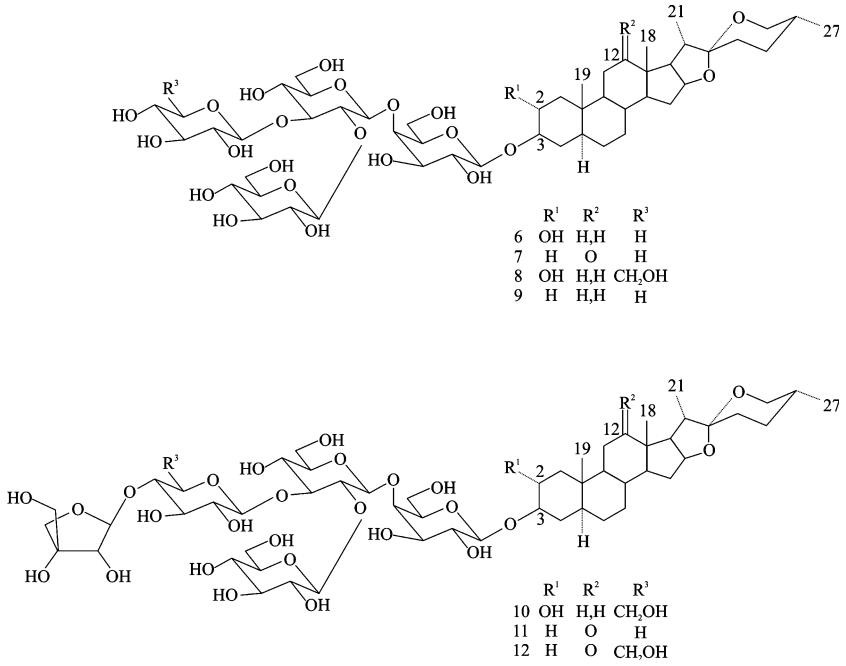
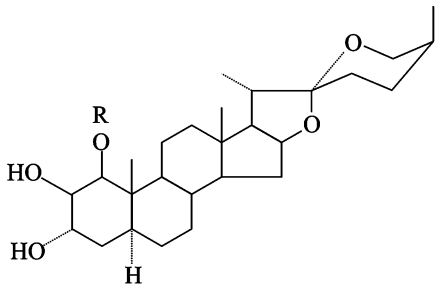


Figure 2. Saponins isolated from *C. comosum*.



13 R = Xyl $\xrightarrow{3}$ Glc $\xrightarrow{3}$ Glc $\xrightarrow{3}$ Glc (Arundinoside - A)

Figure 3. Saponins isolated from *C. arundinaceum*.

by measurement of the inhibitory activity on TPA-stimulated ^{32}P-incorporation into phospholipids of HeLa cells. Compounds 7, 8, 10, 11 and 12 (Figure 2) were found cytotoxic to HeLa cells at 50 μg/ml concentration (Mikami et al., 1996). Compounds 6 and 9 exhibited 23.1% at 57.8% inhibition at 50 μg/ml without cytotoxicity towards HeLa cells. However, more investigations are required against various other human cancer cell lines. Further, these species are traditionally known to be used against bronchitis, however, the active principle responsible for the cure of bronchitis is yet to be investigated.

Saponins of *C. arundinaceum*

Chlorophytum arundinaceum Baker is found in India and is reported to possess adaptogenic activity (Tandon and Shukla, 1995). Gupta et al. (1979) isolated glucopyranoside from the fruits of *C. arundinaceum*. Four sapogenins – stigmasterol, tigogenin, neogitogenin, and tokorogenin – identified on the basis of mass spectral fragmentation – were isolated from this species (Tandon and Shukla, 1992). The same group further identified several compounds *viz.,* nonacosane, tetracosanoinc, triacontanoc, 4-hydroxyl-8, 11-oxidoheneicosanol and pentacosyl docosanoate (Tandon et al., 1992). 2, 2′, 4, 4′-tetrahydro bibenzyl xyloside has also been reported from the same species for the first time in family Liliaceae (Tandon and Shuka, 1993). Later the group isolated a new tokorogenin based saponin arundinoside-A (Tandon and Shukla, 1997). However, no reports are available on the pharmacological assays of the compounds isolated from these species.

Saponins of *C. borivilianum*

C. borivilianum is commonly known as 'Safed musli' in India. Its roots are widely used for various therapeutic applications in the Ayurvedic and Unani (Oudhia and Tripathi, 1999) systems of medicine. It is known to cure many physical illness and weaknesses. It has spermatogenic property and is found useful in curing impotency. It is also reported to cure diabetes, arthritis and increasing general body immunity. However, in recent years its effectiveness in increasing male potency has become very popular and is now considered as an alternative to 'Viagra'. Because of this popularity, many farmers in India are now cultivating this species and earning profits by selling its dried roots. A demand for 35,000 tons per annum of *C. borivilianum* roots has been estimated. The roots are reported to contain 42% of carbohydrates, 8–9% of proteins, 3–4% fibres, and 2–17% (Bordia et al., 1995) of saponins.

Among all the species of *Chlorophytum* present in India, *C. borivilianum* produces the highest yield of roots along with the highest saponin content (Bordia et al., 1995). However, the saponin content is found to be affected by genotype and environment as evident from Table 2 and Table 3. When same accessions were collected from forest and cultivated at sandy loam soil at CTAE, Udaipur and clay loam soil of RCA, Udaipur showed varied response of genotypes to the locations, in terms of saponin content (Table 3).

Table 2. Chemical composition of different samples of *C. borivillianum* roots.

Chemical Parameter	Content (%)		
	Market sample[a]	RC-15[b]	Different genotypes[c]
Carbohydrates	42.00	39.10	16.4–65.8
(a) Reducing sugar	–	22.20	–
(b) Non-reducing sugar	–	16.90	–
Protein	8.50	8.50	3.8–13.0
Saponin	2.00–3.00	4.00	Traces – 17.0
(a) Sugars	–	3.8	–
(i) Galactose	–	0.73	–
(ii) Glucose	–	0.76	–
(iii) Xylose	–	0.74	–
(iv) Arabinose	–	0.79	–
(v) Rhamnose	–	0.78	–
(b) Sapogenin	0.17	0.18	–
Aqueous extract	40.00	30.00	–
Root fiber	3.00–4.00	5.00	–

Source: Bordia et al. (1995).
– Data not available.
[a]Root samples collected from local market.
[b]Elite accession of *C. borivillianum*.
[c]Different genotypes collected from Udaipur.

Genotype RC-14 yielded saponin as high as 9.3%, while at the same site other genotype RC-28 yielded only 1.8% saponin. Further, this species has not been investigated for its phytochemical constituents. In spite of its great popularity, there is no report on the characterization of saponins from this species. This emphasizes the need for evaluation of variations in saponin content and selection of ecotypes.

A summary of the sapogenins and glycosides isolated from various *Chlorophytum* species is presented in Table 4. The review reveals that *Chlorophytum* species hold great promise for the medicinal market due to the presence of valuable saponins. Scientific investigations oriented towards the identification of active principles will provide valuable insights for wider acceptability of species for the cure of various ailments.

Table 3. Effect of environment on saponin content of *C. borivillianum*.

C. borivillianum Collection No.	Saponin (%)		
	Forest Produce	CTAE Produce[a]	RCA Produce[b]
RC-1	1.8	5.0	2.4
RC-6	–	7.0	3.1
RC-8	–	8.6	1.4
RC-14	–	9.3	–
RC-15	6.3	–	Trace
RC-19	–	5.3	7.3
RC-22	–	2.8	8.3
RC-28	–	1.8	1.5

Source: Bordia et al. (1995).
[a]CTAE = College of Agricultural Engineering and Technology Farm, Udaipur.
[b]RCA = Rajasthan College of Agricultural Farm, Udaipur.
– Data not available.

Table 4. Steroidal sapogenins and glycosides isolated from different species of *Chlorophytum*.

Constituents	Source	Activity	Reference
Sapogenins			
Gitogenin	*C. comosum*	Anti-tumour	Mimaki et al. (1996)
Hecogenin	*C. comosum*	Anti-tumour	Mimaki et al. (1996)
Tigogenin	*C. comosum*	Anti-tumour	Mimaki et al. (1996)
	C. arundinaceum	–	Tandon et al. (1992)
Stigmasterol	*C. arundinaceum*	–	Tandon et al. (1992)
Neo-hecogenin	*C. malayense*	–	Li et al. (1990)
	C. malayense	Anti-tumour	Qiu et al. (2000)
Neo-gitogenin	*C. arundinaceum*	–	Tandon et al. (1992)
Tokorogenin	*C. arundinaceum*	–	Tandon et al. 1992
Glycosides			
Chloromaloside A	*C. malayense*	Antitumour	Qiu et al. (2000) and Li et al. (1990)
Chloromaloside B	*C. malayense*	Antitumour	Li et al. (1990)
Chloromaloside C	*C. malayense*	Antitumour	Li et al. (1990)
Chloromaloside D	*C. malayense*	Antitumour	Li et al. (1990)
Chloromaloside E	*C. malayense*	Antitumour	Yang and Yang (2000)
Gitogenin glycosides	*C. comosum*	Antitumour	Mimaki et al. 1996
Hecogenin glycosides	*C. comosum*	Antitumour	Mimaki et al. (1996)
Tigogenin glycosides	*C. comosum*	Antitumour	Mimaki et al. (1996)
Stigmasterol-β-D-glucopyranoside	*C. arundinaceum*	Antitumour	Tandon et al. (1992)

– Data not available.

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