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Ethnic and scientific reports on medicinally potential rare explored genus - thalictrum of family ranunculaceae

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Abstract---Background: Plants remains a source of food as wells as medicine and healthcare needs since the dawn of civilization. Plants and plants derived products are available in crude form as well as in dosage forms which are widely prescribed by the medical practitioners and believed safe to consume as compared to the synthetic compounds based medicines. Many bioactive compounds derived from the plant sources are utilized in various health problems. A vast research on the medicinal plants has been conducted worldwide but there are many plants species which are still unexplored. Despite having ethnic reports as medicine, a very lesser number of plant species of the genus. Methods: We have been consulting various articles from scientific data available on internet specially, ScienceDirect, Scopus, PubMed, Web of Science. Thalictum of family Ranunculaceae have been explored scientifically in terms of pharmacology, phytochemistry, bioactivity studies. Results: Thalictum is the genus of plants bear flowers in the family Ranunculaceae containing about 200 species in the diverse region of the globe. Species of the genus have been used in the management of various healthcare problems like, clearing heat, stimulating diuresis, subdue swelling detoxification, hepatitis, jaundice, measles, swollen body, febrile convulsion, malnutrition of children, fever, etc. and have reported to have scientifically proven pharmacological activities like, antibacterial, antifungal, antimalarial, anti-inflammatory, antiparasitic, cytotoxicity, anticancer, immunomodulatory,

antioxidant, antipyretic, antiulcer, etc. The species of genus *Thalictrum* are reported to contain various medicinally significant class of phytoconstituents like, alkaloids, glycosides, flavonoids, terpenoids, etc. Conclusion: The review report on ethnopharmacological, phytochemical and pharmacological data on various species of the genus *Thalictrum* will be beneficial for the researchers and the scholars working or intent to work in plant based research and certainly generates scopes for the future scientific research studies specially, in the management of infectious and noninfectious diseases by plants based drugs

Keywords--*Thalictrum*, Ethnic medicines, Ethnopharmacology, Phytochemistry, Pharmacology.

Introduction

Plant and plant products have been a reliable source for the treatment of health problems and used as ethnic medicine in a wide spectrum of ailments since the ancient times. Ethnic Herbal medicines have been an essential part of the culture and traditions worldwide and are used in the form of traditional formulations viz. poultices, decoctions, ointments, churnas, infusions, etc.¹ Plant based natural products can be obtained from various parts like, roots, leaves, fruits, flowers, seeds, bark, resins, etc. and the existence of bioactive molecules might be specific to the plant parts. A Phytocompound isolated from a plant source has been considered as bioactive, prototype, lead, and their later structural modifications can have generated potent bioactive compounds with good therapeutic potential². The ethnopharmacological literature has been played a vital role for the scientific studies to isolate bioactive molecules from the traditional medicines.

The genus *Thalictrum* contains about 200 species of family Ranunculaceae, distributed throughout the globe specially in South America, Asia, Africa, North America, Europe etc.³ About 67 species of *Thalictrum* are reported to be a part of the medicinal flora of China. Most common medicinal plants species of the genus are, *Thalictrum cultratum*, *Thalictrum foiosum*, *Thalictrum glandulosissimum*, *Thalictrum finetii*, *Thalictrum baicalense*, *Thalictrum minus*, *Thalictrum squarrosum*. Species of the genus *Thalictrum* are reported to contain alkaloids, specially berberine and benzyloquinoline, flavonoids, glycosides and terpenoids at major extent^{4,5,6,7}. Plants of this genus have been used as ethnic medicines for the treatment of gastrointestinal diseases, cooling, diaphoresis, dysentery, bloodshot, malnutrition, eyes inflammations, etc.^{4,8,9,10,11} The review contents cover ethnic, phytoconstituents and Pharmacological reports of 10 species of *Thalictrum*, which are reported to have ethnic use and scientific reports. The information in the review article might be a key to generate new research ideas on the less explored plant species of the genus *Thalictrum*.

***Thalictrum atriplex* Finet et Gagnep**

The common name for *T. atriplex* is Ma wei Lian and Shiu Huang Lian is a Tibetan and Folk medicine. The roots of *T. atriplex* was utilized to cure diarrhea

along with infectious hepatitis, dysenteric and some gastro enteric ailments¹². Whole plant along with roots also consumed to cure swollen boils⁴. Cytotoxic activity of cycloatriosides A, B and thaliatrioside A against cancer cells (human lung cancer cells and human breast cancer cells) A549, MDA-MB-231 respectively were screened using MTT method.¹⁷ Neothalpine inhibit aggregation of platelets which is induced by adenosine diphosphate and collagen in vitro¹³. Various Phytoconstituents isolated from *T. atriplex* mention in Table 1.

***Thalictrum cultratum* Wallich**

The roots and rhizomes of *T. cultratum* used as substitute of plant coptis, anti-inflammatory and antipyretic⁴ also given in diarrhea, influenza, measles, carbuncles, viral hepatitis, swollen boils, dysentery, and red eyes.¹⁸ From roots thalicultrate L (tetrahydroprotoberberine-aporphine alkaloid), thalicultrates A–K (thalifaberine-type aporphine-benzylisoquinoline alkaloids) and Thalifarone, Thalifaberine, Thalifabatine Dehydrothalifaberine and Thalibealine isolated and all the alkaloids evaluated for antiproliferative activity against prostate cancer PC-3 and human leukemia HL-60 cells. Most of the alkaloids possessed effective cytotoxicity against cancer cells. The most active compound showed apoptosis and at S phase arrest the HL-60 cell cycle along with loosening mitochondrial membrane potential. The Phytoconstituents isolated from *T. cultratum* mention in Table 2.

***Thalictrum faberi* Ulbrich**

It is an everlasting herb which is native to china, utilized in stomach cancer and Chinese traditional medicine as antiphlogistic²³, swelling eye pain and as Substitute of coptis.⁴ Out of all the isolated compounds Thalifaberine and Thalifasine reported as cytotoxic against various human cancer Cells like human epidermoid carcinoma, Human fibrosarcoma, Human colon cancer, Human breast cancer, murine lymphoid leukemia, hormone-dependent human prostatic cancer, human lung cancer, hormone –dependent human breast cancer, human glioblastoma, human oral epidermoid carcinoma (A431, HT-1080, Col-2, BCA-1, P-388, LNcaP, Lu- 1, ZR-751, U373, KB respectively). Thalifasine showed antimalarial activity against *Plasmodium falciparum*²³. The phytoconstituents reported from this plant stated in Table 3.

***Thalictrum foetidum* Linnaeus**

The roots and rhizomes of *T. foetidum* used traditionally for detoxification of blood, conjunctivitis, infectious hepatitis, carbuncles, swelling eye pain, swollen boils⁴. Pharmacologically *T. foetidum* reported as antialzheimer, it shown its activity by suppressing amyloid precursor protein, acetylcholinesterase along with glial fibrillary acidic protein (GFAP) and increased glucose and decreased acetylcholinesterase expressively in the serum of experimental animal.³¹ Various Phytoconstituents isolated from *T. foetidum* enlisted in table 4.

***Thalictrum foliolosum* DC**

Thalictrum foliolosum DC commonly known as Mamira, pilijari belongs to family Ranunculaceae. Traditionally *T. foliolosum* was used to clear the brain, have purgative action, used in ophthalmia as collyrium, recovers eye-sight, good in toothache, in diarrhea, effective in piles, nail diseases, and spots on skin. The plant roots combine tonic and aperient properties and has been documented as useful in convalescence after acute disease, in mild forms of intermittent fevers, and in atonic dyspepsis. In India and Afghanistan, root is largely used as an anjan, or application of ophthalmia.³²

Pharmacologically, the aqueous extract of rhizomes has shown antipyretic activity in albino rats, in which pyrexia induced by yeast. The water extract at doses 200 and 400 mg/kg showed remarkable antipyretic activity after 2 hrs. of insertion of doses whereas 500 mg/kg extract shown activity within one hour comparing to standard drug paracetamol.³⁹ The isolated compounds Thalfoliolosumines A and B isolated from entire part of *T. foliolosum* reported reasonable in-vitro antiproliferative activity against HL-60, PC-3 and MCF-7 cells. IC₅₀ values was found to be 7.50 and 6.97 μ M for Thalfoliolosumines A and B respectively and shown good inhibitory effect against U937 cells. 8-oxyberberine and jatrorrhizine also possessed strong antiproliferative activity against cell lines with IC₅₀ 0.93, 1.69 μ M respectively.³³ Another isoquinoline alkaloids isolated from 70% ethanolic extract of roots evaluated in-vitro for cytotoxic activity against human lung cancer cell lines (A549, H23, H441, H460, H2170 and HTB-58. The two alkaloidal compound named 5,6,7,12-tetramethoxy-2-methyl-13-hydroxy-11-(4'-carbonylphenoxy) benzylisoquinoline and 5,6,7,12-tetramethoxy-2-methyl-13-hydroxy-11-(4'-methoxycarbonylphenoxy) benzylisoquinoline showed maximum activity against tumor cell lines with reported IC₅₀ values less than 20 μ M.³⁷ Bisbenzyltetrahydroisoquinoline alkaloids such as Thalrigosidine, thalrugosaminine, thalirugidine and thalirugine isolated from whole plant reported with strongest antioxidant activity in ABTS assay.³³ The root extract of *T. foliolosum* rich in phenolic and flavonoidal content reported well scavenging of DPPH free radicals.⁴⁰ The chloroform extract of *T. foliolosum* leaves shown maximum antioxidant activity against DPPH and FRAP assay method. Along with that molecular docking study also indicated that alkaloid berberine strongly interacts with CYP51 and human peroxiredoxin 5 proteins, thus *T. foliolosum* consider as rich source of berberine and potent antioxidant.⁴¹ *T. foliolosum* is reported as good antimicrobial plant. Antimicrobial activity of root extract evaluated against *Escherichia coli*, *Candida albicans*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*. *T. foliolosum* rich in berberine showed maximum activity on *S. aureus* and *C. albicans*. For the determination of the MIC of various microbial strains, dilution method was utilized along with streptomycin and gentamycin as standard control.⁴⁰ In vitro antimicrobial activity of Pet ether, Chloroform, Methanol, Aqueous extract of *T. foliolosum* plant also evaluated.⁴² *T. foliolosum* leaves extract evaluated against numerous fungal strains (*Candida albicans* (ATCC90028), *Saccharomyces cerevisiae* (H1068) and *Candida albicans* (MTCC277) for antifungal activity. Chloroform extract of leaves possessed maximum antifungal activity specified by the area of diameter of Zone of inhibition 16 ± 0.7 mm, 18 ± 0.5 mm, 16 ± 0.7 mm and MIC values 3.13 ± 0 μ g/ml, 1.56 ± 0 μ g/ml, 3.13 ± 0 μ g/ml against *C. albicans* (MTCC277), *S. cerevisiae*

(H1068) and *C. albicans* (ATCC90028) respectively.⁴¹ Das et al evaluated the antimalarial activity of n-butanol, chloroform and ethyl acetate extract of *T. foliolosum* roots against resistant and sensitive strain of *Plasmodium falciparum*. Out of all extracts n-butanol and chloroform extract reported as more effective against both type of strains of *P. falciparum* i.e. chloroquine resistant (RS) and sensitive (SS). IC₅₀ value of chloroform extract was 1.1 ± 0.0 and 0.5 ± 0.0 against RS and SS strains respectively.⁴³ Another study reported antimalarial activity of leaves of *T. foliolosum* evaluated against chloroquine resistant (RKL-9) and chloroquine sensitive (MRC-2) strain of *P. falciparum*. Out of all the extracts, the Ethanolic extract showed significant in-vitro antimalarial activity against both the strains. Ethanolic extract categorized as highly active and promising active against chloroquine resistant and chloroquine sensitive respectively.⁴⁴ Four alkaloids reported from stem of *T. foliolosum* evaluated for inhibitory activities against DNA topoisomerase IB of *Leishmania donovani*. 6, 5', 6', 7', 12-pentamethoxy-2, 2'-dimethyloxycanthan out of all four alkaloids inhibit the enzyme completely at 50 µM concentration. This alkaloid found to be most effective in destroy both types of parasites like wild type and SAG resistant promastigotes.³⁶ The hydro-ethanolic extract of *T. foliolosum* whole plant evaluated for antiepileptic activity in Wistar albino rats. Doses at 300mg/kg and 400 mg/kg injected intraperitoneal showed remarkable rise in GTCS (Generalized tonic-clonic seizures) latencies.⁴⁵ The Phytoconstituents isolated from *T. foliolosum* mention in Table 5.

***Thalictrum fortune* S. Moore**

It is a long lasting plant scattered in the southeastern places of country China. For thousands of years the parts of this plant has been utilized in Traditional medicines of China for the management of bacterial and tumor diseases along with its immune regulatory effects.⁴⁶ Traditionally it used in furunculosis, smallpox and as substitute of Coptis⁴. Aerial parts of *T. fortunei* used as cytotoxic, anticancer, Proapoptotic⁴ and in ophthalmia, dysentery and jaundice.⁴⁷ Pharmacologically, the two cycloartane isolated by Zhang et al. assessed for their cytotoxic activity against human heptoma cells (Bel-7402), human non-small cell lung cancer cells (NCIH-460), human colon carcinoma LoVo cells by MTT assay (dimethylthiazoyl 1-3,5-diphenyltetrazolium bromide). The IC₅₀ value of two compounds was found to be 24.33, 6.83, 5.61 µg/ ml and 7.79, 3.32, 3.08 µg/ ml for human colon carcinoma LoVo cells, human heptoma cells (Bel-7402), human non-small cell lung cancer cells (NCIH-460) respectively.⁴⁷ Ten Cycloartane triterpenoid saponins isolated from n-butanol fraction of ethanol extract evaluated for *in-vitro* cytotoxic activity against A549 (lung cancer cells) and HepG2 (liver cancer cells) by MTT assay method. These saponin compounds had no good cytotoxic effects⁴⁸. Eight terpenoid compound isolated from aerial part evaluated on tumor cells by MTT assay. Out of all the compounds, 3-O-β-D-glucopyranosyl-(1→4)-β-D-fucopyranosyl(22S,24Z)-cycloart-24-en-3β,22,26-triol 26-O-β-D-glucopyranoside showed stronger inhibitory activity on Bel-7402 (human hepatoma Bel-7402 cell line), LoVo (human colon lovo cells), NCIH-460 (human non-small cells lung cancer), SGC-7901 (human gastric carcinoma SGC-7901) with IC₅₀ 66.4, 84.8, 73.5, 89.6 µM respectively. The mechanism of antitumor activity of strongest antitumor compound on Bel-7402 explored through flow cytometry, nucleus dyeing, western blot and fluorescence assay. Apoptosis and

loss of mitochondrial membrane potential (MMP) found in Bel-7402 cells reported in flow cytometric analysis. In fluorescence assay, intracellular reactive oxygen species (ROS) distinctly provoked by strongest compound treatment equated to control cells. The significant increase in the expression levels of cleaved caspase-3, P53 and Bax protein and reduction in expression level of Bcl-2 protein found in immunoblot results of strongest compound. These all findings indicate *T. fortunei* inhibit the growth of tumor cells.⁴⁶ The Phytoconstituents isolated from *T. fortunei* mention in Table 6.

***Thalictrum minus* Linn.**

This plant distributed in northern hemisphere and rarely found in southern hemisphere. Antibacterial activity of Dichloromethane: methanol extract of root and its isolated compounds evaluated against five mastitis bacterial strains (*Staphylococcus equorum*, *Staphylococcus xylosus*, *Enterococcus faecalis*, *Staphylococcus lentus* and *Pantoea agglomerans*). The Extract possessed broad spectrum antibacterial activity. Three compounds isolated from the root extract, thalrugosaminine and hydroxythalidasine these two compounds showed maximum activity with Minimum inhibitory concentration values 64-128 µg/ml. The *Staphylococcus* strain were observing to be most sensitive strain.⁵⁹ Antimicrobial activity of Thalicoside A1, Thalicoside A2, Thalicoside A3 isolated from aerial parts of *T. minus* evaluated against *Candida albicans*, *Staphylococcus aureus* and *Pseudomonas aeruginosa*. Out of all the Thalicosides, Thalicoside A2 at concentration 1 mg/ml possessed inhibitory activity against tested strain *C. albicans* and *S. aureus*.⁵² The Phytoconstituents reported from *T. minus* mention in Table 7.

Thalictrum simplex

Thalictrum simplex is the plant utilized as Traditional Tibetan and Mongolian Medicineto treat acute and chronic infectious diseases.^{60,61} and for blood purification and wound healing^{60, 62}. Anti-influenza activity of (-)-thalimonine isolated from aerial parts was evaluated against A/Germany/34, A/Germany/27, str. Rostock (H7N1) and str. Weybridge (H7N7) influenza virus. The isolated alkaloid markedly reduced the virus-specific protein synthesis, haemagglutinin production, virus induced cytopathic effects, infectious virus yield. (-)-thalimonine inhibited viral reproduction in a specific and selective manner⁶³. The isolated compound (-)-thalimonine also evaluated for antiviral activity, replication of HSV-1 was inhibited by isolated alkaloid in dose dependent manner. (-)-thalimonine also possessed immunological activity and at the concentration between 10 and 100 µM (-)-thalimonine inhibited the antibody response against SRBC. This effect was also dose dependent.⁶⁷ The Phytoconstituents reported from *T. simplex* mention in Table 8

***Thalictrum squarrosum* Stephan ex Willd**

It is widely spread from East Siberia to north China. The dried whole plant utilized as Heat-clearing and Detoxification, invigorate stomach and relieve hyperacidity, diaphoresis.⁴ For biological activity *T. squarrosum* is still unexplored as no reported data was found on various search engines.

***Thalictrum wangii* B. Boivin**

It is a long lasting Chinese medicinal plant found in areas of Lijiang Country and cold alpine of Southern Tibet. Tibetan people utilized this plant as anti-inflammatory and antidote drug.⁷⁶

These entire isolated compounds investigated for cytotoxicity against (GSC-3) glioma stem cells and (293 T) human normal embryonic kidney cell lines. Aporphine, oxoaporphine alkaloids and 6,7,12-trimethoxy-2-methyl-13-hydroxy-11-(4'-formylphenoxy) affect the (293 T) cell lines at 20 µg/ml and inhibited the growth of GSC-3. The IC₅₀ value for such bioactive isolated compounds was found 15-20 µg/ml calculated by MTS method which were nearly equals to recognized antitumor drug i.e. taxol (13.59 µg/ml) and also better than first class drug temozolomide) for human glioblastoma multiform (IC₅₀> 50 µg/mL) respectively.⁷⁸ Aporphine alkaloid isolated from whole plant of *T. wangii* were Thallactones A and Thallactones B, thaliglucine N-oxide along with their biosynthetically related precursor northalphenine. All isolated aporphine compounds except Thallactone B evaluated for immunosuppressive activity against mitogen-induced (Con-A) splenocyte proliferation. The result showed that these aporphine compounds inhibited T lymphocyte significantly in a dose dependent manner. It was noted that activities of these compounds were even better than the reference control dexamethasone at a concentration between 25-50 µM. This potent immunosuppressive activity makes it more attractive to scientist for further evaluation and research.⁷⁹ The Phytoconstituents reported from *T. wangii* mention in Table 10.

Discussion

Ethnopharmacological records indicate that plant species of the genus *Thalictrum* have lots of therapeutical potential for the treatment of communicable and non-communicable diseases. There is a strong need to carry out the research to find out the bioactive molecules that further can be developed as a drug candidate or their chemical derivatives for the treatment diseases. Majority species of *Thalictrum* have ethnic use for the treatment of inflammations, blood detoxification, bacterial and viral infections and for cooling effects, which further unlock the scopes of scientific studies related to immunomodulators, anti-inflammatory, antibacterial, antiviral, liver diseases, skin problems, anticancer, etc.

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Table 1
Phytoconstituents isolated from *Thalictrum atriplex* Finet et Gagnep

Plant Part	Phytoconstituents	Reference
Roots and aerial part	Neothalpine and thaliatrine, thalifaberine, thalirecebine and thalistine	13,14
Aerial parts	kaempferol 3-O- [3 ^{ac} -acetyl- α -L-arabinopyranosyl(1' " - 6")]- β -D-glucopyranoside	15
	Protocatechuic acid, para coumaric acid, Kaempferol, Caffeic acid along with β sitosterol	16
Whole plant	Cycloatriosides A (3-O- β -D-galactopyranosyl (20S, 24R)-3 β , 16 β ,25,29-tetrahydroxy-20,24-epoxycycloartane-29-O- β -D-glucopyranoside) cycloatriosides B (3-O- β -D-galactopyranosyl-(1 \rightarrow 2)- α -arabinopyranosyl-(1 \rightarrow 6)- β -D-glucopyranoside) thaliatroside A	17

Table 2
Phytoconstituents isolated from *Thalictrum cultratum* Wallich

Plant Part	Phytoconstituents	Reference
Whole plant	(-) - 2-northalmine, (-)-O-methylthalmine, (-)-thiamine, (-)-2-northalidasine, (-)- thalrugosinone, (-)-thalidasine, (-)-N desmethylthalidasine,	19
	Thalifaramine, Thalifaberine, Thalifaretine, Thalifarazine, Thalifaroline, Thalifaricine, Thalifarone	20
	(+)-2'-noroxyacanthine, (+)-neothalibrine-2'- α -N-oxide, (+)-thalidasine-2- α -N-oxide, (-)-5-hydroxythalidasine-2- α -N-oxide, (-)-thalrugosaminine-2- α -N-oxide, (+)-cultithalminine, (-)-thaligosine-2- α -N-oxide, (+)-2'-northaliphylline, (+)-thaliphylline-2'- β -N-oxide	21
Roots	thalicultrate L (tetrahydroprotoberberine-aporphine alkaloid), thalicultrates A-K (thalifaberine-type aporphine-benzylisoquinoline alkaloids) and Thalifarone, Thalifaberine, Thalifabatine Dehydrothalifaberine and Thalibealine	21
	new benzyl-aporphine alkaloids 6a,7-dehydrothaliculine and Thaliculine	22

Table 3
Phytoconstituents isolated from *Thalictrum faberi* Ulbrich

Plant Part	Phytoconstituents	Reference
Roots	Thalifaberidine (6'8-desmethylthalifabrine), Thalifaramine, Thalifaricine, Thalifarazine, Thalifarone	23
	3-hydroxy-6'-desmethyl-9-O methylthalifaboramine, 3-hydroxythalifaboramine, 3,5'-dihydroxythalifaboramine, 3-hydroxy-6' desmethylthalifaboramine, 6'-desmethylthalifaboramine, 5'-hydroxythalifaboramine	24
	Thalifasine, Dehydrothalifaberine, Thalifaberine, Thalifabine, Thalifarapine, Thalifabatine are Aporphine-benzylisoquinoline dimers and Faberidine, Dehydrohuangshanine, Huangshanine, Faberonine are Fetidine-type alkaloids	25
	Thalifabromine, a new dimeric aporphinoid alkaloid	26

Table 4
Phytoconstituents isolated from *Thalictrum foetidum* Linnaeus

Plant Part	Phytoconstituents	Reference
Epigeal part	Cyclofoetoside A (24S-cycloartane-3 β , 16 β , 24, 25, 29-pentaol 3-O- α -L-arabinopyranoside 16-O-[O- α -L-rhamnopyranoside-(1 \rightarrow 6)- β -D-glucopyranoside])	27
Whole part	Aporphine alkaloids, Thalfotines A-D	28
Roots	9-(2'-formyl-5', 6'-dimethoxyphenoxy)-1, 2, 3, 10-tetramethoxy dehydroaporphine; (-)-9-(2'-methoxycarbonyl-5', 6'-dimethoxyphenoxy)-1, 2, 3, 10-tetramethoxy aporphine; (-)-2'-methoxycarbonyl thaliadin; 3-methoxy-2'-formyl oxohernandalin; (-)-9-(2'-methoxyethyl-5', 6'-dimethoxyphenoxy)-1, 2, 3, 10-tetramethoxy aporphine; (-)-3-methoxy hydroxyhernandalinol; 3-methoxydehydrohernandaline; 6-(1, 3-dioxolo [4, 5-g] isoquinolin-5-ylcarbonyl)-2; 3-dimethoxy-benzoicacidmethyl ester; 8-oxyberberine; Thaliadine; Berberine; 9-(2'-formyl-5',6'-dimethoxyphenoxy)-1, 2, 3, 10-tetramethoxy oxoaporphine; O-methylflavinantine	29
	O-bridged spirobenzylisoquinoline alkaloid named Thalicfoetine have a spirotetrahydropyridine-furanone core	30

Table 5
Phytoconstituents isolated from *Thalictrum foliolosum* DC

Plant Part	Phytoconstituents	Reference
Entire plant	Thalfoliolosumines A and Thalfoliolosumines B, chloro-containing benzyloisoquinoline alkaloids along with eight isoquinoline alkaloids named as thalrigosidine, thalirugine, 8-oxyberberine, palmatine, thalirugidine, berberine, thalrugosaminine, jatrorrhizine Thalfoliolosumines A (9'R-hydroxy-3',4'-methylenedioxy-6'-vinylbenzyl-3-chloro-5,6-dimethoxyisoquinoline)	33
Roots	Thalrugosidine, Thaligosine, Thalirugidine, Oxyberberine (berlambine), Thalrugosaminine	34
Rhizomes	N, O, O-Trimethylsparsiflorine, Magnoflorine, Thalidasine, Reticuline, Thalrugosidine, Berberine, Palmatine, Thalicarpine	35
Stem	6, 6', 7', 12-tetramethoxy-5'-hydroxy-2, 2'-dimethyloxycanthan, Thalifendine, 6, 5', 6', 7', 12-pentamethoxy-2, 2'-dimethyloxycanthan and Berberine	36
Roots	Thalifendine, Columbamine, Palmatine, Jatrorrhizine, Berberine, Rugosinone, Thalidastine, Xanthoplanine, Dehydrodiscretamine, Magnoflorine, Tembetarine	37
	3-methoxy-10-O-acetylprodensiflorin B, 5,6,7,12-tetramethoxy-2-methyl-13-hydroxy-11-(4'-carbonylphenoxy) benzyloisoquinoline, 5,6,7,12-tetramethoxy-2-methyl-13-hydroxy-11-(4'methoxycarbonylphenoxy) benzyloisoquinoline	38

Table 6
Phytoconstituents isolated from *Thalictrum fortune* S. Moore

Plant Part	Phytoconstituents	Reference
Aerial part	3-O- β -D-glucopyranosyl (1 \rightarrow 4)- β -D-fucopyranosyl-(22S,24Z)-cycloart-24-en-3 β ,22,26,30-tetraol 26-O- β -D-glucopyranoside; 3-O- β -D-glucopyranosyl (1 \rightarrow 4)- β -D-fucopyranosyl-(22S,24Z)-cycloart-24-en-3 β ,22,26,29-tetraol 26-O- β -D-glucopyranoside	47
Whole plant	Thalaside A (3-O- β -D-glucopyranosyl-(1 \rightarrow 4)- β -D-xylopyranosyl (22S,24Z)-cycloart-24-en-3 β ,22,26,30-tetraol 26-O- β -D-glucopyranoside); Thalaside B (3-O- β -D-glucopyranosyl-(1 \rightarrow 4)- β -D-xylopyranosyl-(1 \rightarrow 4)- α -L-arabinopyranosyl-(1 \rightarrow 6)- β -D-glucopyranosyl-(1 \rightarrow 4)- β -D-fucopyranosyl (22S,24Z)-cycloart-24-en-3 β ,22,26-triol 26-O-(6-O-acetyl- β -D-glucopyranoside); Thalaside C (3-O- β -D-glucopyranosyl-(1 \rightarrow 4)- β -D-xylopyranosyl- (1 \rightarrow 6)- β -D-glucopyranosyl-(1 \rightarrow 4)- β -D-fucopyranosyl (22S,24Z)-cycloart-24-en-3 β , 22,26-triol 26-O-(6-O-acetyl- β -D-glucopyranoside); Thalaside D (3-O- β -D-xylopyranosyl-(1 \rightarrow 4)- α -L-arabinopyranosyl-(1 \rightarrow 6)- β -D-glucopyranosyl-(1 \rightarrow 4)- β -D-fucopyranosyl (22S,24Z)- cycloart-24-en-3 β ,22,26-triol 26-O- β -D-glucopyranoside); Thalaside	48

	E (3-O-β-D-glucopyranosyl-(1→4)-β-D-fucopyranosyl (22S,24Z)-cycloart-24-en-3β,22,26,30-tetraol 26-O-(6-O-acetyl-β-Dglucopyranoside); Thalicide F (3-O-β-D-quinovopyranosyl-(1→6)-β-D-glucopyranosyl-(1→4)-β-D-fucopyranosyl (22S,24Z)-cycloart-24-en-3β,22,26,30-tetraol 26-O-β-D-glucopyranoside); 3-O-β-D-glucopyranosyl (1→4)-β-D-fucopyranosyl (22S,24Z)-cycloart-24-en-3β,22,26,30-tetraol 26-O-β-Dglucopyranoside; 3-O-β-D-glucopyranosyl-(1→4)-β-D-fucopyranosyl (22S,24Z)- cycloart-24-en-3β,22,26-triol 26-O-β-D-quinovopyranosyl-(1→6)-β-D-glucopyranoside; 3-O-β-D-glucopyranosyl-(1→4)-β-D-fucopyranosyl (22S,24Z)- cycloart-24-en-3β,22,26-triol 26-O-β-D-glucopyranoside; 3-O-β-Dglucopyranosyl (24S)-cycloartane-3β,16β,24,25,30-pentaol 25-O-β-D-glucopyranosyl- (1→6)-β-D-glucopyranoside	
	3β,16β,24S)-cycloartane-3,16,24,25,30-pentol 3,25-di-β-D-glucopyranoside, 3β,16β,24S)-24-(acetyloxy)cycloartane-3,16,25,30-tetrol 3,25-di-β-D-glucopyranoside, 3β,16β,24S)-24-(acetyloxy)-3-(β-D-glucopyranosyloxy)cycloartane-16,25,30-triol 25-[β-D-glucopyranosyl-(1→6)-β-D-glucopyranoside, 3β,16β,24S)-24-(acetyloxy)-3-(β-D-glucopyranosyloxy)cycloartane-16,25,30-triol 25-[β-D-glucopyranosyl-(1→4)-β-D-glucopyranoside	49
	3-O-β-D-xylopyranosyl-(1 → 6)-β-D-glucopyranosyl-(1 → 4)-β-D-fucopyranosyl (22S,24Z)-cycloart-24-en-3β,22,26-triol 26-O-(6-O-acetyl)-β-D-glucopyranoside, 3-O-α-L-arabinopyranosyl-(1 → 6)-β-D-glucopyranosyl-(1 → 4)-β-D-fucopyranosyl (22S,24Z)-cycloart-24-en-3β,22,26-triol 26-O-(6-O-acetyl)-β-D-glucopyranoside, 3-O-β-D-glucopyranosyl (24S)-cycloartane-3β,16β,24,25,30-pentaol 25-O-β-D-glucopyranosyl-(1 → 6)-β-D-glucopyranoside, 3-O-β-D-glucopyranosyl (24S)-cycloartane-3β,16β,24,25,30-pentaol 25-O-β-D-glucopyranosyl-(1 → 4)-β-D-glucopyranoside.	50
	Thalifortine, N-phenyl-2-hapthylamine and another compound similar with aromolirie	51

Table 7
Phytoconstituents isolated from *Thalictrum minus* Linn

Aerial part	Thalicoside A1 (3-O-β-d-galactopyranosyl-29-O-β-d-glucopyranosyl-3β,16β,29-trihydroxy-22(S),25-epoxycycloartane) Thalicoside A2 (3-O-α-l-arabinopyranosyl-29-O-β-d-glucopyranosyl-3β,16β,29,22(S)-tetrahydroxycycloart-24-ene) Thalicoside A3 (3-O-α-l-arabinopyranosyl-29-O-β-d-glucopyranosyl-3β,16β,29-trihydroxy-22(S),25-epoxycycloartane)	52
Epigeal part	Thalicoside C (3β,16β,22(S),29-tetrahydroxy-9,19-cyclo-20(S)-lanost-24-ene 3-O-β-galactopyranoside 22,29-di-O-β-D-glucopyranoside)	53
	Thalicoside E (9,19-cyclo-20(S)-lanost-23-ene-3β,16β,22ζ,25,29-pentaol 3-O-β-D-galactoside 29-O-β-D-glucopyranoside)	53
	Thalicoside E (9,19-cyclo-20(S)-lanost-23-ene-3β,16β,22ζ,25,29-pentaol 3-O-β-D-galactoside 29-O-β-D-glucopyranoside)	54

Above-ground part	Thalicoside F (3- β -O-[α -L-rhamnopyranosyl-(1 \rightarrow 2)- β -D-glucopyranosyl-(1 \rightarrow 4)- α -L-arabinopyranosyl]-11 α , 12 α -epoxyoleanane-28,13 β -olide)	55
Terrestrial part	Thalicoside G ₁ (3-O- β -D-galactopyranosyl-29-O- β -D-glucopyranosyl-9 β , 19-cyclo-20(S)-lanost-24(Z)-ene-3 β , 16 β , 22(S), 26, 29-pentaol)	56
	thalicosides G ₂ (3-O- β -D-galactopyranosyl-29-O- β -D-glucopyranosyl-9 β , 19-cyclo-20(S)-lanost-25-ene-3 β , 16 β , 22(S), 24 ζ , 29-pentaol)	57
Aerial part	Thalmethine, O-methylthalmethine, Thaliberine and O-methylthaliberine and Thaliglucine, Thaliporphine, Berberine, Thalactamine, Thalflavine	58
Roots	bisbenzylisoquinoline alkaloids, 5'-Hydroxythalidasine, O-Methylthaliberine Thalrugosaminine	59

Table 8
Phytoconstituents isolated from *Thalictrum simplex*

Plant Part	Phytoconstituents	Reference
Aerial parts	(-)-thalimonine, (3,4-methylene-deoxy-2,8,9-trimethoxypavinan)	63
	epimeric N-oxides, (-)-thalimonine N-oxide, (-)-thalimonine N-oxide B and (+)-leucoxylinine	64
	Aporphine alkaloids, (+)-thalicsimidine N-oxide, (+)-thalicsimidine, (+)-preocoteine, (+)-ocoteine and (+)-preocoteine N-oxide	65
	Thalicmine, magnoflorine, β -allocryptopine, thalicminine and thalicristine	66

Table 9
Phytoconstituents isolated from *Thalictrum squarrosium* Stephan ex Willd

Plant Part	Phytoconstituents	Reference
Aerial parts	Squarroside I designated as cycloartane type glycosides whereas Squarroside II, III and IV as oleanene glycosides. Squarroside II (3-O- β -D-glucopyranosyl-(1 \rightarrow 4)-[α -L-rhamnopyranosyl-(1 \rightarrow 2)]- β -D-xylopyranosyl oleanolic acid 28- β -D-glucopyranosyl ester	68
	cycloartane 3,21-bisdesmoside, Squarroside C (3-O-[O- α -L-rhamnopyranosyl-(1 \rightarrow 6)]- β -D-glucopyranosyl]-21-O- β -D-glucopyranosyl-21(S), 22(S), 23(R), 3 β , 21 α , 22 β , 30-tetrahydroxy-21,23-epoxycycloart-24-ene)	69
	Squoside A (dolabellane diterpene glycoside), Squarrosides V, VI, VII (Cycloartane glycosides)	70

Squarrogenin 1 and squarrogenin 2, squarrosides A1 and A2. Squarrogenin 1 (21R, 22S, 23R)-21-methoxy-21,23-epoxycycloart-24-ene-3 β ,22 β -30-triol Squarrogenin 2 as (21S, 22S, 23R)-21-methoxy-21,23-epoxycycloart-24-ene-3 β ,22 β ,30-triol	71
7-O-(6-O-acetyl- β -allopyranosyl)-4'-O-(β -allopyranosyl)apigenin	72
artificial genin, squarrofuric acid (3 β ,30-dihydroxy-20(S),22(S)-22,25-epoxy lanost-9(11)-en-21-oic acid)	73
Squarroside A1 (21R, 22S, 23R)-3 β -(β -D-glucopyranosyloxy)-21 α -methoxy-21,23-epoxycycloart-24-ene-22 β ,30-diol), Squarroside A2 (the (21S)-epimer of compound A1 Squarroside B1 (21R, 22S, 23R)-3gb-[O- α -L-rhamnopyranosyl-(1 \rightarrow 6)- β -D-glucopyranosyloxy]-21 α -methoxy-21,23-epoxycycloart-24-ene-22 β ,30-diol Squarroside B2 (the (21S)-epimer of compound (B1)	74
Squarroside B3 - (3-O-[O-(α -L-rhamno-pyranosyl)-(1 \leftarrow 6)- β -D-glucopyranosyl]-21 (S),22(ϵ),23(R)-3 β ,21,22,30-tetralmydroxy-21, 23-cpoxy cycloartlt-24-ene, Squarroside B4 - 21(R) epimer of B3.	75

Table 10
Phytoconstituents isolated from *Thalictrum wangii* B. Boivin

Plant Part	Phytoconstituents	Reference
Roots	(-)-thalibealine, berberine, (+)-magnoflorine and (+)-thalmelatidine	77
	(-)-10-O-acetyl prodensiflorin A (-)-10-O-acetyl prodensiflorin B], (+)-8-(4'-formylphenoxy) glaucine, (+)-8-(4'-hydroxymethylphenoxy) glaucine, (+)-3-methoxy-8-(4'-formylphenoxy) glaucine 1,2,3,9,10-pentamethoxy-11-(4'-formylphenoxy)-7-oxoaporphine, 1,2,9,10-tetramethoxy-11-(4'-formylphenoxy)-7-oxoaporphine 6,7,12-trimethoxy-2-methyl-13-hydroxy-11-(4'-formylphenoxy) 5,6-(methylenedioxy)-7,12-dimethoxy-2-methyl-10-(4'-formylphenoxy). Prodensiflorin B, Thalidine, 4-methoxyoxohernandaline.	78