International Organization for Chemical Sciences in Development

Working Group on Plant Chemistry

CHEMISTRY, BIOLOGICAL AND PHARMACOLOGICAL PROPERTIES OF AFRICAN MEDICINAL PLANTS

Proceedings of the first International IOCD-Symposium
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Institut de Pharmacognosie et Phytochimie, Université de Lausanne, BEP, CH-1015 Lausanne, Switzerland and Department of Pharmacy, University of Zimbabwe, P.O. Box M.P. 167, Harare, Zimbabwe

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Cover photos.
African traditional healer and *Harpagophytum procumbens* (Pedaliaceae)

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Contents

9. Phytochemical studies of medicinal plants from Malawi

J. D. MSONTHI[1], K. HOSTETTMANN[2] AND M. MAILLARD[2]

[1]*Chemistry Department, University of Swaziland, Private Bag 4, Kwaluseni, Swaziland and* [2]*Institut de Pharmacognosie et Phytochimie, BEP Université de Lausanne, CH-1015 Lausanne, Switzerland*

Introduction

Medicinal plants from Malawi have been analyzed phytochemically and biologically largely through collaboration with the Universities of Lausanne, Switzerland; of Rome, Italy and the Technical University of Berlin, Germany.

The selection of plants for investigation has been based on interviews with traditional healers of the Herbalists Association of Malawi under the Chairmanship of Mr. James Gangire Phiri.

A large percentage of the plants selected by the traditional healers gave positive leads to the activity claimed from their medicinal uses. We also used random selection based on literature reviews and chematoxonomic relationships. The studies on these plants included collection, extraction, purification, *in vitro* activity-guided fractionation, isolation of active principles, derivatization and further *in vitro* bioassays.

Included here are antitumoral, antifungal, antibacterial, molluscicidal, hypoglycemic, antifeedant and, to some extent, immunostimulant activities.

Depending on the activity of the compounds, some of them could be used directly after further studies on toxicity, biodegradation and efficacy through standardization.

This chapter covers some of the reports on phytochemistry of medicinal plants from Malawi, with emphasis on biologically active compounds. In order to clarify the organization of this chapter, the results have been separated into three main groups: compounds exhibiting molluscicidal activity, fungitoxic natural products and miscellaneous structures

Results

Molluscicidal activity

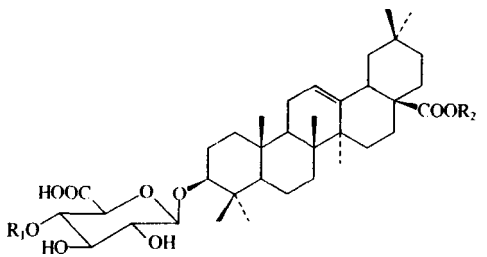
Schistosomiasis (bilharzia) is a parasitic disease affecting millions of people in Africa, as well as in South America and Asia. It is caused by nematodes (*Schistosoma* sp.) that colonize the bladder or intestines. The parasite life cycle needs contact with water sources where the parasite's eggs can hatch into miracidia and enter freshwater snails, such as *Biomphalaria glabrata, Bulinus globosus*, etc. Once in the snail, thousands of cercaria are produced which can eventually penetrate the intact skin of humans in contact with the water source in question.

One way to prevent the transmission of the disease is to destroy the intermediate host of the parasite, by the use of molluscicides.

Plants have been shown (Hostettmann and Marston 1987) to be an interesting source of new natural molluscicides, and those originating in Malawi are listed below.

Talinum tenuissimum Dinter (Portulacaceae)

The tubers of *Talinum tenuissimum* are used in Malawi, according to traditional healers, for the treatment of schistosomiasis. In the course of systematic screening studies on compounds with molluscicidal activity, Gafner *et al.* (1985) noticed that the aqueous extract of the tubers of *T. tenuissimum* also killed *B. glabrata* snails, at a concentration as low as 25 ppm within 24 hours. This observation led to the isolation of new triterpenoid saponins (**1-3**from the crude plant extract.



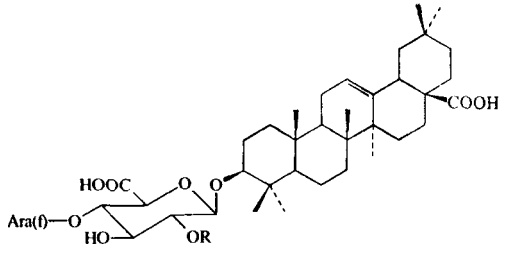
	R_1	R_2
(1)	xylose	glucose
(2)	xylose	H
(3)	H	H

The major bidesmosidic saponin **1** isolated from the methanolic extract was inactive against *B. glabrata*, whereas the monodesmosidic saponins **2** and **3** killed snails at a concentration of 1.5 ppm within 24 hours.

Cussonia spicata Thumb. (Araliaceae)

The bark of *Cussonia spicata* and other species of the genus *Cussonia* are used in African traditional medicine against malaria. An infusion of the roots of *C. spicata* prevents skin irritation and is antifebrile.

The water extract of the stem bark of *Cussonia spicata* showed an activity of 400 ppm within 24 hours against *B. glabrata* snails. This activity was strong enough to undertake a phytochemical investigation of this plant and two molluscicidal saponins (**4**, **5**) were finally isolated from the stem bark of *C. spicata* using MPLC on a RP-8 support.



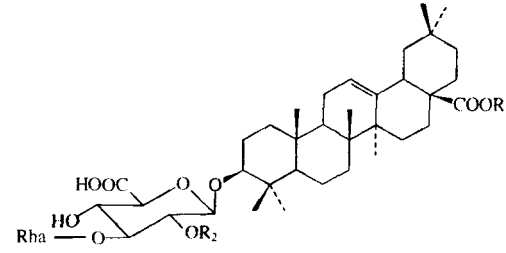
(**4**) R = H

(**5**) R = galactose

Saponin **4** was toxic to *B. glabrata* at 12.5 ppm and compound **5** at 100 ppm. Furthermore, a preliminary screening for spermicidal activity against human spermatozoids showed an activity at a concentration of 1 ppm and 3 ppm within 3 minutes for saponins **4** and **5**, respectively (Gunzinger *et al.* 1986)

Diospyros zombensis White (Ebenaceae)

Numerous *Diospyros* species are utilized in Africa as chewing sticks, but *D. zombensis* is especially used by the traditional healers of Malawi for the treatment of schistosomiasis. In addition to flavonoid glycosides and biologically active naphthoquinones (7-methyljuglone (**12**, see later), and isodiospyrin), molluscicidal saponins were isolated for the first time in the Ebenaceae family from the methanol extract of the root bark (Gafner *et al.* 1987).

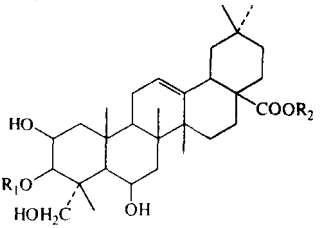


	R_1	R_2
(**6**)	H	H
(**7**)	glucose	H
(**8**)	glucose	xylose
(**9**)	H	xylose

As generally observed in nature, the bidesmosidic saponins (**7** and **8**) were not active against *B. glabrata*, whereas the monodesmosidic saponins **6** and **9** exhibited strong activity (3 ppm within 24 hours)

Clerodendrum wildii Moldenke (Verbenaceae)

Mi-saponin A (**10**), another molluscicidal triterpenoid saponin, has been isolated from the roots of *Clerodendrum wildii*, a medicinal plant from Malawi claimed to be active against intestinal parasites, or in the treatment of malaria. This bitter bidesmosidic saponin showed toxicity towards *B. glabrata* snails (25 ppm) (Toyota *et al.* 1990).

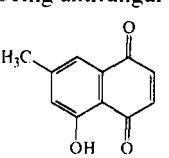


(**10**) R_1=Glc; R_2=-Ara^2-Rha^4-Xyl^3-Rha

(**11**) R_1=R_2=H Protobassic acid

Fungicidal activity

Due to the increasing incidence of opportunistic systemic mycoses associated with AIDS or treatment by immunosuppressive drugs, there is an urgent need to find new antifungal compounds. The study of medicinal plants from Malawi led to the isolation of compounds of diverse structures that showed toxicity activity against a phytopathogenic fungus *Cladosporium cucumerinum* in a TLC bioassay using the spores of this fungus as target organism (Homans and Fuchs 1970). For example, the triterpene glycoside Mi-saponin A (**10**) inhibited the growth of this fungus in the TLC bioassay at 1.5 µg. Its aglycone, protobassic acid **11** was also active in this test when 3.3 µg were spotted onto the TLC plate (Toyota *et al.* 1990). The naphthoquinone 7-methyl juglone (**12**) isolated from the twigs of *Diospyros usambarensis* (Marston *et al.* 1984) or from the root bark of *D. zombensis* (Gafner *et al.* 1987) is one of the most active compounds that have been so far encountered in the *C. cucumerinum* bioassay, being antifungal even at 0.025 µg.



(**12**)

Synthetic antimycotic compounds like the imidazole and triazole derivatives (*i.e.* miconazole, propiconazole and sulconazole) have been tested in this bioassay as positive controls. They inhibited fungal growth at 1, 0.1 and 0.01 µg, respectively, when spotted onto the TLC plate. Azoles act through interference with ergosterol biosynthesis. Sulconazole is thought to perturb also the glucan-synthase or chitin-synthase and this might account for its efficacy against *C. cucumerinum* (Rahalison *et al.* 1994).

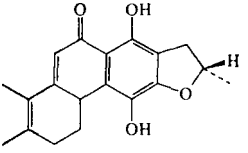
The fungicidal activities of different crude extracts of medicinal plants from Malawi, or of isolated compounds were also measured against human pathogenic microorganisms (Rahalison 1994).

Clerodendrum uncinatum Schinz. (Verbenaceae)

In Malawi, the powdered root bark of *Clerodendrum uncinatum* is supposed to have contraceptive activity. A decoction of these roots is also used as gargle for sore throat and this plant is claimed by the healers to cure schistosomiasis.

In a preliminary biological screening, it was found that the petroleum ether extract of these roots showed interesting fungicidal activity in the TLC bioassay using *C. cucumerinum* spores.

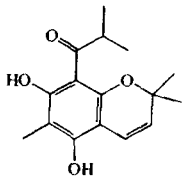
Isolation of the main active compound, the hydroquinone diterpene uncinatone (**13**) was achieved by column chromatography on silicagel and further crystallization. Uncinatone was shown to inhibit the growth of the fungus down to 0.5 µg in the TLC assay (Dorsaz *et al.* 1985).



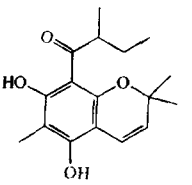
Uncinatone (**13**)

Hypericum revolutum Vahl. (Guttiferae)

Hypericum revolutum is a shrub native to South-East Africa, growing at high altitude in open mountain grassland at the margins of evergreen forest. The light petroleum ether extract of this plant was fungicidal in the TLC assay. Two new benzopyran ketones (**14, 15**) were responsible for this activity. In addition four pentacyclic dimers (**16-19**) of these products were also isolated from the lipophilic leaves and twigs extract of this plant. However, these compounds were devoid of any activity (Décosterd *et al.* 1987). From the same extract, cytotoxic products, hyperevolutin A and B (**20-21**), derivatives of the known active principle hyperforin, were also isolated (Décosterd *et al.* 1989).



(14)



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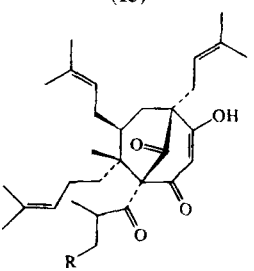
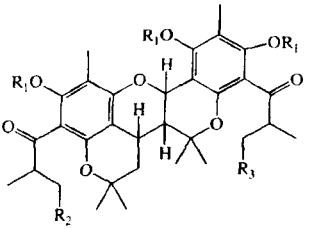




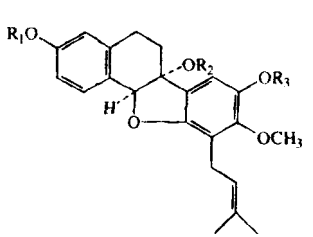
	R_1	R_2	R_3
(16)	H	H	H
(17)	H	H	CH_3
(18)	H	CH_3	H
(19)	H	CH_3	CH_3

(20) R=H Hyperevolutin A

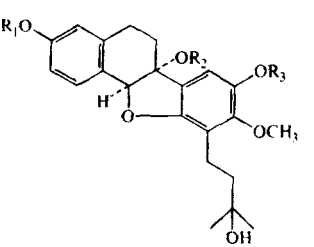
(21) R=CH_3 Hyperevolutin B

Dolichos marginata ssp. *erecta* E. Mey (Bak.) Verdc. (Leguminosae)

Some members of the genus *Dolichos* are used by the traditional healers to treat aches and pains. But the study of *Dolichos marginata* ssp. *erecta* (syn. *Sphenostylis erecta* E. Mey) was provoked by the observation that the lipophilic root extracts of this plant contained several components active in the TLC assay using the spores of *C. cucumerinum*. The major antifungal sphenostylins A-D (**22-25**) were isolated by a combination of medium and low pressure liquid chromatography.



R_1=R_3=CH_3, R_2=H sphenostylin A (**22**)
R_1= R_2=R_3=H sphenostylin B (**23**)



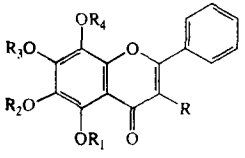
R_1= R_2=R_3=H sphenostylin C (**24**)
R_1=R_2=CH_3, R_3=H sphenostylin D (**25**)

The minimum amounts of sphenostylins A-D required to inhibit the growth of the fungus were respectively 6.25 µg, 10 µg, 50 µg and 20 µg (Gunzinger *et al.* 1988)

Helichrysum nitens Oliv. & Hiern (Asteraceae)

From the aerial parts of *Helichrysum nitens*, eight methoxylated flavonoids have been isolated (**26-33**), of which the majority exhibited strong activity against *C. cucumerinum* (Table 9.1). These compounds have been found externally deposited on the leaf and stem surfaces, suggesting that they should provide chemical barriers to the invasion of micro-organisms. Indeed, the methylated lipophilic flavonoids are especially suitable as protection against fungi and bacteria because of their ease in penetrating membranes. For this reason, the external accumulation of antifungal methylated flavones in *H. nitens* is of ecological significance (Tomas-Barberan *et al.* 1988).

Table 9.1. Antifungal epicuticular flavonoids from *H. nitens*



	R	R_1	R_2	R_3	R_4	Af.A [µg]
26	H	OCH_3		OCH_3		1
27	OCH_3	OCH_3		OCH_3		1
28	H	OCH_3	OCH_3	OCH_3		5
29	OCH_3	OCH_3	OCH_3	OCH_3		5
30	H	OCH_3	OCH_3	OCH_3	OCH_3	2
31	OCH_3	OCH_3	OCH_3	OCH_3	OCH_3	5
32	H	OH	OCH_3	OCH_3		50
33	H	OH	OCH_3	OCH_3	OCH_3	not active

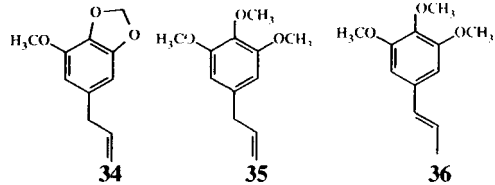
Af.A: Antifungal activity: minimum quantities required to inhibit growth of spores of *C. cucumerinum* on TLC plate

This table also demonstrates how the antifungal activity shown by the fully methylated flavonoids decreases dramatically when the methyl group at position 5 is removed.

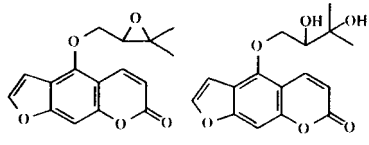
Diplolophium buchanani (Benth. ex Oliv.) Norman (Apiaceae)

Three phenylpropanoids and two furanocoumarins have been obtained from *Diplolophium buchanani* almost exclusively by centrifugal partition chromatography. Fractionation of this plant, endemic to the Zomba and Mulanje Plateaux of Malawi, afforded myristicin (**34**), elemicin (**35**), trans-isoelemicin (**36**), oxypeucedanin (**37**) and oxypeucedanin hydrate (**38**) (Table 9.2).

Table 9.2. Antifungal and larvicidal activities of compounds isolated from *Diplolophium buchanani*



34 **35** **36**



37 **38**

Compound	Antifungal[a] activity	Larvicidal[b] activity
34	20 µg	25 ppm
35 + **36**	8 µg	100 ppm
37	1 µg	25 ppm
38	10 µg	inactive
Miconazole	1 µg	
β-Asarone		16 ppm

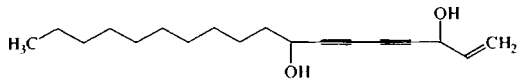
[a] minimum quantity required to inhibit growth of spores on TLC plate

[b] LD_{100} after 24 hours

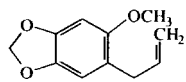
Concerning the biological activities, the efficacy of the strongest antifungal compound, oxypeucedanin **37** was comparable to the commercially available fungicide miconazole. The other isolated compounds were also active but to a lesser degree. These five products were also tested in a larvicidal bioassay using *Aedes aegypti* larvae as target. Myristicin (**34**) and oxypeucedanin (**37**) were larvicidal at concentrations similar to that of the reference compound β-asarone (Marston *et al.* 1995)

Antifungal compounds isolated from medicinal plants from Malawi present various other structural features. For example, the antimalarially used leaves of *Heteromorpha trifoliata* (Umbelliferae) furnished the fungicidal polyacetylene falcarindiol (**39**) and sarisan (**40**), an isomer of myristicin after flash and low-pressure liquid chromatography (Villegas *et al.* 1988). Furthermore, a combination of different techniques of column liquid chromatography allowed the isolation of new naphthoxirene derivatives (**41-44**) and their glycosides from the fungitoxic dichloromethane extract of the root bark of *Sesamum angolense* (Pedaliaceae) (Potterat *et al.* 1987). From the same plant, Potterat *et al.* (1988) described the isolation of the inactive iridoid glucosides sesamoside (**45**), phlomiol (**46**),

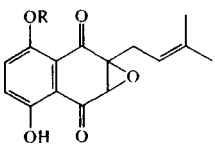
pulchelloside I (**47**) and 6β-hydroxypolamiide (**48**) together with the phenylpropanoid glycoside verbascoside.



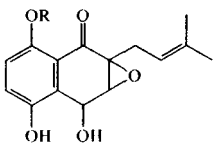
falcarindiol (**39**)



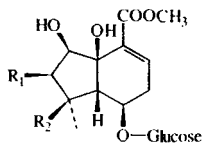
sarisan (**40**)



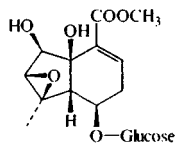
(**41**) R = H
(**42**) R = Glucose



(**43**) R = H
(**44**) R = Glucose



(**45**) R_1 = OH R_2 = OH
(**46**) R_1 = OH R_2 = OH
(**47**) R_1 = OH R_2 = OH



(**48**)

Finally, from the lipophilic crude extract of *Valeriana capense* (Valerianaceae), a series of antifungal valepotriates (including valtrate, isovaltrate, didrovaltrate, chlorovaltrate, valtrate hydrine B4, homovaltrate, dihomovaltrate, homodidrovaltrate, diavaltrate and isovaleroxyhydroxydidrovaltrate) was isolated by a combination of medium-pressure and semi-preparative high-pressure liquid chromatography. Although valepotriates were already isolated in the 1960's, their antifungal activity had not been described before this study (Fuzzati *et al.* 1996). In this work, valtrate was shown to possess a wide spectrum of antifungal activities, in particular against different phytopathogenic fungi (*C. cucumerinum*, *Erysiphe graminis*, etc.) where it gives similar toxicity to commercially used synthetic products.

Miscellaneous

In this section, an non-exaustive series of natural products isolated from medicinal plants from Malawi will be presented. Some of them, in particular the xanthones, are of crucial interest in the discovery new monoamine oxidase inhibitors that should eventually play a role in the management of depression. Others are interesting growth inhibitors of carcinoma cell lines and in some cases the isolation of the products was only been done from a phytochemical point of view.

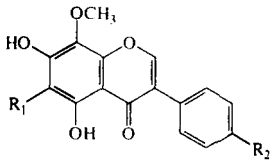
Disturbances in monoamine oxidase (MAO) levels have been reported in a series of disorders (*i.e.* Parkinson's disease, Huntington's chorea, depression, anxiety, etc.). Thus, substances having modulating action on this enzyme should be of great pharmacological interest.

Xanthones from plant sources have been shown to be strong inhibitors of MAO (Suzuki *et al.* 1980, 1981; Schaufelberger and Hostettmann 1988). In order to find further active xanthones, some medicinal plants of Malawi have been investigated.

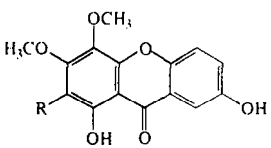
Polygala virgata Thumb. and *Polygala nyikensis* (Polygalaceae)

The genus *Polygala* (containing *ca* 500 species) is known to be a source of xanthones. *P. virgata* is a small shrub up to 1.5 m tall which is quite common on the high plateaux of Malawi. Fractionation of the dichloromethane extract of the root extract of this plant afforded different sinapoyl glycosides (Bashir *et al.* 1993), together with three new methoxylated isoflavones (**49-51**), and xanthones (**52, 53**) (Bashir *et al.* 1992).

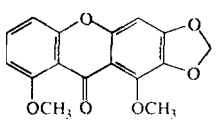
The analysis of the lipophilic extract of the roots of *P. nyikensis*, an endemic species from the Nyika Plateau of northern Malawi, showed in preliminary screening the presence of at least two antifungal compounds. Isolation of these biologically active products afforded four simple xanthones (**54-57**), two of which were active against the plant pathogenic fungus *C. cucumerinum* at the minimal amounts of 0.6 and 0.4 µg, respectively (Marston *et al.* 1993).



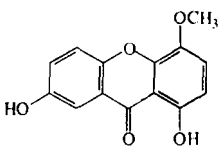
(**49**) R_1=OCH_3, R_2=OH
(**50**) R_1=OCH_3, R_2=OCH_3
(**51**) R_1=H, R_2= OCH_3



(**52**) R=H
(**53**) R= OCH_3



(**54**)



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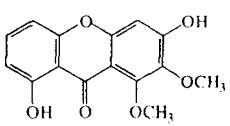

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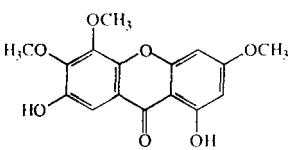


(**57**)

Ectiadiopsis oblongifolia (Meisn.) Schlecht. (Periplocaceae) and *Securidaca longipedunculata* Fresen. (Polygalaceae)

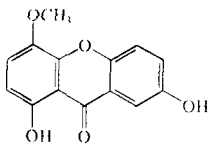
E. oblongifolia is a shrub of Western Africa, where it is used as a medicinal plant with various indications (aphrodisiac, stomach diseases, pains, etc.). Periplocaceae are classified by some authors as a distinct family, and by other as a subfamily of Asclepiadaceae.

The methanolic extract of the bark of this plant have been shown to contain two xanthone pigments (**58, 59**) (Galeffi *et al.* 1990). This discovery was of

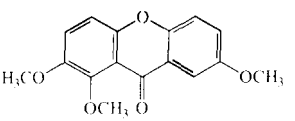
chemotaxonomic significance, owing to the absence of reports on the occurrence of this type of compound in Asclepiadaceae.

Securidaca longipedunculata is widely utilized in Africa as medicinal plant. Many healers have used this plant as a general remedy to treat different diseases and particularly to cure rheumatism, an indication which can be related to the large amount of methylsalicylate in the roots. These are quite toxic and some cases of death by introduction into the vagina have been reported. Also ingestion of the oil obtained from the seeds is reported to be fatal within a few hours.

Phytochemical investigation of the roots of *S. longipedunculata* collected in Malawi afforded one xanthone (**60**) with the rare oxygenation pattern 1,2,7 (Galeffi *et al.* 1990). Xanthones are known to be present in some representatives of the Polygalaceae family, but have only been found in the genus *Polygala*. Most of the isolated xanthones possess a typical 1,2,3 oxygenation pattern (Bashir 1993).



(58)



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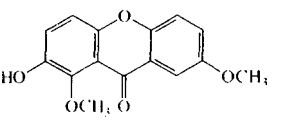


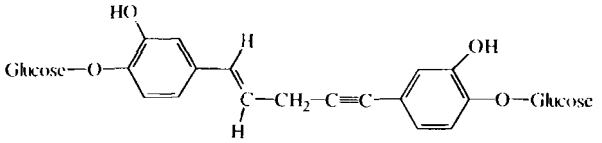
(60)

Chironia krebsii Griseb. (Gentianaceae)

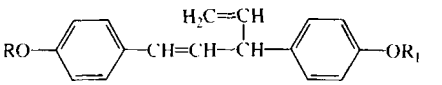
Rpresentatives of the Gentianaceae family are also known to be natural sources of xanthones. The phytochemical investigation of the roots and aerial parts of the endemic species *Chironia krebsii* allowed the isolation and the characterization of a series of xanthone aglycones together with some glycosides (Wolfender *et al.* 1991). This work and further studies of the content of this plant, using new analytical methods including LC-MS techniques form a major part of chapter 2.

Hypoxis nyasica Bak. and *H. obtusa* Burch. (Hypoxidaceae)

The rhizomes of *Hypoxis* sp. are used in African traditional medicine for the treatment of urinary infections, prostatic hypertrophy and internal cancer (Watt and Breyer-Brandwijk 1962). Separation of the methanolic extract of the rhizomes of *H. nyasica*, using different chromatographic techniques, including liquid-liquid partition chromatography, afforded nyasoside (**62**) and the mononyasines A and B (**63**, **64**), three glucosides of nyasol (**65**), together with the known norlignan diglucoside hypoxoside (**61**) (Messana *et al.* 1989).

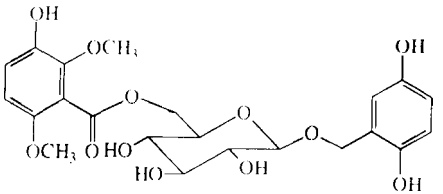


hypoxoside (**61**)



R=R_1=glucose: nyasoside (**62**)
R=H; R_1=glucose: mononyasine A (**63**)
R=H; R_1=glucose: mononyasine B (**64**)
R=R_1=H: nyasol (**65**)

The investigation of the methanolic extract of the whole fresh plant of *H. obtusa* has led to the isolation of a new phenolic glycoside named obtusaside (**66**) (Msonthi *et al.* 1990)

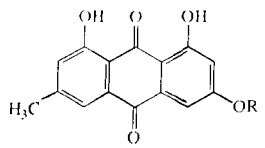


Obtusaside (**66**)

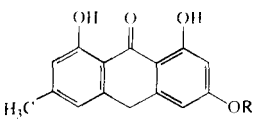
Psorospermum febrifugum Spach (Guttiferae)

Psorospermum febrifugum is a shrub which grows in many parts of Africa. The roots are used for treating wounds and the leaves and bark for skin diseases. It is supposedly a febrifuge and antileprous. Like many members of the Guttiferae, a yellow resin can be obtained from the bark and root bark.

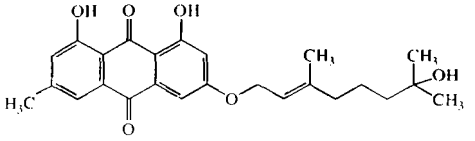
A series of anthracene and anthraquinone derivatives (**67-71**), of which the new anthraquinone (**69**) and the new tetrahydroanthracene (**70**), were isolated from the root bark using a combination of flash-, low-pressure-chromatography on reversed phase and centrifugal-TLC. These compounds show *in vitro* cytoxic activity against the Co-115 human carcinoma cell line (Table 9.3) (Marston *et al.* 1986).



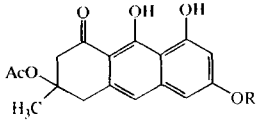
(**67**)



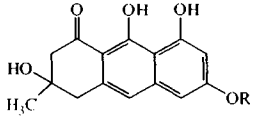
(**68**)



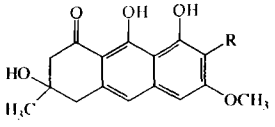
(**69**)



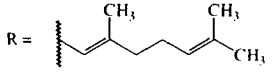
(**70**)



(**71**) Vismione D



(**72**)



R = geranyl

Table 9.3. Cytotoxicities of *P. febrifugum* anthranoids to the human colon carcinoma cell line Co-115 after a 5 day incubation period

Compound	LD_{50} (μg/ml)
67	>10
69	>10
68	4.3
70	3.8×10^{1}
71 (vismione D)	1.5×10^{1}
5-Fluorouracil	6.5×10^{-2}
Vinblastine	5.5×10^{-3}

The isolated products gave varying degrees of cytotoxicity. While the two anthraquinones **67** and **69** were inactive, the two major components of the petroleum ether extract of the root bark of *P. febrifugum*, the tetrahydroanthracenes **70** and **71** exhibited major and reproducible toxicity to the Co-115 human colon carcinoma cell line. Their cytotoxicities approached the LD_{50} found for the clinically-important antitumor agent 5-fluorouracil, but they were less active than vinblastine, an antileukemic alkaloid isolated from *Catharanthus roseus* (Apocynaceae).

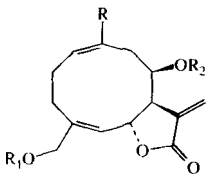
In a effort to isolate more important quantities of the biologically active constituents of *P. febrifugum*, a reinvestigation of the root bark has been performed. Since the separation of the anthranoid constituents by flash chromatography and low pressure reversed-phase chromatography resulted in considerable loss of material, centrifugal partition chromatography (CPC) was

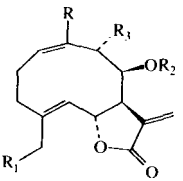
used. Thus, in a single CPC step (Sanki Cartridge system), three pure compounds **65**, **67** and **71** and a mixture of two anthranoid pigments (**71** and the minor component **72**) were obtained without any loss of material. A non-aqueous solvent system was used for their separation and a 100 mg sample of crude extract was separated within four hours using the upper phase of the solvent system nC$_6$H$_{14}$-MeCN-MeOH (40:25:10) as mobile phase (Marston *et al.* 1988).

Acanthospermum hispidum DC. (Asteraceae)

Traditional medicinal uses of *Acanthospermum hispidum* are numerous. It is used to treat stomach complaints, wounds, migraine. In Ivory Coast, a decoction is drunk as a purgative and counter-poison and an aqueous macerate is drunk and put into baths for arthritis and rheumatism. *Acanthospermum* species contain the characteristic canthospermolides, that show *in vitro* and *in vivo* anticancer activity. *Acanthospermum hispidum* has been investigated to look for more lactones of this type.

Phytochemical investigation of the aerial parts of *A. hispidum* led to the isolation of 10 sesquiterpene lactones (**73-82**), three of which are new naturally occurring compounds: 4*E*-acanthospermolide **73** and the 4*Z*-derivatives **76** and **82** (Jakupovic *et al.* 1986).





	R	R_1	R_2
73	CH_2OH	Ac	MeBu
74	CHO	H	MeBu
75	CHO	H	*i*Val

	R	R_1	R_2	R_3
76	CH_2OH	OH	*i*Bu	OAc
77	CH_2OH	OH	MeBu	OAc
78	CHO	H	MeBu	OAc
79	CHO	OH	MeBu	H
80	CHO	OH	*i*Val	H
81	CHO	OH	MeBu	OAc
82	CHO	OH	MeBu	OMe

Conclusion

As the above mentioned examples indicate, medicinal plants from Malawi can be considered as an important source of new biologically active compounds, with a wide range of pharmacological and therapeutical properties.

With the present socio-economic, socio-political and demographic constraints of the Third World, it is imperative that whatever research is performed must be converted from purely academic publications into a more practical utilization of

the biologically active compounds so far isolated. It is indeed the role of governments, together with universities, pharmaceutical companies and related private industries to jointly promote collaborative development of such bioactive compounds for medical use both locally, nationally and for export.

Acknowledgments

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