

Preface to the Second Edition

More than 12 years have passed since the first and very successful attempt was made to reproduce the thin layer chromatography (TLC) separation of 170 medicinal plant drugs in the form of color TLC fingerprints in a book. The reproduction of natural color photographs in UV 365 nm was a difficult undertaking at that time due to the relatively unsophisticated film and filter technology. The first German edition of this book with its appended English translation met with worldwide acceptance in the field of natural product chemistry and has remained an indispensable aid in the laboratory analysis of medicinal drugs.

Due to the higher demands now placed on plant drug quality, the introduction of herbal preparations with medicinal significance, and the increasing number of phytochemical preparations, the analytical and standardization procedures of the plants have gained even greater importance. We have tried to do justice to this development in this second edition.

This TLC atlas now includes about 230 medicinal plants of worldwide interest. The photographs of the TLC fingerprints and the descriptions of the characteristic compounds of each plant extract are a quick and reliable source for the identification and purity check of plant material and phytopreparations.

Most of the TLC systems are standard systems and have been optimized when necessary. In spite of other available analytic techniques, such as gas chromatography and high performance liquid chromatography, TLC still remains a most useful, quick, effective, and low-cost method for the separation and identification of complex mixtures of herbal drug preparations and plant constituents.

The authors are most grateful to Ms. Ute Redl for her comprehensive technical assistance. We also thank Ms. Veronika Rickl not only for the excellent quality of the photographs, but also for the layout of the TLC fingerprint pages in the book and for the drawing of the chemical formulae.

Munich, March 1996

SABINE BLADT
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2 Drugs Containing Anthracene Derivatives

The characteristic constituents of this drug group are anthraquinones, oxanthrones, anthranols and anthrones with laxative properties. The anthraquinones possess phenolic groups on C-1 and C-8 and keto groups on C-9 and C-10. In the anthrones and anthranols, only C-9 carries an oxygen function. In addition, a methyl, oxymethyl or carboxyl group may be present on C-3, and a hydroxy or methoxy group on C-6. Most compounds in this group are present in the plant as O-glycosides. The glycoside linkage is usually at C-1, C-8 or C-6-OH. C-Glycosides occur as anthrones only, with the C-C bond always at C-10. In the O- and C-glycosides, the only sugars found so far are glucose, rhamnose and apiose.

2.1 Preparation of Extracts

Powdered drug (0.5 g) is extracted for 5 min on a water bath with 5 ml methanol. The filtrate is used for TLC: 5 µl (Aloe) and 20 µl (Rheum, Frangula, Cascara).

General method,
methanolic extract

Sennae folium or fructus are extracted with 50% methanol; 20 µl is used for TLC.

Senna

Powdered drug (0.5 g) and 25 ml 7.5% hydrochloric acid are heated under reflux for 15 min. After cooling, the mixture is extracted by shaking with 20 ml ether. The ether phase is concentrated to about 1 ml, and 10 µl is used for TLC (e.g. Rhei radix).

Hydrolysis of
anthraquinone
glycosides

2.2 Thin-Layer Chromatography

Aloin, frangulin A/B, glucofrangulin A/B, rhein, aloe-emodin and rhaponticoside (stilbene glucoside) are applied as 0.1% methanolic solutions.

Reference
solutions

Sennosides A and B are prepared as a 0.1% solution in methanol-water (1:1).

A total of 10 µl of each reference solution is used for TLC.

Chromatography is performed on silica gel 60F₂₅₄ precoated plates (Merck, Germany).

Adsorbent

- Ethyl acetate-methanol-water (100:13.5:10)

Chromatography
solvents

With the exception of Senna preparations, the solvent system is suitable for the chromatography of all anthracene drug extracts.

- n-propanol-ethyl acetate-water-glacial acetic acid (40:40:29:1) ► Senna
- light petroleum-ethyl acetate-formic acid (75:25:1) ► anthraquinone aglycones

- toluene-ethyl formiate-formic acid (50:40:10) or (50:20:10) ► for the non-laxative dehydrodianthrone of *Hyperici herba*

2.3 Detection

- UV 254 nm All anthracene derivatives quench fluorescence
- UV 365 nm All anthracene derivatives give yellow or red-brown fluorescence
- Spray reagents (See Appendix A)
 - Potassium hydroxide (KOH No. 35; → Bornträger reaction)
After spraying with 5% or 10% ethanolic KOH, anthraquinones appear red in the visible and show red fluorescence in UV-365 nm.
Anthrones and anthranols: yellow (vis.), bright yellow fluorescence (UV-365 nm).
Dianthrone do not react.
 - Natural products-polyethylene glycol reagent (NP/PEG No.28)
Anthrones and anthranols: intense yellow fluorescence (UV-365 nm).
 - Sennoside detection
The TLC plate is sprayed with concentrated HNO₃ and then heated for 10 min at 120°C. It is then sprayed with 5% ethanolic KOH. After further heating, sennosides appear as brown-red zones in UV-365 nm and brown zones in the visible.
Sennosides can also be detected with a 1% solution of sodium metaperiodate in 10% ethanolic KOH. After spraying and heating (approximately 5 min), yellow-brown zones are obtained in UV-365 nm.
 - Rhaponticoside detection
Phosphomolybdate-H₂SO₄ reagent (PMA-H₂SO₄ No.36)
Rhaponticoside gives dark blue zones in the visible
 - Hypericin detection
A 10% solution of pyridine in acetone intensifies the red fluorescence of hypericin in UV-365 nm.
 - “Isobarbaloin” test for the differentiation of *Aloe capensis* and *Aloe barbadensis*.
One drop of saturated CuSO₄ solution, 1 g NaCl and 10 ml 90% ethanol are added to 20 ml of an aqueous solution of *Aloe barbadensis* (Curacao aloe, 1:200). A wine-red colour is produced, which is stable for at least 12 h. Solutions of *Aloe capensis* fade rapidly to yellow.

2.4 Circular TLC in Addition to the Ascending TLC

This method is generally useful for the separation of drug extracts containing a high proportion of ballast substances, e.g. mucilages from *Sennae folium*.

Two diagonal pencil lines are drawn from the corners of the TLC plate. The centre point of the plate is marked and a circle is drawn around it with a diameter of approximately 2 cm. The circle is thus divided into four segments by the diagonals. The perimeter of each segment serves for the application of drug extracts or reference solutions (see figure below).

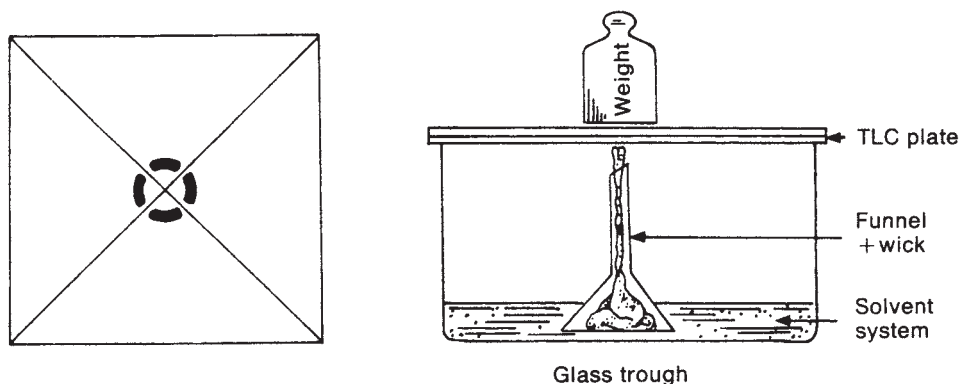
Application

100 ml of solvent are placed in a round, straight-sided chamber (glass trough, 10 cm high, 20 cm in diameter). A glass funnel is loosely packed with cotton, which extends as a wick through the tube of the funnel. The funnel is placed in the solvent system, so that the solvent soaks into the cotton. With the loaded side facing downwards, the TLC plate is placed over the top of the trough, so that the cotton makes contact exactly at the marked centre.

Procedure

The solvent migrates circularly from the point of application. The zones of the separating substances form single arcs, which increase in length from the starting point to the periphery of the spreading solvent.

The same adsorbent (silica gel 60 F₂₅₄ precoated plates, 20 × 20 cm; Merck, Darmstadt), the solvent systems and detection methods can be used as described for ascending TLC. Good separations are obtained by solvent migrations of 6 cm only.



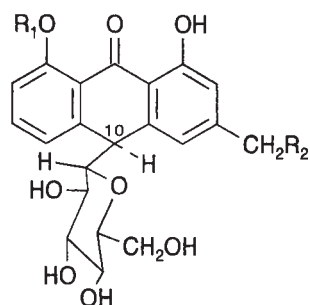
2.5 Drug List

	Drug/plant source Family/pharmacopoeia	Main constituents Hydroxyanthracenes
Fig. 1,2	Aloes Various types such as: Cape and Curacao aloes Socotrine aloes DAB 10, Helv VII, USP XXII, MD Uganda, Kenya aloe, Indian aloe Asphodelaceae (Liliaceae)	Dried juice of aloe leaves. Aloin A, B (10-C- β -D glucopyranoside of aloe emodin-anthrone), α - and β -stereoisomers Aloinoside A and B (stereoisomers of aloin-11- α -L-rhamnoside), aloe-emodin (aglycone) Aloeresins (non-laxative compounds): aloenin A (chromone-C-glucoside), aloenin B (p-coumaric acid ester of aloeresin A), aloenin C (glucoside of aloenin B)
Fig. 1,2	Aloe capensis Cape aloes Aloe ferox MILLER and hybrids DAB 10, BHP 90, ÖAB 90, USP XXII, Helv VII, Jap XI	Not less than 18% hydroxyanthracenes calculated as aloin (e.g. DAB 10) Aloin A/B, aloeresins A/B (type I) Aloin A/B, aloinosides A/B, aloenin A/B (type II), 5-hydroxyaloin A/B, aloe-emodin (<1%)
Fig. 1,2	Aloe barbadensis Curacao aloes, Aloe vera Aloe barbadensis MILL. DAB 10, BHP 90, Helv VII, ÖAB 90, USP XXII, MD	Not less than 28% hydroxyanthracenes calculated as aloin (DAB 10) Aloin A/B, 7-hydroxyaloin A/B (3%) 8-Methyl-7-hydroxyaloin A/B, aloenin B/D
Fig. 2	Aloe perryi Socotrine aloes Aloe perryi BAK. MC	Up to 14% hydroxyanthracene derivatives calculated as aloin Aloin A/B, aloinosides A/B, aloeresins A/B
Fig. 4	Rhamni purshiani cortex Cascaræ sagradae cortex Cascara sagrada bark Sacred bark, chitten bark Rhamnus purshianus D.C. Rhamnaceae DAB 10, PhEur II, ÖAB 90, Helv VII, MD USP XXII (extract)	Not less than 8% hydroxyanthracenes with at least 60% cascarosides calc. as cascaroside A (DAB 10) Cascarosides A and B (diastereoisomers of aloin-8-O- β -D-glucoside); cascarosides C and D (diastereoisomers of deoxyaloin-8-O- β - D-glucoside); Aloin, deoxyaloin (10%– 20%), small amounts of emodine; frangula- emodin-O-glycosides (10%–20%)
Fig. 3	Frangulae cortex Rhamni frangulae cortex Alder buckthorn bark Rhamnus frangula L. Rhamnaceae DAB 10, PhEur II, Helv VII, MD	Not less than 6% anthraquinone glycosides Glucofrangulin A and B (emodin-6-O- α -L- rhamnosyl-8-O- β -D-glucoside and -6-O- α -L- apiosyl-8-O- β -D-glucoside). Frangulin A and B (emodin-6-O- α -L-rhamnoside and emodin-6-O- α -L-apioside). Emodin-8- β -O-glucoside, -diglucoside Physcion, chrysophanol glycosides

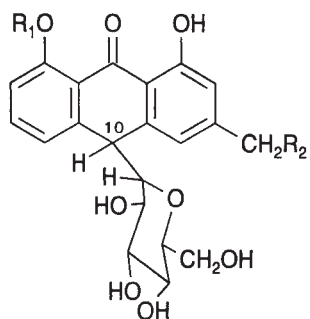
Drug/plant source Family/pharmacopoeia	Main constituents Hydroxyanthracenes	
Frangulae fructus Alder buckthorn fruits Rhamnus frangula L. Rhamnaceae ÖAB	Low concentrations of anthraquinone aglycones and traces of anthraquinone glycosides.	Fig. 3,4
Oreohertzogiae cortex Rhamni fallaci cortex Rhamnus alpinus L. ssp. fallax (BOISS.) PETITMAIRE Rhamnaceae	1%–3% Hydroxyanthracene derivatives Emodin-glucoside, physcion-rutinoside Flavonoids: e.g. xanthorhamnin ▶ adulterant of Frangulae cortex	Fig. 3
Rhamni cathartici fructus Buckthorn berries Rhamnus catharticus L. MD	Low contents of anthraquinones in fruit flesh, 0.7%–1.4% hydroxyanthracenes in semen: frangulaemodin, -emodinanthrons Flavonol glycosides >1%: xanthorhamnines = triglycosides of rhamnocitrin (7-methyl-kaempferol and 7-methyl-queracetin) Catharticin (rhamnocitrin-3-O-β-rhamnoside)	Fig. 3,4
Rhei radix Rhubarb rhizome Rheum officinale BAILLON Rheum palmatum L. and hybrids Polygonaceae DAB 10, ÖAB. MD, Japan, China	1%–6% Hydroxyanthracenes (not less than 2.5%); 60%–80% of mono- and diglucosides of physcion, chrysophanol and rhein (e.g. physcion-8-O-gentiobioside); rhein, physcion, chrysophanol, emodin, aloe-emodin; bianthronglycosides: rheidin A–C, sennidin C,D, galloyl-β-D-glucose	Fig. 5,6
Rhei rhapontici radix Garden rhubarb Rheum rhaponticum L. Polygonaceae	0.3%–0.5% anthraquinone aglycones and glucosides, 7%–10% stilbene derivatives: rhaponticoside 5%, desoxyrhaponticoside, Adulterant of Rhei radix	
Sennae folium Senna leaves Cassia senna L. (Alexandrian senna) Cassia angustifolia VAHL (Tinnevelly senna) Caesalpinaceae DAB 10, ÖAB 90, Helv VII, Jap XI, MD	2%–3.5% dianthrone glycosides (not less than 2.5%). calc. as sennoside B for Alexandrian and Tinevelly senna (e.g. DAB 10). As principal active compounds: sennoside A and B as 8,8'-diglucosides of sennidin A/B (= stereoisomeric 10-10'-dimers of rhein anthrone) Sennoside A (dextrorotary), sennoside A ₁ (optical isomer), sennoside B (optically inactive mesoform) low amounts of Sennoside C and D (=heterodianthrone), rhein, emodin and their mono- and diglycosides	Fig. 7,8

Drug/plant source Family/pharmacopoeia	Main constituents Hydroxyanthracenes
Fig. 7,8 Sennae fructus Senna pods Cassia senna L. (Alexandrian senna) Cassia angustifolia VAHL (Tinevelly senna) Caesalpiniaceae DAB 10, PhEur I, ÖAB, Helv VII, MD, USP XXII	2.2%–3.4% dianthrone glycosides Alexandrian senna pods > 3.4% (DAB 10) Tinevelly senna pods > 2.2% (DAB 10) Senoside A,B besides C,D; rhein, mono- and diglycosides of emodin and rhein Naphthalenes: 6-hydroxy musizin glucoside (C. senna); tinevellin-glucoside (C. angustifolia)
Fig. 9,10 Hyperici herba St. John's wort Hypericum perforatum L. Hypericaceae (Glusiaceae) DAC 86, Helv VII, MD	0.05–0.6% dehydrodianthrone Hypericin, pseudohypericin, protohypericin Flavonol glycosides: rutin, hyperoside, quercitrin, isoquercitrin; quercetin; biapigenin Chlorogenic acid. Hyperforin (fresh plant)

2.6 Formulae

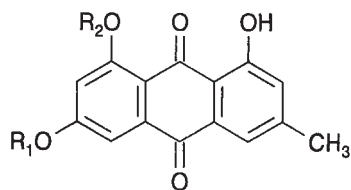


	R ₁	R ₂
Aloin A	H	OH
(-)-11-Desoxyaloin	H	H
Aloinoside A	H	O- α -L-rhamnose
Cascaroside A	β -D-glucose	OH
Cascaroside C	β -D-glucose	H

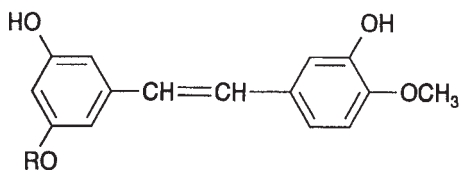
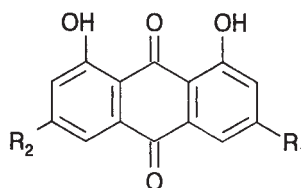


	R ₁	R ₂
Aloin B	H	OH
(-)-11-Desoxyaloin	H	H
Aloinoside B	H	O- α -L-rhamnose
Cascaroside B	β -D-glucose	OH
Cascaroside D	β -D-glucose	H

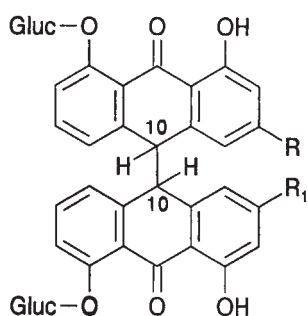
	R ₁	R ₂
Glucofrangulin A	α -L-rhamnose	β -D-glucose
Glucofrangulin B	β -D-apiose	β -D-glucose
Frangulin A	α -L-rhamnose	H
Frangulin B	β -D-apiose	H
Frangula emodin	H	H



	R ₁	R ₂
Rheum emodin	CH ₃	OH
Aloe emodin	CH ₂ OH	H
Rhein	COOH	H
Chrysophanol	CH ₃	H
Physcion	CH ₃	OCH ₃

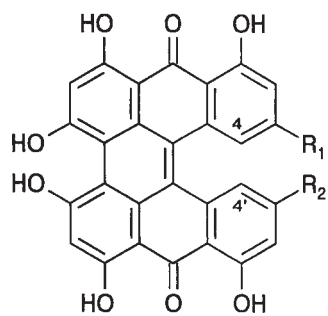


Rhaponticoside R = β -D-glucose
 Rhapontigenin R = H



Sennoside A: R, R₁ = COOH (+)-form
 Sennoside B: R, R₁ = COOH mesoform

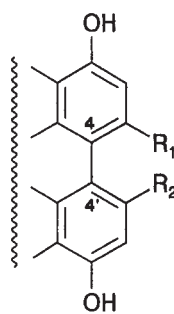
Sennoside C: R = COOH R₁ = CH₂OH (+) form
 Sennoside D: R = COOH R₁ = CH₂OH mesoform



Protohypericin

 $R_1 = R_2 = \text{CH}_3$

Protopseudohypericin

 $R_1 = \text{CH}_3$ $R_2 = \text{CH}_2\text{OH}$ 

4-4': Hypericin

 $R_1 = R_2 = \text{CH}_3$

4-4': Pseudohypericin

 $R_1 = \text{CH}_3$ $R_2 = \text{CH}_2\text{OH}$

2.7 Chromatograms

Aloes

Drug sample	1 Aloe capensis (type I) 2 Aloe capensis (type II) 3 Aloe barbadensis (Curacao aloe) (methanolic extracts, 5 µl)	4 Aloe perryi (Socotraine aloe) 5 Aloe of Kenian origin 6 Aloe of Ugandan origin
Reference Compound	T1 aloin T2 7-hydroxyaloin	T3 aloin ($R_f \sim 0.45$) ► aloe emodin ($R_f \sim 0.95$)
Solvent system	ethyl acetate-methanol-water (100:13.5:10)	
Detection	Fig. 1 Without chemical treatment → A UV-365 nm, B UV-254 nm Fig. 2 10% ethanolic KOH reagent (No. 35) → C UV-365 nm, D vis	

Aloe species are characterized by aloin A/B, aloe-emodin and the non-laxative aloeresins (aloesin A–C). In addition some aloes contain aloinosides and substituted aloins (5- or 7-hydroxyaloin A/B).

Fig. 1 Aloe capensis (1,2)

- A Cape Aloe (1) is characterized by the yellow fluorescent zone of aloin ($R_f \sim 0.5/T2$) and aloe-emodin (solvent front). The zones of aloeresins such as aloesin A and B ($R_f \sim 0.55$ and $R_f \sim 0.25$, respectively) fluoresce light blue. Trade samples of Cape aloe (2) can show besides the yellow fluorescent aloin and aloe-emodin, additional yellow zones of the aloinosides A/B (R_f 0.25–0.3) and additional glycosides (e.g. $R_f \sim 0.75$). The blue fluorescent zones are less prominent than in sample 1 (e.g. aloe resins).
- B All major compounds, such as aloins or aloinosides and specifically the aloesins show quenching in UV-254 nm.
Note: 7-hydroxyaloin (T2) a characteristic compound in Curacao aloes (3) is absent in Cape aloes (1,2).

Fig. 2 TLC synopsis of aloes (1–6)

- C Treatment with KOH reagent intensifies the yellow fluorescence of aloin and aloinosides as well as the blue fluorescence of the aloe resins. Aloe-emodin shows a typical red Bornträger reaction in UV-365 nm.

Aloe resins	Aloin	Aloinosides	Aloesins	Remarks
1 Cape aloe	+	++	+	Cape and Curacao aloes are differentiated by the "isobarbaloin-test" of KLUNGE (see section 2.3) which gives yellow or wine red colour, respectively Socotraine and Curacao aloes show a dark zone directly below aloin, e.g. 7-hydroxyaloin in 3
2 Cape aloe	+	--	++	
3 Curacao aloes	++	--	++	
4 Socotraine aloes	+	+	++	
5 Kenya aloes	++	+	(+)	
6 Uganda aloes	+	(+)	(+)	

- D All Aloe (1–4) samples show aloin as prominent yellow zones (vis.). The samples 2 and 4 contain, in addition, aloinosides (yellow/ R_f 0.25–0.3), and a dark violet-red zone (vis.) characterizes Curacao (3) and Socotraine aloe (4). This zone directly below aloin can be identified in (3) as 7-hydroxyaloin.

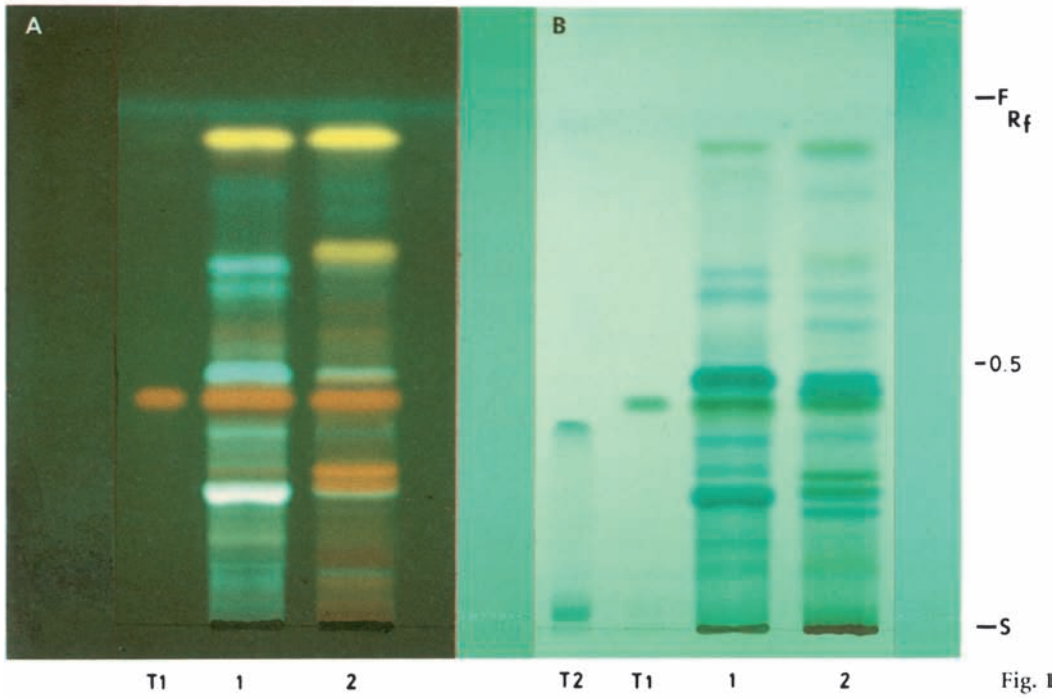


Fig. 1

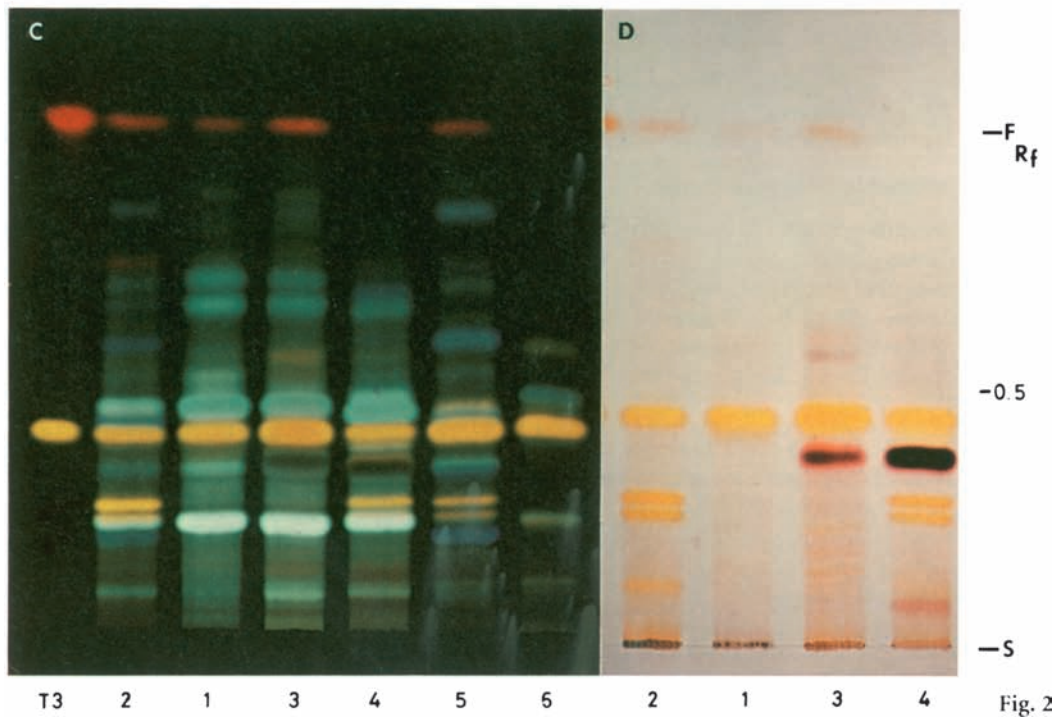


Fig. 2

Rhamnus species

Drug sample	1 Frangulae cortex (<i>Rhamnus frangula</i>) 2 <i>Oreohertzogiae</i> cortex (<i>Rhamnus alpinus</i> ssp. <i>fallax</i>) 3 Frangulae fructus (<i>Rhamnus frangula</i>) 4 <i>Rhamni carthartici</i> fructus (<i>Rhamnus cartharticus</i>) 5–7 <i>Cascarae</i> cortex (<i>Rhamnus purshianus</i> -trade samples) (methanolic extracts, 20 µl)
Reference compound	T1 glucofrangulin A (R_f 0.25) ► aloin (R_f 0.45) ► frangulin A (R_f 0.75) ► emodin (front) T2 aloin
Solvent system	ethyl acetate-methanol-water (100:13.5:10)
Detection	Fig. 3 KOH reagent (No. 35) A → vis; B, C → UV-365 nm Fig. 4 Natural products-polyethylene glycol reagent (NP/PEG No. 28) D, E → UV-365 nm

Fig. 3 Anthraquinones

- A **Frangulae cortex** (1) is characterized by two pairs of red-brown anthraquinone glycosides (vis.): glucofrangulin A (R_f 0.2), B (R_f 0.3) and frangulin A (R_f 0.75), B (R_f 0.8). Aglycones such as emodin, physcion and chrysophanol move with the solvent front. **Oreohertzogiae cortex** (2) counts as an adulterant of *Frangulae cortex*: glucofrangulin A/B present in considerably lower concentration, only traces of frangulin A/B, additional anthraquinone glycosides such as physcion-rutinoside ($R_f \sim 0.3$) and emodin-glucoside ($R_f \sim 0.5$) dominate. A yellow zone at $R_f \sim 0.2$ in both samples (1,2) is due to flavonol glycosides see Fig. 4 D.
- B All anthraquinones of *Frangulae* and *Oreohertzogiae cortex* (1,2) show a bright orange-red fluorescence in UV-365 nm.
- C **Frangulae fructus** (3) shows only traces of frangula-emodin at the solvent front. **Rhamni carthartici fructus** (4). Four to five orange-red zones are detectable in the R_f range of glucofrangulin ($R_f \sim 0.25$), frangulin ($R_f \sim 0.8$) and above.

Fig 4 Flavonoids and cascarosides

- D **Frangulae cortex** (1): one green fluorescent flavonoid glycoside ($R_f \sim 0.2$) and the zones of frangulin A/B with brown fluorescence. **Frangulae fructus** (3): two yellow orange fluorescent flavonol glycosides (R_f 0.15/0.45). **Rhamni cathartici fructus** (4): a band of prominent orange-yellow fluorescent xanthorhamnins (triglycosides, see 2.5 Drug List) between the start and $R_f \sim 0.25$, and between $R_f \sim 0.75$ up to the solvent front. Xanthorhamnin ($R_f \sim 0.2$) is found in (3) and (4).
- E **Cascarae cortex** (5–7) samples are characterized by anthrone glycosides: two pairs of yellow fluorescent cascarosides A/B (R_f 0.05–0.15) and cascarosides C/D (R_f 0.2–0.25). The cascarosides A/B dominate. The amount of yellow fluorescent aloin (T2), deoxyaloin (R_f 0.65) and the red-brown fluorescent aglycones emodin, aloe-emodin, chrysophanol (solvent front) varies. Four blue fluorescent naphthalide derivatives are detectable in the R_f range 0.3–0.45.

Note: Cascarosides A–C also fluoresce bright yellow when treated with the KOH reagent.

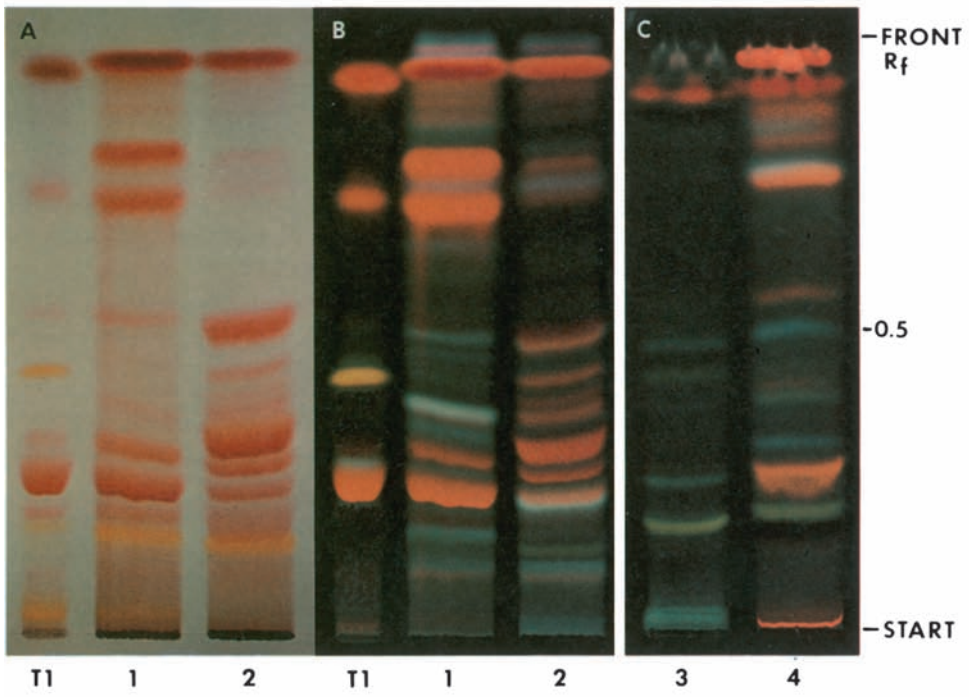


Fig. 3

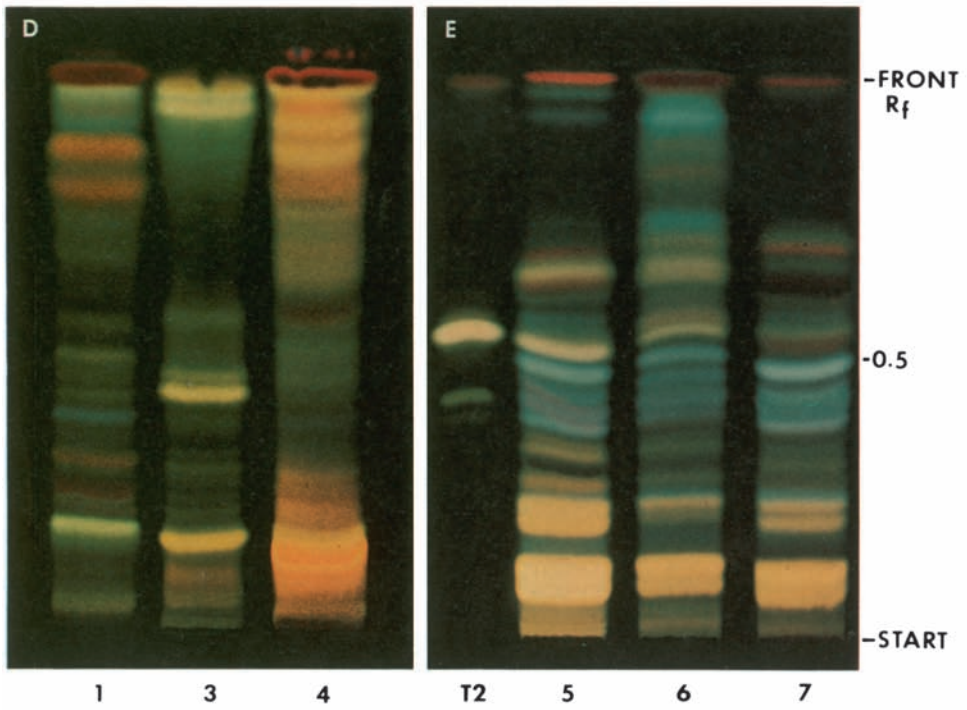


Fig. 4

Rhei radix

Drug sample	1 Rhei palmati radix (methanolic extract, 20 μ l) 2 Rhei rhapontici radix (methanolic extract, 20 μ l) 3 Rhei palmati radix (hydrolysate, 10 μ l) 4 Rhei rhapontici radix (hydrolysate, 10 μ l)
Reference compound	T1 rhein T2 rhaponticoside T3 emodin ($R_f \sim 0.4$)
Solvent system	Fig. 5 ethyl acetate-methanol-water (100:13.5:10) \rightarrow glycosides Fig. 6 light petroleum-ethyl acetate-formic acid (75:25:1) \rightarrow aglycones
Detection	A Without chemical treatment \rightarrow UV-365 nm B Phosphomolybdic acid/H ₂ SO ₄ reagent (PMS No. 34) \rightarrow vis C Without chemical treatment \rightarrow UV-254 nm D Without chemical treatment \rightarrow UV 365 nm

Fig. 5 Glycosides

- A** **Rhei radix** (1) is characterized in UV-365 nm by the prominent yellow fluorescent anthraquinone aglycone zone (emodin, aloe-emodin, physcion, chrysophanol) at the solvent front. Their 8-O-monoglucosides migrate as a brown-red band to R_f 0.45–0.55. The corresponding diglycosides are present as minor compounds in the R_f range 0.1–0.3. The polar aglycone rhein (T1) at $R_f \sim 0.4$ is overlapped by blue fluorescent zones. **Rhei rhapontici radix** (2) contains anthraquinone aglycones and monoglucosides in low concentration only. In addition the prominent violet-blue fluorescent stilbene derivatives rhaponticoside/deoxyrhaponticoside (R_f 0.45–0.55/T2) are present. They overlap the anthraquinone monoglucoside zone.
- B** Treatment with the PMA reagent produces light yellow zones of anthraquinones (1) and a characteristic dark blue band of rhaponticoside/deoxyrhaponticoside (T2) and rhapontigenin (solvent front) in sample 2.

Fig. 6 Aglycones

- C,D** The aglycone mixtures (3,4) obtained by HCl hydrolysis of Rheum extracts (1,2) are separated in the lipophilic solvent system and evaluated in UV-254 nm and UV-365 nm. All aglycones show fluorescence quenching in UV-254 nm and uniformly yellow or orange-brown fluorescence in UV-365 nm.
- Rhei palmati radix** (3). Aloe-emodin and rhein (R_f 0.15–0.25/T1), emodin ($R_f \sim 0.3$ /T3), chrysophanol and physcion (R_f 0.6–0.7) are characteristic aglycones.
- Rhei rhapontici radix** (4). The hydrolysate shows a qualitatively similar, but quantitatively different aglycone pattern with traces of rhein (T1) only. In addition blue fluorescent stilbene aglycones are found at R_f 0.05–0.1.

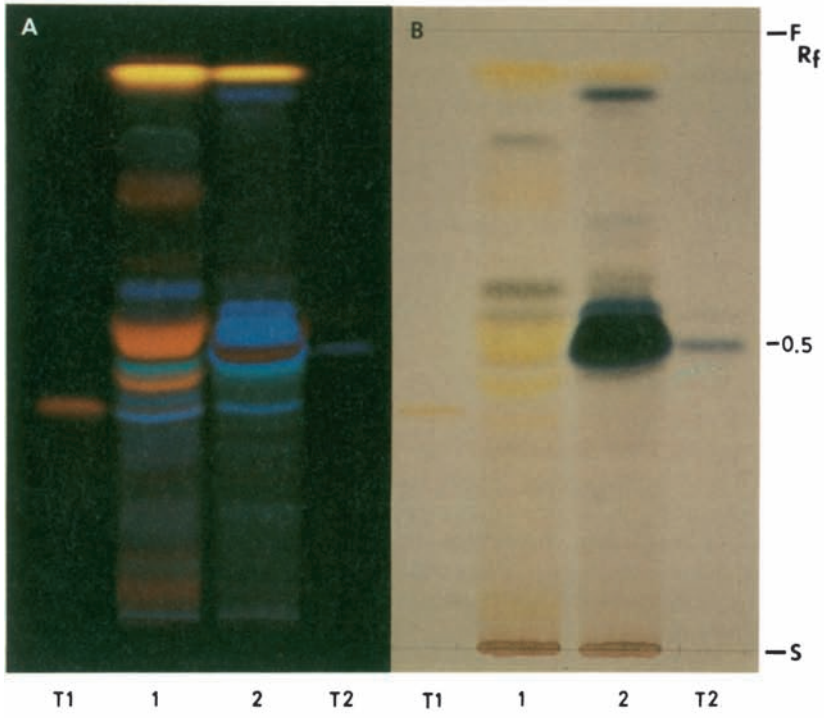


Fig. 5

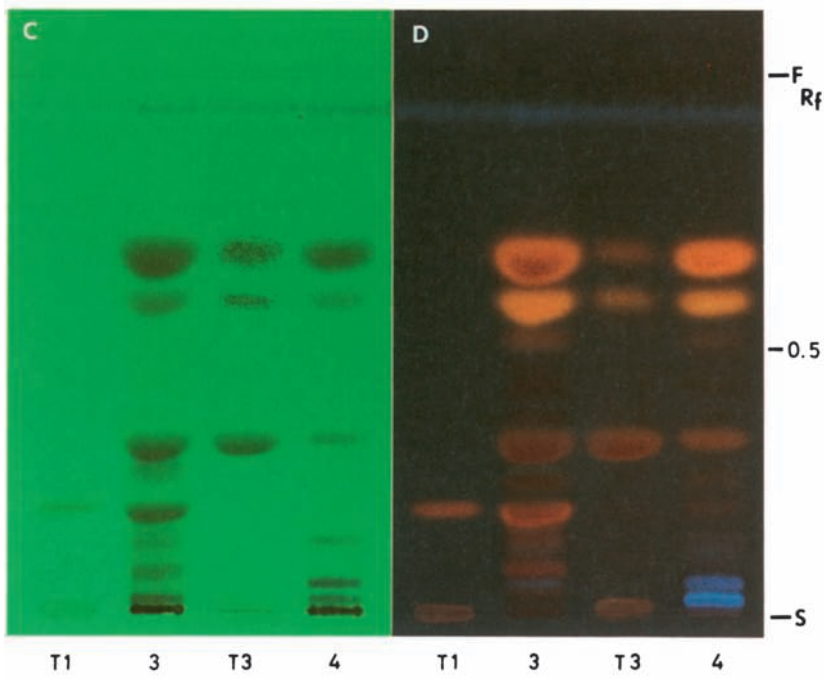


Fig. 6

Sennae folium, fructus

Drug sample	1 Sennae fructus (methanolic extract, 20 µl) 2 Sennae folium (methanolic extract, 20 µl)
Reference compound	T1 sennoside A ¹⁾ T2 sennoside B ¹⁾
Solvent system	n-propanol-ethyl acetate-water-glacial acetic acid (40:40:29:1)
Detection	Fig. 7 HNO ₃ -potassium hydroxide reagent (HNO ₃ /KOH No.30) → vis Fig. 8 A HNO ₃ -potassium hydroxide reagent (HNO ₃ /KOH No.30) → UV-365 nm B Sodium metaperiodate reagent (see 2.3 Detection) → UV-365 nm

Fig. 7 Sennae fructus (1) and folium (2)

Treatment of the TLC plate with concentrated HNO₃, heating for approximately 30 min at 150°C and spraying with KOH reagent produces six to eight brownish and yellow zones (vis) in the R_f range 0.1 up to the solvent front.

The dark-brown zones are due to the sennosides B,A (R_f 0.25 and R_f 0.4) and the sennosides D,C (R_f 0.5 and R_f 0.7). The yellow zones indicate anthraquinone aglycones (e.g. rhein/R_f ~ 0.8; emodine/solvent front) and their glucosides (R_f ~ 0.3/R_f ~ 0.6).

Fig. 8A Evaluation under UV-365 nm light is more sensitive. The main brown zones (vis.) of Sennae extracts (1,2) now appear light brown to orange-brown. The minor compounds of the R_f range 0.5–0.9 are also more easily detectable.

The two dianthron glycosides, sennoside A (R_f 0.4/T1) and sennoside B (R_f 0.25/T2) are the major compounds in Sennae fructus (1) and S. folium (2).

In Sennae folium extract (2) a R_f value depression of sennoside A and specifically of sennoside B occur, caused by the mucilages also extracted from the plant material with 50% methanol. To avoid this effect the circular TLC method can be used (see Fig. 9).

Sennoside D (R_f ~ 0.55) is more highly concentrated in Sennae folium extracts (2) than in Sennae fructus extracts (1). Sennoside C can be localized at R_f ~ 0.7. Rhein is detectable as a yellow zone at R_f ~ 0.8 and its 8-O-glucoside is found between sennoside D and C.

B Direct treatment of the TLC plate with the sodium metaperiodate reagent and heating for 5 min under observation at 100°C reveals green-yellow or dark brownish zones when evaluated under UV-365 nm. It is a fast detection method, but less sensitive compared with the HNO₃/KOH reagent.

¹⁾The commercial reference compound "sennoside A" contains small amounts of sennoside C and D. The reference compound "sennoside B" shows, in addition, sennoside A as minor component.

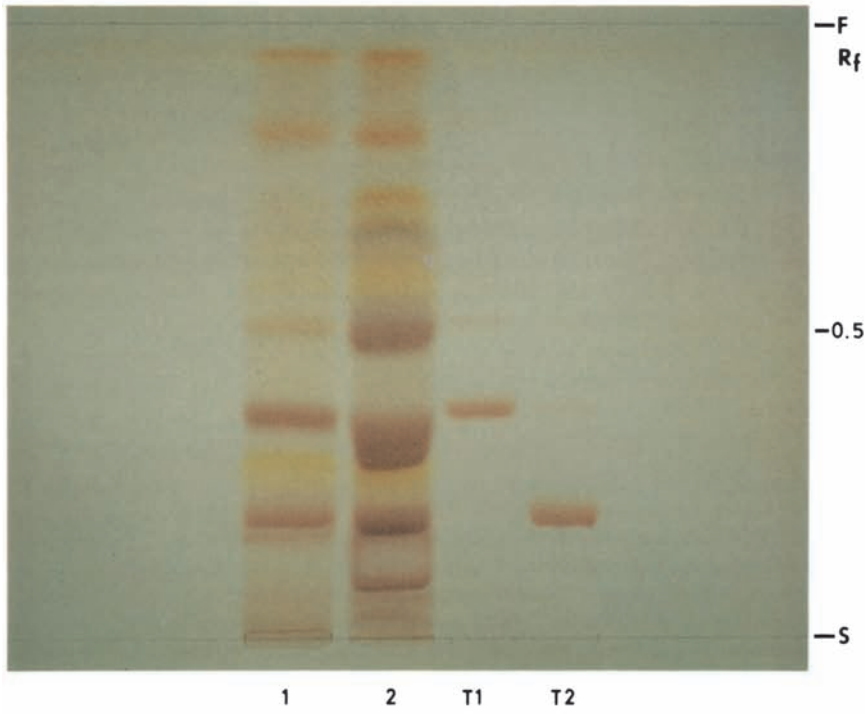


Fig. 7

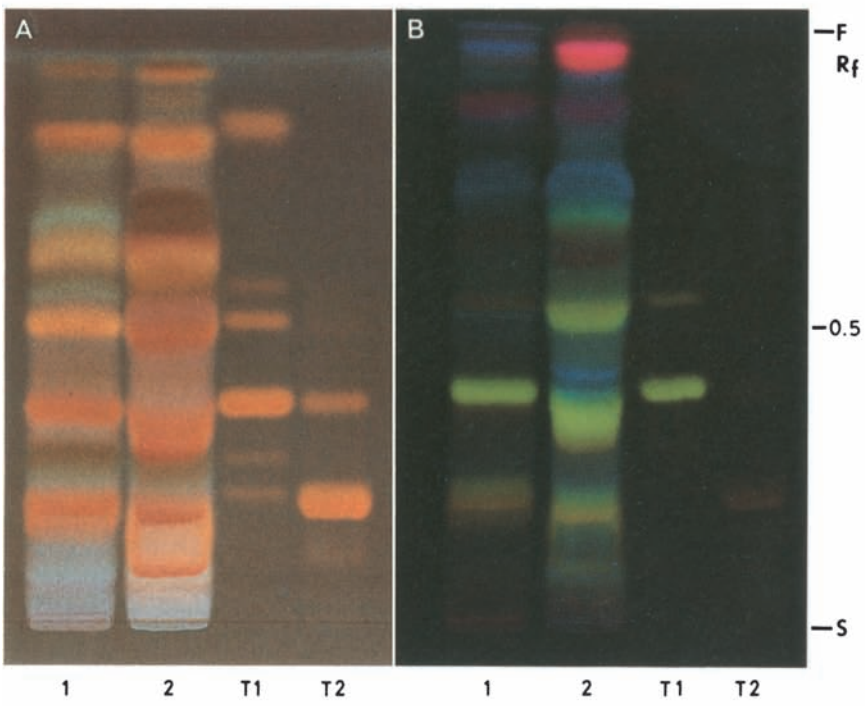


Fig. 8

Circular TLC (CTLC) in comparison to ascending TLC of Senna extracts

Drug sample, segment	Sennae folium (upper segment)	A sennoside A	D sennoside D	
	Sennae fructus (lower segment)	B sennoside B	Al aloin	Rh rhein
Solvent system	n-propanol-ethyl acetate-water-glacial acetic acid (40:40:29:1)			
Detection	Fig. 9 CTLC Sodium metaperiodate reagent (see 2.3 Detection) → vis Asc. TLC HNO ₃ -potassium hydroxide reagent (HNO ₃ /KOH No. 30) → vis			

Description The CTLC in general is a convenient method to achieve good separations over the short distance of 5–6 cm. Extracts and reference compounds are applied in the inner circle (start) in an overlapping mode, to make sure that compounds are clearly identified by references. Ballast substances of the extracts such as mucilagines are diluted in the circular separation lines. The disturbance and R_f value depression of sennoside A,B are reduced (preparation see 2.4 Circular TLC).

Fig. 9 The sennosides are detected as bright yellow-brown bands with sodium metaperiodate (CTLC) and as darker brown zones with the HNO₃-KOH reagent (asc. TLC). The CTLC of Sennae folium und Sennae fructus shows as two prominent circles sennoside A and B (→ test A/B) in the inner parts of both segments. The bands of sennoside D (→D) and C are found slightly below the aloin test (→ test Al). Rhein (test Rh) is clearly seen in Sennae fructus extracts. The influence of mucilagines on the R_f value of sennoside B results in a dwelling circle (CTLC) and causes an R_f value depression in the picture of the ascending TLC (compare with Figs. 7,8).

Hyperici herba

Drug sample	1 Hyperici herba (Hypericum perforatum) (methanolic extracts, 25 μl) 2 Hyperici herba (commercial trade sample)
Reference compound	T1 hypericin T2 rutin (R _f 0.35) ► chlorogenic acid (R _f 0.4) ► hyperoside (R _f 0.5) ► isochlorogenic acid
Solvent system	Fig. 10 A,B ethyl acetate-formic acid-glacial acetic acid-water (100:11:11:26) C toluene-ethyl formate-formic acid (50:40:10)
Detection	A,B Natural products-polyethylene glycol reagent (NP/PEG No. 28); A UV-365 nm, B vis. C 10% pyridine in ethanol → vis

Fig. 10A Hyperici herba (1,2) is characterized in UV-365 nm after treatment with NP/PEG reagent by the prominent red-violet fluorescent zones of the non-laxative dehydrodianthrone, the hypericins (R_f 0.75–0.8), five bright yellow fluorescent flavonolglycosides (R_f 0.35–0.7) and blue fluorescent phenol carboxylic acids such as chlorogenic acid (R_f ~ 0.4/T2). The flavonolglycosides are identified as rutin (R_f ~ 0.35/T2), hyperoside (R_f ~ 0.5/T2), isoquercitrin (R_f ~ 0.6) and quercitrin (R_f ~ 0.7). The aglycones, e.g. quercetin, migrate with the red fluorescent chlorophylls to the solvent front.

- B** Hypericins are seen as green-brown and the flavonolglycosides as orange-yellow zones (vis).
- C** Variation of the solvent system and the detection with pyridine reagent reveals a broad band of red zones in the R_f range 0.5–0.6 (T1). Red zones at R_f 0.9–0.95 show chlorophyll compounds.

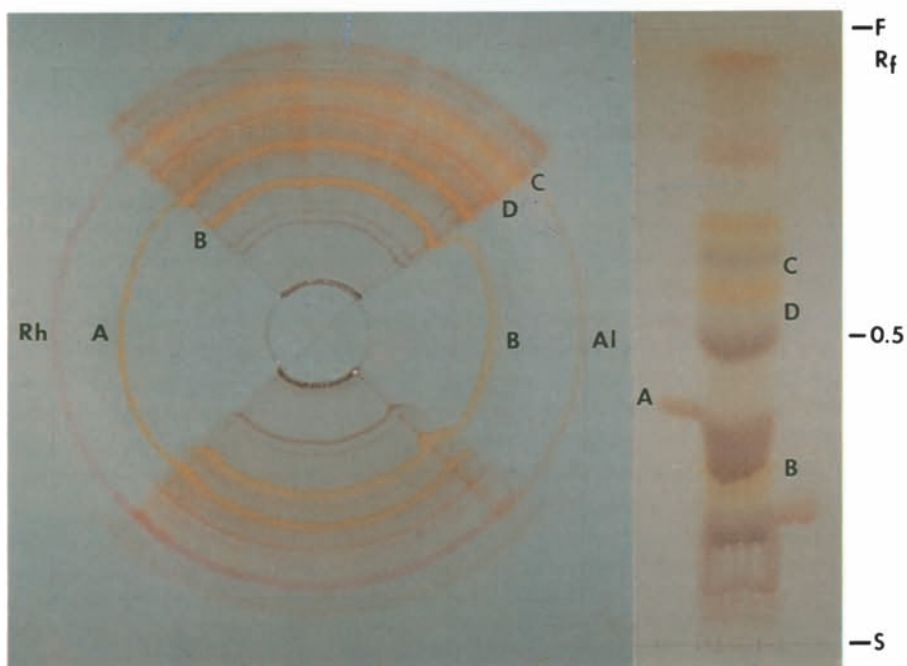


Fig. 9

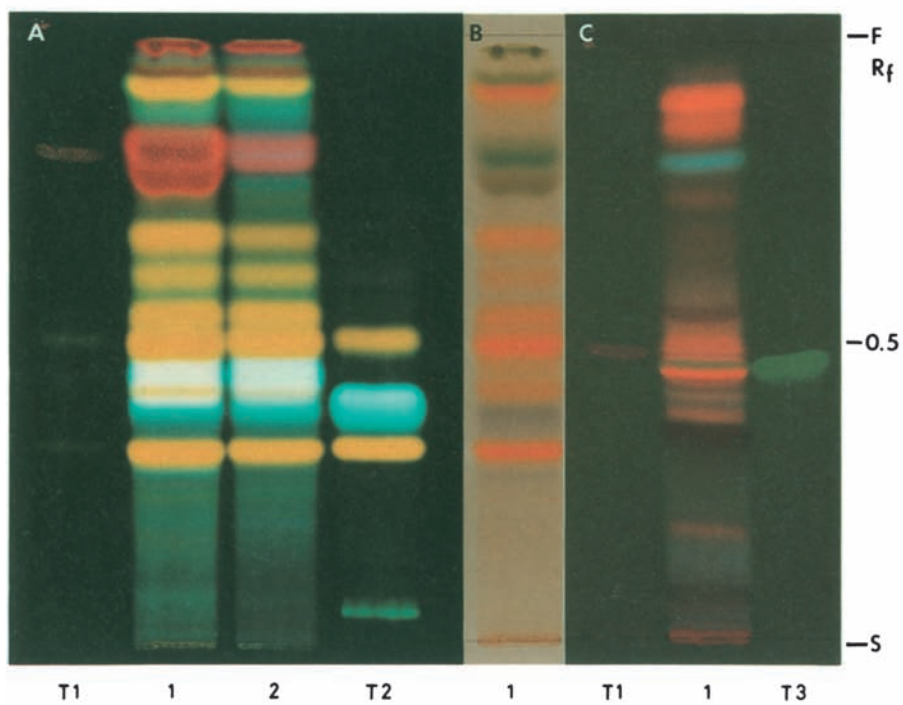


Fig. 10