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Analysis of Herbal Products by Thin-layer Chromatography: A Review

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ABSTRACT

The standardized thin-layer chromatographic procedures can be used effectively for the screening analysis as well as quality evaluation of the plant or its derived herbal products. . New approaches in thin-layer chromatography enable analysts to separate and determine useful natural products in complex mixtures of plant products. Various chromatographic systems useful for the identification; separation and quantification of herbal products are reported in this review.

KEY WORDS

Thin-layer chromatography, analysis, herbal products

INTRODUCTION

Plants synthesize substances that are useful for the maintenance of health in humans and other animals.Plants synthesizes a variety of phytochemicals most of them are derivatives of a few biochemical motifs. All plants produce chemical compounds as part of their normal metabolic activities. These include primary and secondary metabolites. The functions of secondary metabolites are varied. For example, some secondary metabolites are toxins used to deter predation, and others are pheromones used to attract insects for pollination. Botanicals are highly complex mixtures of compounds covering a broad range of substance classes and exhibit natural variability. These include alkaloids, phenolics, terpenoids, steroids, glycosides etc.

Due to low toxicity and known pharmacological activity, herbal drugs have been popularly and extensively used for many centuries. Sick animals tend to forage plants rich in secondary metabolites, such as tannins and alkaloids[1]. Since these

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phytochemicals often have antiviral, antibacterial, antifungal and antihelminthic properties, a plausible case can be made for self-medication by animals in the wild[2].Herbal drugs, singularly and in combinations, contain a myriad of compounds in complex matrices in which no single active constituent is responsible for the overall efficacy. The quality control and quality assurance still remains a challenge because of the high variability of chemical components involved. Due to natural variability, chemical analysis of plant material is a great challenge and requires special approaches. Planner chromatography is most versatile option for the required identification tests for the quality control of herbal products. In its traditional form, thin layer chromatography (TLC) is frequently used for the analysis of botanical raw materials. Thin layer chromatography has a long record in almost all pharmacopeias for its use in the identification of herbal medicines. The Visualization of the entire pattern of compounds present in an herbal drug (so-called fingerprinting) is important in the quality and stability testing of herbal products. The TLC fingerprint with a visible pattern of bands provides fundamental data and is typically used to demonstrate the consistency and stability of herbal materials. The advantages of using TLC to construct the fingerprints of herbal medicines are its simplicity, versatility, high velocity, specific sensitivity and simple sample preparation. Thus, TLC is a convenient method of determining the quality and possible adulteration of herbal products.

This review presents the contribution of thin-layer chromatography in the analysis of herbal products from 2000-2009. This review involved almost all the aspects of thin-layer chromatography including, detection, separation and quantification. S.Luo (1989) contributed a review on TLC application in the determination of the constituents of Chinese traditional herbal drugs[3].J.Qu et al. (2005) have also reviewed TLC autobiography including the screening of natural compounds with antibacterial and antifungal activity, antioxidants etc. and also discussed the advantages of the technique compared to other related techniques[4].

Thin-layer chromatography of herbal products

Table 1 shows several thin-layer chromatographic systems designed for the analysis of botanicals. For quality control of herbal products, thin-layer chromatography (TLC) is the most versatile technique for the identification of botanical raw materials.

Table-1

Thin-layer chromatographic analysis of herbal products

Title	Analyte	TLC System	Remark	Ref.
Application of HPTLC to alternative medicines – qualitative and quantitative	'Amla' (Emblica officinalis), 'Beheda' (Terminalia belerica), and	**Stationary phase:** Silica gel **Mobile phase**	Densitometry at 254 and 366nm quantitation is done	5

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evaluation of the Ayurvedic formulation 'Triphala Churna'	'Harhra' (Terminalia chebula) and Gallic acid)	Toluene – ethyl acetate – formic acid 5:5:1	by densitometry and a validation of data are also performed	
Screening of Chinese herbal drug extract for inhibitory activity on nitric oxide production and identification of an active compound of *Zanthoxylum bungeanum*	*Myristica fragrans*, *Plantago asiatica*, *Rubia cordifolia*, and *Zanthoxylum bungeanum*	**Stationary phase:** Silica gel **Mobile phase:** Methanol-water, 3:7	Methanol, acetone, acetic acid, 3:6:1	6
HPTLC and Vedio Tech. for stability testing of plant extracts	Valerinic acid	**Stationary phase:** HPTLC silica gel 60 F 254 **Mobile phase**: Methanol: water, 7:3	-	7
Herbal products a new approach for diabetic patients	Azadirachta indica, Catharanthus roseus and Momordica charntia	**Stationary phase:** Silica gel **Mobile phase :** Dichloro methane – methanol, 2:8	-	8
Qualitative identification of herbal drugs by preparative TLC	Different herbals	**Stationary phase:** Silica gel **Mobile phase:** Toulene-ethyl acetate, 3:7	-	9
Occurrence and activity of natural antioxidants in herbal spirits	Spirits (alcoholic or hydroalcoholic solutions of volatile substances with flavoring or medicinal properties) and one red wine	**Stationary phase:** Silica gel **Mobile phase:** Toluene – ethyl formate – formic acid, 79:20:1	The antioxidant activity could be evaluated from the fluroscence persisting time of the respective spots	10

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			and correlated with linoleic acid oxidation and DPPH titration methods	
Identification, isolation, and determination of flavones in Origanum vulgare from Macedonian flora	Apigenin, Luteolin, Chrysoeriol, and Diosmetin	**Stationary phase:** Silica gel **Mobile phase** Toluene – ethyl acetate – formic acid 58:33:9, Chloroform – methanol, 97:3, Chloroform – n-hexane-methanol, 40:40:3 and Toluene – methyl ethyl ketone – acetic acid, 18:5:1	Detection by spraying with aluminium chloride reagent and under UV-254nm	11
Fractionation and antioxidants screening of Quercus Cortex extract	Quercus Cortex, Caffeic acid, p-Cumaric acid, Ellagic acid, (+)-epicatechin, (+)-catechin, Quercetin, Rutin, Protocatechu acid, Quinic acid, Synapic	**Stationary phase:** Silica gel **Mobile phase** Ethyl acetate – formic acid – water 17:2:3	Visualization under UV at 366nm; and by spraying with 1,1-diphenyl-2-picrylhydrazyl reagent	12
HPTLC-aided phytochemical fingerprinting analysis as a tool for evaluation of herbal drugs	Ushaq (ammoniacum gum)	**Stationary phase:** Silica gel **Mobile phase:** n-hexane and ethyl acetate, 5:5	Post chromatographic derivatization with anisaldehyde-sulfuric acid reagent	13
Recent investigations on	Rutin, Chlorogenic acid,	**Stationary**		

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St. John's Wort by HPTLC	Hyperoside, Quercetin, hyperforin, Quercitrin and Biapigenin	**phase:** Silica gel **Mobile phase** Ethyl acetate – dichloromethane – acetic acid-formic acid-water 100:25:10:10:11	Visualization of Hypericin and Pseudohypercin under UV 366nm. Quantitation by densitometry fluorscence	14
TLC determination of catechin and epicatechin in an extract from Uncaria tomentosa bark by chemically modified stationary phases	Plant extracts and Catechin and Epicatechin	**Stationary phase:** Cellulose,, Silica gel, and Cyano-, amino-, and RP-18 modified silica **Mobile phase** Acetone – acetic acid 93:7 and Water – methanol – formic acid , 84:15:1 or 69:30:1	Visualization was spraying out with vanillin and sulfuric acid reagent	15
Identification and quantification of caffeic and rosmarinic acid in complex plant extracts by the use of variable-temperature two dimensional nuclear magnetic resonance spectroscopy	Plant extracts, Caffeic and Rosmarinic acid	**Stationary phase:** Silica gel **Mobile phase** Chloroform – ethyl acetate – formic acid, 5:4:1 and ethyl acetate – methanol – water, 77:13:10	Visualization was carried out by spraying with solution of Iron III chloride (2% methanol) and Aluminum chloride (1% in ethanol)	16
Insecticidal fatty acids and triglycerids from Direa	Triglycerides (1,3-dilinoleoyl-2-olein, 1,3-	**Stationary phase:** silica gel	-	17

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palustrins	dioleoyl-2-linolein, 1,2,3-trillinolein) and linoleic acid, oleic acid, and their esters	**Mobile phase** Hexane – ether 6:1		
Tagetolone and tagetenolonone: Two phytotoxic polyketides from Alternaria tagetica	Tagetotone diacetate	**Stationary phase:** silica gel **Mobile phase** Dichloromethane-acetone-acetic acid 95:5:1and Hexane-ethyl acetate 4:1	-	18
Reactions of p-coumaric acid with nitrite: product isolation and mechanism studies	Coumaric acid, 4-hydroxybenzaldehyde, 1,4-dihydroxybenzeneacetaldehyde, 4-hydroxy-benzenepropanoic acid, 4-hydroxy-3-nitrobenzenepropanoic acid	**Stationary phase:** silica gel **Mobile phase:** Dichloromethane – methanol – formic acid 190:10:1; 188:12:1 and dichloromethane – methanol 47:3, 19:1	Visualization under UV at 254 and 366nm and by spraying with paulys reagent and heating	19
Cytotoxic amides from piper sintenense	Pipersintenamide, piperboricoline, sintenpyridone, α-sitosterol, β-sitostenone, and stigmasta-4, 22-diene-3-one on with	**Stationary phase:** silica gel **Mobile phase:** n-hexane-ethyl acetate 10:1, dichloromethane, dichloromethane – ethylacetate 10:1, 20:1 and 30:1, chloroform,	Analysis of piper sintenense was performed	20

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		chloroform – methanol 30:1 and chloroform – acetone 15:1 and 20:1		
In vitro inhibition of [3 H] – angiotensin II binding on the human AT1 receptor by proanthocyanidins from Guazuma ulmifolia bark	-(+) epicatechin, (+) – catechin, procyanidin-B2, and procyanidin-C1	**Stationary phase:** Silica gel **Mobile phase:** Ethyl acetate-acetic acid-formic acid – water 75:2:3:20	Detection was carried out with vanillin sulfuric acid reagent	21
Two norditerpenoid ester alkaloids from Aconitum bulleyanum	Talatisamine, 8-α-acetyl-14-p-methoxybenzoate and 14-p-methoxybenzoate of talatisamine	**Stationary phase:** Silica gel **Mobile phase:** Chloroform methanol 20:1	Analytical and preparative TLC was performed with dragodroffs as detector	22 2002
Application of normal – and reversed-phase 2D-TLC on a cyanopropyl-bonded polar stationary phase for separation of phenolic compounds from the flowers of Sambucus nigra	Flavones and flavanones (myricetin, luteolin, apigenin, acadetin, hyperoside, quercetin, rutin, quercitrin, astragalin, kaempferol, isoquercitrin, naringenin, naringin, hesperitin, hesperidin) and phenolic acids (caffeic, ferulic, and chlorogenic acid)	**Stationary phase:** CN-(cyanopropyl) modified silica gel **Mobile phase** 60% acetone in hexane for the development in first direction and 50% methanol in water for development in second direction	Visualization with poly(ethylene glycol) 400nm and 2-(diphenylboryoxo)ethylamine	23
Evaluation of a	Echinacoside and cichoric	**Stationary**	The method	

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quantitative HPTLC method for analysis of echninacoside and cichoric acid in commercial Echinacea preparations	acid	**phase:** silica gel **Mobile phase** ethyl acetate-formic acid – acetic acid-water 100:11:11:27	described has proven to be very reliable and repeatable.	24
Identification of Ophiopogon japonicas (Thunb) Ker-Gawl and its counterfeit, Lophatherum gracile Brongn	Ophiopogon japonicas, Lophatherum gracile Brongn	**Stationary phase:** Silica gel **Mobile phase** Chloroform – methanol-water 13:7:2	-	25
A new and convenient method for quantitative estimation of chrysophanol, an antioxidant in the rhizomes of Rheum emodi (Roxb)	Chrysophanol	**Stationary phase:** Silica gel **Mobile phase** Hexane – ethyl acetate 9:1	Detection by spraying with 10% sulfuric acid in ethanol and heating. Identification by finger print technique	26
Chromatographic analysis of ginesenoides occurring in the roots of American ginseng (Panax quinquefolium L.) and in Asian ginseng (Panax ginseng C. A Mayer) preparations	ginesenoides Rg1, Rbl, and Re	**Stationary phase:** Silica gel **Mobile phase** Chloroform – methanol – water 13:10:2	Detection by spraying with Godin,s reagent	27
New prenylated benzoic acid and other constituents from almond hulls (Prunus amygdalus Bartsch)	3-prenyl-4-B-D-glucopyranosyloxy-4-hydroxylbenzoic acid, catechin, procatechuic, and ursulinic acid	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol – water 100:20:3	Visualization by spraying with 5% sulfuric acid	28

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		and 10:1:1		
Studies on the constituents of a Brazilian folk infusion. Isolation and structure elucidation of new triterpene saponins from llex amara leaves	Triterpene saponins (e.g. 3α-O-β -D-glucopyranosyl-(1-3)α-L-2-α-acetyl-arbinopyranosylolean-12-en-28-oic acid 28-O-β-D-glucopyranosyl ester 5 known saponins and one flavonoid glycoside	**Stationary phase:** Silica gel **Mobile phase:** n-butanol – acetic acid-water 13:3:5, chloroform – methanol – water 70:30:3	Visualization by spraying with blood reagent	29
Insecticidal activity of huperzine A from the New Zealand clubmoss Lycopodium varium	Huperzine A	**Stationary phase:** Silica gel **Mobile phase:** Methanol – chloroform 1:9	Visualization under UV-254nm followed by dipping in dragendroff soloution	30
2 D TLC-graft planar chromatography in the analysis of a mixture of phenolic acids	Phenolic acids (3,5-dihydroxybenzoic acid, vanillic acid, p-coumaric acid, p-hydroxybenzoic acid, gentisic acid, caffeic acid, syringic acid, sinapic acid, ferulic acid, protocatechuic acid, 2,4-dihydroxybenzoic acid	**Stationary phase:** Silica gel and RP-18 **Mobile phase** Methanol – water 2:3	Detection under UV at 254 and 366nm by coupling with bis-diazotized sulfanilamide	31
Antimicrobial flavonoids from Bolusanthus speciosus	5,7,3-trihydroxy-4'-methoxy-5'-prenylisoflavone, 5,7,3'-trihydroxy-4-methoxy-6,5'-diprenylisoflavone, 5,7,2'-tetrahydroxy-8,3'-diprenylisoflavone, bolusanthin II, bolucarpan A,B,C,D	**Stationary phase:** Silica gel **Mobile phase:** n-hexane – acetone 3:1 by 4-fold development	Testing for antimicrobial activity was done by TLC bioautographic technique	32

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Characterization of tannins from rhubarb by TLC/HPTLC	Rhubarb extract	**Stationary phase:** Silica gel **Mobile phase:** Acetone – water – formic acid 18:1:1 or toluene- acetone – formic acid 3:6:1 over 75 mm after partial chamber saturation	Documentation under white light and at 366nm	33
HPTLC of flavonoids hypericin and pseudohypericin	Flavonoids hypericin and pseudohypericin	**Stationary phase:** Silica gel **Mobile phase:** Ethyl acetate – dichloromethane – formic acid – acetic acid – water 100:25:10:11	Quantitaive dtermination by absorbance measurement at 310nm without derivization	34
Simple thin layer chromatographic test for antioxidative compounds using the DPPH assay	Mushroom extracts	**Stationary phase:** Silica gel **Mobile phase:** Dichloromethan e – ethyl acetate-methanol 3:1:1	Determination of bioactivity with DDPH-biotest by spraying with 5 mg (2,2-di(4-tert-octylphenol)-1-picrylhydrazyl in 10 ml acetone	35
Three pyrone glucoside derivatives from Conyza albida	Z-lachnophyllum ester, E-lachnophyllum lactone, and Z-cumulene	**Stationary phase:** Silica gel **Mobile phase:** Diethyl ether – petroleum ether 5:1	Qualitative identification was performed	36

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Cytotoxic sesquiterpene lactones from Carpesium abrotanoides	Carpesiolin, carabrone carabrol, telekin, ivalin, and 11,13-didehydroivaxillin	**Stationary phase:** Silica gel **Mobile phase:** n-hexane-ethyl acetate – acetone 3:1:1 and 8:1:1 as well as n-hexane-acetone 2:1	Preparative TLC was done	37
Inhibitory activity on binding of specific ligands to the human angiotensinll AT1 and endothelin 1 ETA receptors: Bioactive benzophenanthridine alkaloids from the root of Bocconia frutescens	Chelirubine, sanguinarine, macarpine, and chelerythrine	**Stationary phase:** Silica gel and aluminium oxide **Mobile phase:** Chloroform – methanol 49:1	Detection under UV light	38
Quinoline alkaloids and anti – platelet aggregation constituents from the leaves of Melicope semecarpifolia	Melisemine, confusadine, melicarpinone, edulinine, (S)-(-)-7,8-dimethyoxyplatydesmine, isoplatydesmine, skimmianine, confusaneline, Haplopine and kokusaginine	**Stationary phase:** Silica gel **Mobile phase:** chloroform – acetone 5:1 and 10:1, chloroform – methanol, benzene-ethyl acetate 1:1, benzene – methanol 10:1	Preparative and analytical TLC was performed	39
Separation of some flavonoids by use of the prisma model and forced flow planar techniques	Flavonoids (7-o-glucoside luteolin, 7-O-glucoside apigenine, 5'-O-glucoside tricetin, 3-O- rhamnoside quercetin, 3-O-rhamnoside	**Stationary phase:** Silica gel **Mobile phase:** Ethanol – ethyl acetate –	-	40

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	kaempferol, luteolin, quercetin, kaempferol, isoginkgetin ginkgetin	dioxane – hexane		
Phenolic acids in the herb, fruits and roots of Peucedanum verticillare L. Koch ex DC	Phenolic acids (e.g. p-coumaric, chlorogenic, hydroxybenzoic, isovanillic, caffeic, rosmarinic, syringic, vanillic, protocatechuic, ferulic, y-and b-resorcylic and gentisic acid	**Stationary phase:** Cellulose **Mobile phase:** Toluene-sodium ethyl-formic acid 5:4:1, sodium formate – formic acid – water 10:1:200, and 15% aqueous acetic acid	Visualization with 3% methanolic solution of iron (iii) chloride, diazotized sulfanilic acid	41
Circular and linear OPLC of ginesenosides in Panax quinquefolium L. cultivated in Poland	Ginsenosides (e.g. Rb 1, Rc, Re, Rd, Rg1, and Rg2)	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol – ethyl acdetate – water 15:22:40:9	Quantitation by densitometry at 540nm	42
Quantitative and qualitiative analysis of the tropane alkaloids from Datura innoxia by TLC	Tropane alkaloids (i.e. atropine, homatropine, L-hyoscamine, scopolamine, scopolamine N-oxide, tropine, tropic acid) on silica gel with methanol – acetone – NH_3	**Stationary phase:** Silica gel and RP-18 **Mobile phase:** methanol – acetone – diethylamine 25:24:1 and methanol-acetone- NH_3 10:3:1	Quantitation by densitometry after spraying with dragondroff reagent at 520nm	43
An improved procedure	Shouwu formulation	**Stationary**	Identification by	44

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for the identication of shouwu pills by thin-layer chromatography		**phase:** Silica gel **Mobile phase:** Benzene – ethanol 2:1 for the first and benzene – ethanol 4:1 for the second	finger printing technique	
Optimization of the separation of flavonoid glycosides and rosmarinic acid from Mentha piperita on HPTLC plates	Caffeetannins and flavonoid glycosides (eriocitrin, hesperidin luteolin-7-O-ruthnoside, diosmin and rosmarinic acid	**Stationary phase:** Silica gel **Mobile phase:** Acetone – acetic acid 17:3	Detection under UV at 365nm before spraying with bis-diazotized sulphanilamide	45
TLC separation of Uncaria tomentosa alkaloids on chemically modified stationary phases	Alkaloids	**Stationary phase:** Silica gel **Mobile phase:** Ethyl acetate – methanol – water 100:13.5:10(1), ethyl acetate – methanol – water – acetic acid 100:2.7:5:3(II), ethyl acetate – methanol – water – formic acid 100:2.7.5:3, and ethyl acetate – iso –propanol – NH3 100:2:1 (IV) as mobile phases	Detection with Dragandroff or iodine reagent	46

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Phenolic acids in peucedanum verticillare L. Koch ex	TLC and 2-D TLC of phenolic acids (p-coumaric, resorcylic, α-resorcylic, and gentisic acid	**Stationary phase:** Silica gel **Mobile phase:** Toluene – ethyl formate – formic acid 5:4:1, sodium formate – formic acid – water 10:1:200, and 15% aqueous acetic acid for one-dimensional speration	Detection under UV 254nm and 366 nm. Visualization also by 3% methanolic solution of iron (iii) chloride and 1:1 diazotized sulfanillic acid in 20% sodium carbonate solotion	47
High-performance thin-layer chromatographic method for estimation of rutin in medicinal plants.	Rutin from medicinal plants (e.g. Tephrosia purpurea, Leptadenia reticulate, Ruta graveolense)	**Stationary phase:** Silica gel **Mobile phase:** Ethyl acetate – butanol – formic acid – water 5:3:1:1	The method was validated for precision(intra- and intra-day), repeatability and accuracy	48
A new spray reagent for detection and differentiation of sulfur compounds in plant extracts.	Plant extracts with different sulfur-containing groups (e.g. allicin and disulfides)	**Stationary phase:** Silica gel **Mobile phase:** Toluene – ethyl acetate 10:3 and 7;3	Visualization by spraying with a solution of 3 g bismuth nitrate in 100 ml acetone can be used.	49
Cellulose HPTLC plates in the separation of selected flavan-3-ols using aqueous eluents	flavan-3-ols (e.g. (+)-catechnin, (-) epicatechin, (+)-gallocatechin, (-) +epigallocatechin, (+)-catechin, (-) epicatechin, (+)-gallocatechin, (-)-epigallocatechin, (+)-catechin gallate, (-)-	**Stationary phase:** Cellulose **Mobile phase:** Aqueous solutions containg acetone, acetic	Separation were performed at ambient temperature and humidity (20-24 ^{0}C 45-46 %)	50

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	epicatechin gallate, epicatechin-(4α)-catechin, epicatechin-(4α-epicatechin]	acid, tetrahydrofuran, acetonitrile, ethyl acetate, methanol, ethanol 1-propanol, 2-propanol, 1-butanol, and 2-butanol as organic modifiers		
Study on the biotransformation of glycyrrhizin	The zymolysed glycyrrhin	**Stationary phase:** Silica gel **Mobile phase:** Butanol – acetic acid-water 4:1:2	Quantitation densitometry at 360nm	51
Comparison of medium pressure soli-liquid extraction and rotation planar extraction of Ficus leaves with reference to optimum operating parameters	Ficus sycomorus	**Stationary phase:** Silica gel **Mobile phase:** Hexane – ether – 1,4-dioxan-ethanol 39:5:3:3	Visualization under UV at 254nm and 366 nm	52
Comparing identification between Cassia obtusifolia L and Cassia sophera L.	Cassia	**Stationary phase:** Silica gel **Mobile phase:** Petroleum ether (30-60 ^{0}C)-ethyl acetate-formic acid 15:5:1	Comparison also by microscopy and UV spectroscopy	53
Determination of isoimperatorin in Exocarpium citri grandis	Isoimperatorin	**Stationary phase:** Silica gel **Mobile phase:**	Detection under UV. Identification by fingerprinting	54

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from various species and origins by thin-layer chromatography		Petroleum ether, ethyl acetate 5:1	technique	
Studies on the quality standard for Wanshouchun oral liquid	Wanshouchun	**Stationary phase:** Silica gel **Mobile phase:** n-hexane – ethyl acetate 4:1;2) petroleum ether 60-90 0C)-ethyl acetate 1:1;3) benzene – chloroform – ethyl acetate 10:8:1.	-	55
TLC and HPLC analysis of the phenolic acids in Silphium perfoliatum L. leaves, inflorecences and rhizomes	Free phenolic acids and those released after acidic and basic hydrolysis (gallic, chlorogenic, protocatechuic, m-and p—hydroxybenzoic, vanillic, isovanillic, caffeic gentisic, syringic, o-, m-, and p-coumaric, ferulic, salicylic, α -and-β - resorcylic, sinapic and veratric acid	**Stationary phase:** Cellulose, polyamide 11 and silica gel **Mobile phase:** Benzene – methanol – acetic acid 45:8:4	Phenolic acids can be susucessfully seprated on polyamide 11, detection under UV at 254nm	55
Studies on the quality standard for Xiaozhi solution	Emodin and Chrysophenonl	**Stationary phase:** Silica gel **Mobile phase:** Hexane-ethyl acetate – formic acid 60:20:1, chloroform – ethyl acetate – ether –	Identification by fingerprinting technique	56

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		methanol-formic acid-water 12:12:13:5:5:3, chloroform – methanol 4:1		
Analytical study of extracts of St John's wort (Hypericum perforatum), evaluation of HPTLC plates by multivariate data analysis	27 extracts of St. John's wort	**Stationary phase:** Silica gel **Mobile phase:** n-heptane-acetone- t-butyl methyl ether-formic acid 33:35:30:2	New approach to the evaluation of HPTLC plates	57
Preliminary study on the stability of aucubin	Aucubin	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol 8:3	Discussion of the stability condition for the compounds	58
New amides and gastroprotective constituents from the fruit of Piper chaba	Piperine, piperamine, piperlonnguminine, and methyl piperate	**Stationary phase:** Silica gel **Mobile phase:** n-hexane-ethyl acetate 1:1	Detection by spraying with 1% cerium sulfuric 10% aqueous sulfuric acid followed by heating on a plate heater.	59
Sesquiterpene lactones in Arnica Montana: A rapid analytical method and the effects of flower maturity and simulated mechanical harvesting on quality and yield	Acetyldihydrohelenalin, methacryloyldihydrohelenalin, acetyl-, methacryloyl-, isobutyryl-, tigloyl-, 2-methylbutyryl-, and isovalerylhelenalin	**Stationary phase:** Silica gel **Mobile phase:** n-pentane – diethyl ether 1:3	Detection was carried out under UV light at 254nm	60
Cancer chemopreventive activity of rotenoids from	6aa, 12aa-12a-hydroxyelliptone, deguelin,	**Stationary phase:** Silica gel	Detection was carried out in UV	61

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Derris trifoliate	a-toxicarol, rotenone, elliptone	**Mobile phase:** Dichloromethane, benzene – methanol 47:3, n-hexane – ethyl acetate 4:1 and benzene-acetone 47:3	under 254nm	
Densitometic determination of kinetics of hydrolysis of flavonoid glycosides	Isoquercitrin, avicularin, rutin, apigenin 7-glucoside, naringin, and hesperidin	**Stationary phase:** Silica gel **Mobile phase:** Ethyl acetate – methanol – formic acid 90:10:1	Report of the possibilities and advantages of HPTLC for investigation of hydrolysis.	62
Characterization and TLC bioautographic detection of essential oils from some Thymus taxa, determination of the activity of the oils and their components against plant pathogenic bacteria.	Essential oils and thymol, carvacrol, geraniol as standards and streptomycin and gentamycin as positive controls	**Stationary phase:** Silica gel **Mobile phase:** Toluene – ethyl acetate 93:7	Qualitative and quantative analysis at 500nm	63
TLC of ecdysteroids with four mobile phases and three stationary phases	29 Ecdysteroids (eg 20-hydroxyecdysone, polypodine B, 2-deoxyintegristerone, ajugasterone C, isovitexirone, muristerone A, turkestrone, makisterone C, rubrosterone, poststerone, ecdysone, herkesterone	**Stationary phase:** Silica gel, RP-18,Cyano phase **Mobile phase:**	Qualitative and Quantitaive analysis of ecdysteroids using HPTLC under 254nm under reflectance absorbance mode	64
Amarbellisine, a lycorine-	(+)-amarbellisine in the	**Stationary**	Quantitaive	65

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type alkaloid from Amaryllis belladonna L. growing in Egypt	bulbs of Amaryllis belladonna L.	**phase:** Silica gel **Mobile phase:** Chloroform – methanol 9:1 with 1 drop of ammonia	dtermination at 254nm to estimate the alkaloid content in the flowering stage (april) and in the preflowering stage	
Simplified and rapid method for extraction of ergosterol from natural samples and detection with quantitative and semi-quantitative methods using thin-layer chromatography	Ergosterol (ergosta-5,7,22-trien-3beta-ol)	**Stationary phase:** Silica gel **Mobile phase:** Ergosterol was detected using TLC	Quantification limit was 16ng	66
New camptothecin and ellagic acid analogues from the root bark of Camptotheca acuminate	20-formylbenz [6,7] indolizino[1,2-b]quinolin-11(13H)one, 10-methoxy-20-O-methyl-5'hydroxy ellagic acid	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol 4:1, chloroform – ethylacetate 6:1, ethyl acetate – hexane 4:1, and ethyl acetate	Detection was carried out under UV light	67
Xanthones from Gentina campestris as new acetylcholinesterase inhibitors	Bellidin, bellidifolin and the respective glucosides	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol – water 50:10:1	Huperzine A, galanthamin Hbr, and physostigmine as reference compound	68
A new cytotoxic phenylbutenoid dimer from the rhizomes of Zingiber cassumunar	(+/-)-trans-3-(4-hydroxy-3-methoxyphenyl)-4-[(E)—3,4-dimethoxystyryl] cyclohex-1-ene	**Stationary phase:** Silica gel **Mobile phase:** Hexane – ethyl acetate 2:1 and	Detection under UV light at 254nm	69

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		n-hexane – acetone 3:2		
Phosphodiesterase and thymidine phosphorylase – inhibiting salirepin derivatives from Sympotocos racemosa.	Glycosides symploside and symploveroside	**Stationary phase:** Silica gel **Mobile phase:** Methanol – acetone – chloroform 1:50: 149 and 1:68:131	Detection under UV light at 254nm	70
Cytotoxic xanthones and biphenyls from the root of Garcinia linii.	New xanthones linixanthone A, B, C, garcibiphenyl A and B and garcibenzopyran	**Stationary phase:** Silica gel **Mobile phase:** n-hexane – ethyl acetate 5:1 and 10:3 and chloroform methanol 10:1 and 5:1	Detection under UV light at 254 nm	71
Phenylethanoid glucosides from in vitro propagated plants and callus cultures of plantago lanceolata)	Flavonoids (lavandulifolioside, plantamajoside, acteoside, leucosceptoside, and martynoiside	**Stationary phase:** Silica gel **Mobile phase:** n-butanol – acetic acid – water 4:1:5	-	72
Antiallergic phenanthrenes and stibenes from the tubers of Gymnadenia conopsea	Gymconopin A	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol – water 15:3:1	-	73
A new seco-abietane-type	Seco-abietane-type	**Stationary**	Detection under	74

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diterpene from the stem bark of Picea glehni	diterpene from the stem bark diterpenoid 13S-hydroxy-9-oxo-9, 10-seco-abiet-8(14)-en-18, 10alpha-olide, pinoresinol and reduction	**phase:** Silica gel **Mobile phase:** n-hexane – ethyl acetate – methanol 25:25:1, chloroform – methanol 9:1 and 19:1	UV light at 254nm	
Morphological, chemical, and functional analysis of Catuaba preparations	Catuabine and its hydroxymethyl derivative 7-exo-hydroxy-N-methyl-catuabine	**Stationary phase:** Silica gel **Mobile phase:** Dichloromethane – acetone 97:3 and toluene – acetone – methanol-ammonia 45:45:7:3	Detection under UV light under 254 and 366 nm and by spraying with postasssium iodoplatinate reagent	75
A novel cytotoxic oxetane ent-kauranoid from Isodon japonicas.	Mayoecrystal I, a new 11,20,: 1, 20-diepoxy-ent-kaurane diterpenoid and rubescensin	**Stationary phase:** Silica gel **Mobile phase:** Petroleum ether and acetone 4:1	Detection under UV light at 254nm	76
Cancer chemopreventive activity of rotenoids from Derris trifolia	Rotenone and 6a-alpha, 12a-alpha-12a-hydroxyelliptone	**Stationary phase:** Silica gel **Mobile phase:** Benzene – methanol 24:1 and hexane – ethyl acetate 4:1	Detection under UV light at 254nm	77
Bioactive Diels – Alder type adducts from the stem bark of Morus	Guangsangon A and guangsangon B	**Stationary phase:** Silica gel and RP-18	Detection under UV light at 254 nm	78

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macroura		**Mobile phase:** Chloroform – methanol 7:3		
A new sesquiterpene-coumarin ether and a new abietane diterpene and their effects as inhibitors of P-glycoprotein.	Driportlandin, portianquinol as well as formonetin and davidigenin,	**Stationary phase:** Silica gel **Mobile phase:** Dichloromethane – methanol 49:1 dichloromethane – diethyl ether 19:1, dichloromethane – ethyl acetate 19:1 to 47:3; chloroform – ethyl acetate 9:1 and dichloromethane – methanol 19:1	-	79
Anti – inflammatory isoflavonoids from the stems of Derris scandens	TLC of genistein and 7-O-alpha-rhamno (1-6)-beta-glucosylgenistein	**Stationary phase:** Silica gel **Mobile phase:** n-butanol – acetic acid – water 4:1:1 ethyl acetate – methanol – water 77:13: 10, and ethyl acetate – methanol – acetic acid – water 13:3:4:3	-	80
Cytotoxic alkaloids from	Tylophoridicine E and F	**Stationary**	Detection with	81

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the roots of Tylophora atrofolliculata		**phase:** Silica gel **Mobile phase:** Dichloromethane – methanol – ammonia 100: 10:1 or 120:10:1	Dragendroff reagent	
Nor-lignans and steroidal saponins from Asparagus gobicus	Gobicusin B and 4-[5-(4-methoxy-phenoxy)-3-penten-1-ynyl]-phenol	**Stationary phase:** Cellulose and silica gel **Mobile phase:** Chloroform	Detection under UV light at 254 nm	82
New triterpenoid saponins from bulbs of Blbastemma paniculatum	6'-O-palmitoyltubeimoside I, a triterpenoid of the 8-formyldammarene	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol – water 13:7:2 and 13:4:1	Detection by spraying 10% sulfuric acid in ethanol, followed by heating	83
Eremophilane sesquiterpene lactones from Ligularia virgaurea ssp. Oligocephala	10alpha-hydroxy-1-oxoeremophila-7(11), 8(9)-dien-12,8-olide, and toluccanolides A and C	**Stationary phase:** Silica gel **Mobile phase:** Petroleum ether – diethyl ether 1:1	Detection under UV light	84
Preparation of ursane triterpenoids from Centella asiatica using high speed countercurrent chromatography with step gradient elution	Pentacyclic triterpene acids (asiatic acid, madecassic acid) and triterpene glcosides	**Stationary phase:** Silica gel **Mobile phase:** Ethyl acetate-methanol – water 8:2:1	Detection by spraying with 3% sulfuric acid in ethanol, followed by heating to 110^0C.	85
Preparative isolation of cannabinoids from Cannabis sativa by	Delta8-tetrahydrocannabinol, cannabigerol,	**Stationary phase:** Silica gel **Mobile phase:**	Detection under UV light at 254nm and by spraying	86

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centrifugal partition chromatography	cannabigerolic acid, cannabidiolic acid, and (-)-delta9-(trans)—tetrahydrocannabinolic acid	Methanol (5%) –acetic acid 19:1	with modified anisaldehyde-sulfuric acid reagent	
Isotamarixen – a new antioxidant and propyl endopeptidase-inhibiting triterpenoid from Tamarix hispadia	3a-(3",4"-dihydroxy-trans-cinnamoyloxy)-D-friendoolean-14-en-28-oic acid and isorhamnetin	**Stationary phase:** Silica gel **Mobile phase:** Dichloromethane – methanol 46:1 and methanol – chloroform 3:7	Visualization under UV light at 254nm	87
Pubescenes, jatrophane diterpenes from Euphorbia pubescens, with multidrug resistance reversing activity on mouse lymphoma cells	Pubescence D (3□-,9a-diacetoxy-7□ -benzoyloxy-15□ -hydroxy-14-oxo-2□H-jatropha-5E,12E-diene)	**Stationary phase:** Silica gel **Mobile phase** Chloroform-acetone 9:1	Detection under UV at 254nm	88
Antifungai steroid saponins from Dioscorea cayensis	Saponins (26-O-□D-glucopyranosyl-22-methoxy-3□ 26-dihydroxy-25(R)-furost-5-en-3-O-a-L-rhamnopyranosyl-(1-4)-a-L-rhamnopyranosyl-(1-4)-[a-L-rhamnopyranosyl-(1-2)[-□-D- glucopyranoside	**Stationary phase:** Silica gel **Mobile phase** Chloroform-methanol-water 13:7:2	Detection under UV at 254nm	89
Study of the quality standard for Fuketiaojing tablets	Fuketiaojing tablet extracts	**Stationary phase:** Silica gel **Mobile phase** Benzene – ethyl acetate – glacial acetic acid 2:1:1, benzene –	-	90

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		ethyl acetate – glacial acetic acid 92:5:5, cyclo hexane – ethyl acetate 7:3, chloroform – methanol-water 30:10:1		
HPTLC method for guggulsterone. Quantitative determination of E and Z-guggulsterone in herbal extract and pharmaceutical dosage form	E and Z stereoisomers of guggulsterone (the hypolipidemic agent in the gum-resin exudates of Commiphora mukul	**Stationary phase:** Silica gel **Mobile phase** Toluene – acetone 9:1	Quantitative determination by absorbance measurement at 250nm.	91
Quantitative determination of ephedrine chloride in Tongxuan Life pills by thin layer chromatography	Ephedrine chloride`	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol – ammonia 200:35:6	Detection by spraying with 0.5% ninhydrin in ethanol followed by heating at 105 ^{0}C for a few minutes. Quantitative determination at 510nm	92
Studies on the quality standard for compound herba Houttuyniae granules	Houttuyniae granules	**Stationary phase:** Silica gel **Mobile phase:** Toluene – chloroform – acetone 8:5:7, butyl acetate – formic acid – water 14:5:5,	Identification by finger printing technique	93

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		chloroform – methanol – acetic acid 17:2:1		
Estimation of berberine in herbal extract and poly herbal formulations by HPTLC	Berberine	**Stationary phase:** Silica gel **Mobile phase:** n-propanol-formic acid-water 90:1:9	-	94
Novel diterpenoid acetylcholine-esterase inhibitors form Salvia miltiorhiza	Diterpenoid	**Stationary phase:** Silica gel **Mobile phase:** Methanol-water, 4:1	-	95
New lignans and cytotoxic constituents from Wikstroemia lanceolata	(-) aptosimon, (-)-diasesamin-di-y-lactone, (-) sesamin, (+/-)-syringaresinol, (+)-wikstromol, (+)- hinokinin, palmitic acid, stearic acid, 3, 6-dihydroxy-2-methoxy-4-methylacetophenone, 2, 6-dimethyl-p-benzoquinone and lichenxanthone	**Stationary phase:** Silica gel **Mobile phase:** n-hexane – ethyl acetate 5:1 and 10:1, choloroform-acetone 4:1, 20:1	-	96
Euphpubescenol and euphopubescene two new jatrophane polyesters, and lathyrane-type diterpenes from Eupherbia pubescens	Euphopubescenol (5a, 8a, 15β-triacetoxy-3a-benzoloxy-4a-hydroxy-9, 14-dioxo-13 βH-jatropha-6(17), 11E-diene, jolkinaool A	**Stationary phase:** Silica gel **Mobile phase:** Chloroform-methanol 39:1 by 3 fold development	Visualization under UV light and by spraying with sulfuric acid – acetic acid- water 1:20:4 followed by heating	97
HPTLC method for the determination of acteoside in ribwort plantain	acteoside from leaves of Plantago lanceolata	**Stationary phase:** Silica gel **Mobile phase:**	Quantitative determination was performed at	98

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(Plantago lanceolata		Ethyl acetate – formic acid water 18:1:1	334nm Interday and interaday RSD were 0.58 and 2.0%	
TLC as a rapid and convenient method for saponin investigations	Saponins from 70 species of acer	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol – formic acid – water 200:80:20:19	Detection was carried out using anisaldehyde reagent and also by spraying with water or blood reagent	99
Mobile Phase velocity – a tool for separation of alkaloids by OPLC	Allocryptopine, protopine, chelidonine, chelrythrine, chlilutine. Sanguinarine and chelirubine	**Stationary phase:** Silica gel **Mobile phase:** Toluene – ethyl acetate – methanol 14:3:3 for tertiary alkaloids and toluene – ethyl acetate – methanol 83:15:2 for quaternary alkaloids.	Investigations on properties such as retardation factor, reproducibility, efficiency and no of theoretical plates, HETP and resolution were done.	100
Application of densitometry to the determination of catechin in rose-hip extracts.	Rose-hip extracts and (+)-catechin and (-)- epicatechin	**Stationary phase:** Cellulose and silica gel **Mobile phase:** Ethyl acetate – water – formic	Visualization under UV light at 254 and 365 nm before and after spraying with bis-diazotized sulfanilamide	101

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		acid – acid 125:20:3:2		
Modern TLC: A key technique for identification and quality control of botanicals and dietary supplements.	Stephania tetrandra root extracts with tetrandrine as standard	**Stationary phase:** Silica gel and RP-18 **Mobile phase:** Toluene – ethyl acetate – methanol – ammonia 100:100:50:3	Study as per the GMP guidelines using TLC for semi quantification and identification of herbals	102
Separation of the ginsenosides fraction obtained from the roots of Panax quinquefolium L. cultivated in Poland.	Ginsenosides (Rg 1, Re, Rf, Rb 1, Rc, Rb 2, and Rd as standards)	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol – ethyl acetate – water – hexane 10:11:30:4:2	Densitometric evaluation by absorbance measurement at 540nm	103
Two-dimensional planar chromatography of tropane alkaloids from Datura innoxia Mill.	Alkaloids (e.g. atropine, homatropine, L-hyoscyamine, scopolamine N-oxide, tropine, tropic acid) from Datura innoxia	**Stationary phase:** Silica gel **Mobile phase:** Methanol – acetone – aqueous ammonia 10:8:1 or methanol – acetone – diethylamine 25:24:1	Densitometric evaluation at 520nm and 205 nm	104
Quantitative determination of beta asarone in Calamus by high – performance thin-layer chromatography	Beta-asarone (cis-2,4,5-trimethoxy-1-propenylbenzene) and alpha-asarone in Calamus	**Stationary phase:** Caffeine impregnated silica gel	Method allows proper identification of calami rhizome raw	105

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	rhizome	**Mobile phase:** Toluene – ethyl acetate 93:7	material and the specific, accurate and precise quantification of beta- asarone and alpha- asarone.	
Development and validation of a thin-layer chromatography – densitometric method for the quantitation of alliin from garlic (Allum sativum) and its formulations	Alliin	**Stationary phase:** Silica gel **Mobile phase:** Butanol – acetic acid – water 3:1:1 at 25+/- 2^0 C and 40 % relative humidity	Linearity within the range of 250-1500ng/ spot, correlation coefficient of 0.998 and RSD of 2.87% and mean recovery 98.45	106
Thin layer chromatography densitometry and liquid chromatography analysis of alkaloids in leaves of Papaver somniferum under stress conditions	Narceine, morphine, codeined, thebaine, papaverine and narcotine	**Stationary phase:** Silica gel **Mobile phase:** Toluene-acetone – ethanol**,** 25% ammonia 20:20:3:1	Detection with dragondroffs reagent with sodium nitrate, densitometric evaluation at 520nm.	107
The quality standard for compound Xuelian capsules	Chinese Herbal	**Stationary phase:** Silica gel **Mobile phase:** Ethyl acetate – formic acid – water 10:1:2:2, cyclohexane – chloroform – methanol 10:6:1	Quantification was performed by using HPLC	108
Study of the quality standard for Gubiling capsules	Ginsenoside Rg1	**Stationary phase:** Silica gel **Mobile phase:** Ethyl acetate –	Quantification of ginsenoside Rg 1 by HPLC, Results For three real life	109

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		ethanol 4:1:2, ethyl acetate – methyl ethyl ketone – formic acid – water 10:1:1:1:3, cyclohexane – acetone 10:3	time samples are given	
Study of the quality standard for Shenguo granules	Emodin	**Stationary phase:** Silica gel **Mobile phase:** Benzene – ethyl acetate – formic acid 15:2:1:2 n-hexane – ethyl acetate – formic acid 60:20:1**,** Chloroform – methanol – ammonia 40:10:1:4, chloroform-methanol- water 13:7:2	Validation of the method by investigating of its linearity range (0.1µg -1.0µg, r = 0.998): prcesion (RSD =1.05% n= 6)	110
A HPTLC method for standardization of curculigo orchioidesrhizomes and its marketed formulations using gallic acid as standard.	Curculigo orchioidesrhizomes and Gallic acid as standard	**Stationary phase:** Silica gel **Mobile phase:** Toluene – ethyl acetate – acetic acid	The method was validated according to ICH guidelines.	111
Characterization of tea-tree Melaleuca alternifolia oil HPTLC fingerprinting	Hydro-distilled volatile tea-tree oil of Melaleuca alternifolia oil	**Stationary phase:** Silica gel **Mobile phase:** Toluene-ethyl	Nine well distinguished peaks were obtained	112

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		acetate 93:7		
Quantification of eugenol in Cinnamomum tamala Nees and Eberm leaf powder by high performance thin layer chromatography	Cinnamomum tamala leaves and eugenol	**Stationary phase:** Silica gel **Mobile phase:** Toluene – ethyl acetate – formic acid 90:10:0.1	Detection and quantification by densitometry at 280nm	113
Determination of Stachys palustris iridoids by a combination of chromatographic methods	Iridoids (e.g. aucubin, catalpool, harpagide, 8-O-acetylharpagide, ajugoside)	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol – water 25:10:1 and 160:55:8 and ethyl acetate – formic acid 7:4	Detection by spraying with solution of 1% 4-dimethylaminebenzaldehyde in conc. HCl containing acetic anhydride(Ehrlish,s reagent) then heating at 105 ^{0}C for 5 min	114
Determination of emodin and phenolic acids in the petioles of Rheum undulatum and Rheum rhaponticum	Emodin and phenolic acids (protocatechuic, homoprotocatechuic, caffeic, syringic, vanillic, ferulie, p-hydroxyphenylacetic, alpha-resorcylic, p-coumaric, gallic and ellagic acid	**Stationary phase:** Silica gel **Mobile phase:** Toluene – dichloromethane – ethyl acetate 4:4:1	Derivatization was performed by spraying with either diazotized sulfanillic acid in 20% sodium carbonate solution	115
Petasites hybridus extracts in vitro inhibit COX-2 and PGE2 release by direct interaction with the enzyme and by preventing p42/44 MAP kinase activation in rat primary	Petasin and isopetasin	**Stationary phase:** Silica gel **Mobile phase:** Toluene – ethyl acetate 93:7	TLC of Petasin and isopetasin on silica gel without chamber saturation	116

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microglial cells.				
Determination of resveratrol in Polygonum cuspidatum Sieb et Zucc by thin-layer chromatography	Reveratol	**Stationary phase:** Silica gel **Mobile phase:** Petroleum ether (30 0C-900C) – ethyl acetate-methanol – glacial acetic acid 200.50:35:1	Discussion of the application of the procedure for the quality control of the medicine	117
Study of the quality standard for Yupingfeng oral liquid	Yupingfeng oral liquid	**Stationary phase:** Silica gel **Mobile phase:** Cyclohexane – ethyl acetate 7:3	Detection-identification by fingerprint techniques	118
Study of the quality standard for Suzi Jiangqi pills	Hespiridin from Suzi Jiangqi pills	**Stationary phase:** Silica gel **Mobile phase:** Petroleum ether (60-90 ^{0}C) ethyl acetate 9:1; and chloroform – ethyl acetate – methanol – water 15.40: 22:10	Quantification of Hespiridin by HPLC	119
Study of the quality standard for Tongmai Jiangzhi capsules	Curcumin, emodin and chrysophanol	**Stationary phase:** Silica gel **Mobile phase:** Methanol – ethyl acetate – formic acid 55:12:6	Quantification of Curcumin, emodin and chrysophanol was performed by HPLC	120
Determination of ecdultin in Bazi Bushen capsules	Ecdultin	**Stationary phase:** Silica gel	Validation of the procedure by	121

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by thin-layer chromatography) Chinese)		**Mobile phase:** Benzene – ethyl acetate 30.1	investigation of the optimum excitation wavelength ; linearity range (0.022-0.13µg/spot, R =0.9998);repeatability (1.5% n=6 precision(0.87 % n=6 within plate and 1.42 %, n=6 plate to plate)	
Quantification of valerenic acid in Valeriana jatamansi and Valriana officinalis by HPTLC	Valerenic acid in Valeriana jatamansi and Valeriana officinalis	**Stationary phase:** Silica gel **Mobile phase:** Hexane– ethyl acetate – acetic acid 16:40:1	Quantitative determination by absorbance measurement at 700 nm. Calibration curve was linear in the range of 500 ng-2.5 µg/zone	122
New indolopyridoquinazoline, benzo(e)phenanthridines and cytotoxic constituents from Zanthoxylum integrifolium	Newalkaloids, 7,8-dehydro-1-methoxyrutaecarpine, isodecerine and 8-demethyloxychelerythrine t	**Stationary phase:** Silica gel **Mobile phase:** n-hexane, ethyl acetate 5:3	Chloroform – ethyl acetate 25:1, and chloroform – methanol 25:1 Detection under UV light at 254nm	123
Rotenoids and isoflavones from Sarcolobus globosus	Sarcolobin, sarcolobone, 6,7-dimrethoxy-2,3-dihydrochromone	**Stationary phase:** Silica gel **Mobile phase:** Chloroform-petroleum ether – ethyl acetate 20:11:10	Centrifugally accelerated TLC on silica gel with an chromatotron instrument in a nitrogen atmosphere	124

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Two novel ent-kauranoid deterpeneoids from isodon japonica leaves	Diterpenoids, shikokianin and rabdoternin A	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol 30:1, and of rabdosichuanin and lasiokaurin with chloroform – acetone 6:1	Detection under UV light at 254 nm	125
Determination of fulvotomentoside A in Lonicera Fulvotomentosa Hsu et S.C. Cheng by thin-layer chromatography	Fulvotomentoside	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol – water 61:32:5	The procedure was validated regarding linearity range (0.21%, n=5 within plate and 0.87% n=5 plate to plate)	126
Separation of diosgenin in Trigonella foenum-graecum L. and its compound preparations by thin layer chromatography	Cyclohexane – ethyl acetate 10:1	**Stationary phase:** Silica gel **Mobile phase:** Cyclohexane – ethyl acetate 1:10, followed by cyclohexane – ethyl acetate 2:1	Visualization under UV 365 nm	127
Comparison of methods for determination of tanshinone IIA in Huoxue Huayu granules (Chinese)	Tanshinone ii A in huoxue granules	**Stationary phase:** Silica gel **Mobile phase:** Benzene – ethyl acetate 19:1	Quantitative determination by densitometry at 470nm. Also determination of the compound by HPLC	128

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Analysis of Milagai Thailam for its capsaicin and piperine content by HPTLC	Milagai Thailam	**Stationary phase:** Silica gel **Mobile phase:** Toulene - acetone 7:3 The method was found suitable for other herbal formulations too containing capsaicin and piperine	-	129
HPTLC method for quantitative determination and fingerprinting of isoleucin in trigonella foenum graecum	Trigonella foenum graecum	**Stationary phase:** Silica gel **Mobile phase:** n-propanol – ammonia 11:9	Methanolic extract contained 0.17% isoleucin and ethyl acetate extract 0..08%.	130
HPTLC method for analysis of guggisterone in formulations and Guggul resin extract	Guggulsterones E and Z in herbal extract and market formulations containing commiphora mukul	**Stationary phase:** Silica gel **Mobile phase:** n-hexane – ethylacetate 3:1	The method was validated as per ICH guidelines	131
HPTLC method for quantitative determination and fingerprinting of isoleucin in trigonella foenum graecum	Isoleucin	**Stationary phase:** Silica gel **Mobile phase:** n-propanol – ammonia 11:9	-	132
HPTLC method for analysis of guggisterone in formulations and Guggul resin extract	Guggulsterones E and Z in herbal extract and market formulations containing commiphora mukul	**Stationary phase:** Silica gel **Mobile phase:** n-hexane – ethylacetate 3:1	-	133
HPTLC method development for estimation of stigmasterol	Stigmasterol in leptadernia reticulate	**Stationary phase:** Silica gel **Mobile phase:**	Both hydrolyzed and unhydrolyzed samples were	134

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in leptadenia reticulate		n-hexane – ethyl acetate 4:1	analysed.	
Two new triterpenes from the husks of Xanthoceras sorbifolia	21,22-diangeloyl-24-hydroxy-R1-barrigenol	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol 15:1	Detection under UV light at 254 nm	135
Cytotoxic and anti-platelet aggregation constituents from the root wood of Melicope semecarpifolia	Melicopone acetophenone derivative [1,2-bis(4-hydroxy-3-methoxyphenyl)ethanone]	**Stationary phase:** Silica gel **Mobile phase:** Dichloromethane-ethyl acetate 5:1	Detection under UV light at 254 nm	136
Identification of new dicaffeoylquinic acids from chrysanthemum morifolium and their antioxidant activities	3,5-dicaffeoylquinic acid and 1,3-dicaffeoyl-epi-quinic acid and 6 known dicaffeoylquinic acid derivatives	**Stationary phase:** Silica gel and RP-18 **Mobile phase:** 40% Aqueous methanol	Detection under UV light at 254nm	137
Diterpenes isolated from Croton zambesicus inhibit KCL-induced contractions	Ent-18-hydroxytrachyloban-3beta-ol on silica	**Stationary phase:** Silica gel **Mobile phase:** Toluene-ethyl acetate – acetonitrile 5:2:3 and 40:9:1	Visualization by spraying with anisaldehyde-sulfuric acid reagent followed by heating at 105^0C	138
Quantitation of oleanolic acid in Oldenlandia corymbosa L. whole plant powder by High Performance Thin-layer chromatography	Oleanolic acid	**Stationary phase:** Silica gel **Mobile phase:** Dichloromethane – toluene – acetone – methanol	Oleanolic acid response was linear over the range 1-9µg.	139

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		30:40:15:3		
Quantitative determination of triterpenes from Amphiptherygium adstringens by Liquid chromatography and Thin Layer Chromatography and morphological analysis of cuachalalate preparations	Masticadienonic and 3-hydroxymasticadienonic acid	**Stationary phase:** Silica gel **Mobile phase:** Hexane acetone – formic acid – acetic acid 30:10:1:1	Quantification by determination of the absorption at 200nm. Detection by dipping into anisaldehyde-sulfuric acid reagent for 1 sec. and heating at 100 ^{0}C for 5 min	140
New prenylated metabolites of Deguelia longeracemosa and evaluation of their antimicrobial potential	Isorobustin, robustin, robustic acid, 4-hydroxy-3-(3,4'-methylenedioxyphenyl)-5-methoxy-6-(3,3-dimethylallyl-2",2"-dimethylpyrano-(5",6".8,7) coumarin 4-hydroxy-3-(3'-hydroxy-4'hydroxy-3-(3'-hydroxy-3-[4'-O-(3'-hydroxy-4'methoxyphenyl)-5-methoxy-6-(3,3-dimethylallylphenyl]-5-methoxy-2",2"-dimethylpyrano-(5",6",6,7) coumarin)	**Stationary phase:** Silica gel **Mobile phase:** Hexane-ethyl acetate 7:3 and 3:1, n-hexane-dichloromethane -ethyl acetate 3:1:1 and 9:1:4	Detection under UV light at 254 or 366 nm and by dervatization with an ethanolic soloution of anisaldehyde-sulfuric acid (90:5)	141
Induction of apoptosis by isoflavonoids from the leaves fo Millettia taiwaiana in human leukemia HL-60 cells	Furowanin A, millewanin F, isocrysenegalensein E, 8-gamma, gamma-di-gamma, gamma-dimethylallylwighteone, enchressone b10 6,8-di-gamma, gamma-dimethylallylorobol on	**Stationary phase:** Silica gel **Mobile phase:** n-hexane-acetone 3:1 , chloroform acetone 24:1 and 9:1	Detection under UV light at 365 nm	142

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	silica gel			
Xanthine oxidase inhibitors from the flowers of Chrysanthemum	Acacetin, jaceidin, tricetin 3,4,5- trimethyl ester, dismetin, apigenin, eupafolin, chrysoeriol, (+)-eriodictyol, 3,4-dihydroxybenzaldehyde, p.coumaric acid, 5-O caffeoylquinic acid methyl ester, 4,5-O-dicaffeoylquinic acid	**Stationary phase:** Silica gel **Mobile phase:** Acetonitrile – methanol –water 1:1:3	Detection under UV at 254nm	143
Antimicrobial principles from Aframomumlongifolius	Aframolin B (8beta(17)-epoxy-15, 15-dimethoxylabd-12(E)-en-16-al), and aframodial	**Stationary phase:** Silica gel **Mobile phase:** Hexane – ethyl acetate 2:3	Analytical and preparative TLC of aframodial was performed	144
New macrocylic lathyrane diterpenes from Euphorbia lagascae as inhibitors of multidrug resistance of tumour cells	Isofraxidin, latilagascene A, ent-16alpha, 17-dihydroxykauran-3-one	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol 9:1	Detection under UV-light at 254nm or by spraying with sulfuric acid – vanillin(1:1) solution	145
Five new oleanolic acid glycosides from Achyranthes bidentata with inhibitory activity on osteoclast formation	18-(beta-D-glucopyranosyloxy-28-oxoolean-12-en-3beta-yl 3-o-(beta-D-glucopyranosy)-beta-D-glucopyranosiduronic acid methyl ester, achyranthoside C dimethyl ester, achyranthoside C butyl dimethyl ester, achyranthoside E. dimethyl ester, achyranthoside E butyl methyl ester	**Stationary phase:** Silica gel and RP-18 **Mobile phase:** Chloroform – methanol – water 8:5:2 or methanol –water 1:1	Detection under UV-Light at 254nm or by spraying with cerium sulfate-10% sulfuric acid	146

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Use of HPTLC to establish a distinct chemical profile for Shankhpushpi and for quantification of scopoletin in Convolvulus pluricaulis Choisy and in commercial formulations of Shankhpushpi.	Scopoletin	**Stationary phase:** Silica gel **Mobile phase:** Toluene – diethyl ether 1:1	The method was validated for linearity, accuracy, interday and intraday precesion, specificity, repeatability of measurement of peak area and limit of detection was 50ng/spot	147
Thin-layer chromatography of phenolic acids on aminopropylsilica	Phenolic acids (salicylic, m-hydroxybenzoic, p-hydroxybenzoic, protocatechuic, alpha-resorcylic, beta-resorcylic, gallic, vanillic, syringic, gentisic, veratric, cinnamic, o-coumaric, m-coumaric, p-coumaric, caffeic, ferulic and sinapic acid	**Stationary phase:** Silica gel **Mobile phase:** Mixtures of diisoproplyl ether and acetic acid with toluene petroleum ether, or heptanes, partly with two developments	The best separation was obtained with heptane-diisopropyl ether-acetic acid 4:5:1, or petroleum ether-diisopropylether-acetic acid 6:3:1	148
HPTLC determination of swertiamarin and amarogentin in Swertia species from the western Himalayas	Swertiamarin and amarogentin	**Stationary phase:** Silica gel **Mobile phase:** Ethyl acetate – methanol – water 77:8:8	Quantitation in reflectance/ absorbance mode at 235 nm	149
A simple and convenient method of standardization of Piper longum – an ayurvedic medicinal plant	Plant extracts, using pellitorine and dihydropiperlongumine	**Stationary phase:** Silica gel **Mobile phase:** Hexane – ethyl acetate 3:1	Quantitation by densitometry in absornbance/ reflectance ,mode at 260nm	150

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Separation and identification of piperine and chavicine in black pepper by TLC and GC-MS	Piperine and chavicine	**Stationary phase:** Silica gel **Mobile phase:** Heptane – ethyl acetate 3:2	Detection under UV light at 254nm	151
Determination for glibenclamide adulteration in herbal drugs	Glibenclamide as adulterant in antidiabetic herbal drugs	**Stationary phase:** Silica gel **Mobile phase:** Toluene – ethyl formate – formic acid 5:4:1	A comparative study was done for the results obtained with HPLC and UV spectrophotometry	152
HPLC and HPTLC densitometric determination of andrographolides and antioxidant potential of Andrographis paniculata.	Andrographolide (AP) and 14-deoxy-11,12-didehydroandrographolide (DIAP)	**Stationary phase:** Silica gel **Mobile phase:** Chloroform – methanol 4:1	HPTLC method leads to accurate results when compared with HPLC method	153
Iridoids of Stachys species growing in Hungary	Harpagide, acetylharpagide, harpagoside, ajugoside, aucubin, and catalpol	**Stationary phase:** Silica gel **Mobile phase:** On silica gel with chloroform – methanol – water 25:10:1	Comparison of the Iriodoid composition of ten Stachys species by use of TLC – densitometric method	154
Planar chromatographic study of flavonoids and soyasaponins for validation of fingerprints of Desmodium adscendents of different origin	Flavonoid and triterpenoid soyasaponin content (rutin, vitexine, isovitexine, soyasaponin I and VI as standards	**Stationary phase:** Silica gel **Mobile phase:** Ethyl acetate – formic acid-acetic acid – water 100:11:11:26	Detection with diphenylboric acid 2- aminoethylester followed by PRG reagent.	155
Evaluation of antioxidant and antiacne properties of	-	**Stationary phase:** Silica gel	Different mobile phas scanned using	156

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terpenoidal fraction of Hemidesmus indicus		**Mobile phase:** Silica gel G 60 F_{254}	CAMAG TLC scanner III at 254nm (absorbance/reflectance mode) and 366 nm (fluorescence/reflectance mode) and R_F values, spectra and peak areas of the resolved bands were reces	
Search for suitable mobile phase in TLC analysis of different drugs of forensic interest and their gas liquid chromatographic experiment	Cannabis and related plant products from Cannabis sativa	**Stationary phase:** Silica gel **Mobile phase:** Silica gel G	Different solvent systems attempts were made to find out the suitable developing solvent systems for TLC analysis of constituents of cannabis, opium alkaloids, cocaine and methaqualone	157
High-performance thin layer chromatography method for estimation of conessine in herbal extract and pharmaceutical dosage formulations	Conessine	**Stationary phase:** TLC aluminium plates pre-coated with silica gel 60 F_{254} **Mobile phase:** Ethyl acetate, water acetic acid, 4:5:1	After derivatized the plate with modified Dragendroff's reagent, Camag TLC scanner III was used for spectrodensitometric scanning and analysis of the plate in absorbance mode at 520 nm.	158

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			The system was found to give compact spots for conessine (R_F value of 0.82). The data for calibration plots showed good linear relationship with r2 = 0.9998 in the concentration range of 1–10 µg with respect to peak area.	
Simultaneous estimation of andrographolide and wedelolactone in herbal formulations	Andrographolide and wedelolactone	**Stationary phase:** Silica gel **Mobile phase:** Precoated silica 60 F_{254} toluene : acetone : formic acid (9:6:1)	The calibration curve was found to be linear between 200 to 400 ng/spot for andrographolide and 100 to 200 ng/spot for wedelolactone. The limit of detection and the limit of quantification for andrographolide were 26.16 and 79.28 ng/spot, respectively and for wedelolactone 5.06 and 15.32 ng/spot, respectively	159
TLC Determination of Strychnine and Brucine of *Strychnos nux vomica* in	Strychnos nux vomica	**Stationary phase:** Silica gel **Mobile phase:**	The limit of detection (LOD) and limit of	160

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Ayurveda and Homeopathy Drugs		Chloroform–ethyl acetate–diethyl amine (0.5:8.5:1)	quantification (LOQ) for strychnine were 1.9 and 8.25 ng and for brucine 2.2 and 9.2 ng	
Development and validation of HPTLC method for determination of Glycyrrhizin in herbal extract and in herbal gel	Glycyrrhizin	**Stationary phase:** TLC aluminium plates **Mobile phase:** Ethyl acetate-methanol-water-formic acid (15:2:1:1)	The linear regression analysis data for the calibration plots showed good linear relationship with r_2=0.9981 in the concentration range 2-15 µl with respect to peak area	161
Quality assurance of herbal drugs valerian by chemotaxonomic markers	Valerin	**Stationary phase:** Silica gel Polyamide F254 **Mobile phase:** Methanol-methyl-ethyl ketone, 4:3:3	The developed plates are viewed under 366 nm UV Light	162

Thin-layer chromatography (TLC) continues to be an important method for qualitative analysis of plant products because of its inherent advantages—many samples can be analyzed simultaneously and quickly and multiple separation techniques and detection procedures can be applied. The absence of a need for UV activity (as in LC), paramagnetic properties (as in NMR), or volatility (as for GC) makes TLC one of the most powerful and general analytical tools. It is clear from the Table 1 that most of the mobile phase systems comprising of harmful chemicals as one of the component are not especially useful due to their strong toxic nature. It is now highly recommended that avoid use of these toxic chemicals because these release toxins in the environment. For the sustainable green environment chromatographers are now devoted to develop new environmental friendly chromatographic systems. The interest in TLC has increased with the improvements in TLC instrumentation and methods and further in the last few years with the development of new MS methods for detection. The combination of modern high-

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performance thin-layer chromatography (HPTLC) with automated sample application and densitometric scanning makes this sensitive and reliable technique highly suitable for qualitative and quantitative analysis of herbal products. Quantitative TLC measurements are performed by densitometric scanning. With densitometric measurements the analytes are identified by their (corrected) R_F values and by inspection of UV/VIS spectra of the analytes and standard compounds measured in situ.

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