A current update on the phytopharmacological aspects of *Houttuynia cordata* Thunb

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ABSTRACT

The present review is an attempt to put an insight into a medicinal plant *Houttuynia cordata* Thunb, which is indigenous to North-East India and China. It is an aromatic medicinal herb belonging to family *Saururaceae* and is restricted to specialized moist habitats. The review provides detailed information regarding the morphology, distribution, phytochemistry, ethnopharmacological uses and also describes various pharmacological activities reported on the plant *H. cordata*. The review describes therapeutic efficacy of the whole plant and its extracts, fractions and isolated compounds in different diseased condition. Among the important pharmacological activities reported includes, anti-mutagenic, anti-cancer, adjuvanticity, anti-obesity, hepatoprotective, anti-viral, anti-bacterial, anti-inflammatory, free radical scavenging, anti-microbial, anti-allergic, anti-leukemic, chronic sinusitis and nasal polyps activities. Thus, the present review will act as a source of referential information to researchers to perform clinical studies on isolated compounds that may serve the society and will help in improving human health care system.

Key words: Anti-viral, aristolactams, *Houttuynia cordata*, *Saururaceae*

INTRODUCTION

In most of the developing countries, 70-95% of the population rely on traditional medicines for primary health-care and out of these 85% of people use plants or their extracts as the active substance.[1] The search for new biologically active compounds from plants usually depends on the specific ethnic and folk information obtained from local practitioners and is still regarded as an important source for drug discovery. In India, approximately 2000 drugs are of plant origin.[2] In view of the widespread interest on using medicinal plants, the present review on *Houttuynia cordata* Thunb. provides up-to-date information with reference to botanical, commercial, ethnopharmacological, phytochemical and pharmacological studies that appears in the literature. *H. cordata* Thunb. belongs to the family *Saururaceae* and is commonly known as Chinese lizard tail. It is a perennial herb with stoloniferous rhizome having two distinct chemotypes.[3,4] The Chinese chemotype of the species is found in wild and semi-wild conditions in the North-East of India from April to September.[5-7] *H. cordata* is available in India, especially in Brahmaputra valley of Assam and is utilized by various tribes of Assam in the form of vegetable as well as in various medicinal purposes traditionally.[8]

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TAXONOMICAL CLASSIFICATION

Kingdom: *Plantae*; Phylum: *Magnoliophyta*; Class: *Magnoliopsida*; Sub-class: *Magnoliidae*; Order: *Piperales*; Family: *Saururaceae*; Genus: *Houttuynia* Thunb.; Species: *H. cordata*.[9]

BOTANICAL DESCRIPTION

The plant *H. cordata* is an aromatic medicinal herb with creeping root stock. It grows about 20-50 cm in height with leaves measuring 4-8 cm in length, 3-6 cm in width and are broad, ovate-cordate. Stipular sheath are 1-2.5 cm, 1/4-1/2 as long as petiole, usually ciliate, base enlarged and slightly clasping; petiole 1-3.5 cm, glabrous. Leaf blades are broadly ovate or ovate-cordate, 4-10 cm long, 2.5-6 cm wide, thinly papery, densely glandular, usually glabrous. Sometimes they are pubescent at vein axils, usually purplish abaxial, base cordate, apex shortly acuminate; veins 5-7, basal or innermost pair arising ca. 5 mm above the base, if 7-veined, then outermost pair very slender or inconspicuous; reticulate veins ± conspicuous. Inflorescences 1.5-2.5 cm long,

3-6 mm wide; peduncles 1.5-3 cm, subglabrous; involucral bracts oblong or obovate, 10-15 mm long, 5-7 mm wide, apex rounded. Flowers are naked with dense spikes, subtended by four white and petalloid bracts, involucres, non-petal, yellow inflorescences ca. 1-3 cm long, three stamens, flowering in June-July.[10] Rhizomes are creeping, thin while basal part of stems creeping rooted in whorls at nodes, apical part erect, glabrous or pubescent on nodes, sometimes purplish red.[11] The chromosomal number of *H. cordata* was reported as $2n = 96$.[12]

ETHNOMEDICAL USES

In the North-East region of India, whole plant of *H. cordata* is eaten raw as a medicinal salad for lowering the blood sager level and is commonly known by the name Jamyrdoh.[13] Moreover, leaf juice is taken for the treatment of cholera, dysentery, curing of blood deficiency and purification of blood.[14] Young shoots and leaves are eaten raw or cooked as a pot-herb. A decoction of this plant is used internally for the treatment of many ailments including cancer, coughs, dysentery, enteritis and fever. Externally, it is used for the treatment of snake bites and skin disorders. The leaves and stems are harvested during the growing season and are used as fresh decoctions. The leaf juice is also used as antidote and astringent.[15] The root, young shoots, leaves and sometimes the whole plant is traditionally used to cure various human ailments throughout South-East Asia. In Indo-China region, the entire plant is considered for its cooling, resolvent and emmenagogue properties. The leaves are recommended for the treatment of measles, dysentery and gonorrhea. The plant is also used in the treatment of eye troubles, skin diseases, hemorrhoids, relieving fever, resolving toxin, reducing swelling, draining pus, promoting urination and in certain diseases of women.[16]

PHARMACOLOGY

H. cordata possess a number of medicinally important activities such as anti-leukemic,[17] anti-cancer,[18] adjuvanticity,[19] anti-oxidant[20] and inhibitory effects on anaphylactic reaction and mast cell activation.[21] Moreover, *H. cordata* has also been utilized for the treatment of herpes simplex virus type 1 (HSV-1), influenza virus, human immunodeficiency virus type 1,[22] and chronic sinusitis and nasal polyps.[21]

Anaphylactic inhibitory activity

Oral administration of *H. cordata* water extract inhibited compound 48/80-induced systemic anaphylaxis in mice. Water extract of *H. cordata* at 100 mg; p.o. also inhibited the local allergic reaction, passive cutaneous anaphylaxis (PCA), activated by anti-dinitrophenyl (DNP) immunoglobulin E (IgE) antibody in rats. It also reduced the compound 48/80-induced mast cell degranulation and colchicine-induced deformation of rat peritoneal mast cells (RPMC). Moreover, *H. cordata* water extracts dose-dependently inhibited histamine release and calcium uptake of RPMC induced by compound 48/80 or anti-DNP IgE. The same extract also increased the level of intracellular cyclic adenosine monophosphate (cAMP) and inhibited significantly the compound 48/80-induced cAMP reduction in RPMC. These results suggest that water extracts of *H. cordata* may be beneficial in the treatment of mast cell-mediated anaphylactic responses.[21]

Anti-mutagenic activity

Aqueous extracts of *H. cordata* has been reported to possess anti-mutagenic effect on benzo (a) pyrene, aflatoxin B1 and oxidized frying oil (OFO), which demonstrated a dose-dependent response using the Ames test in Sprague-Dawley rats, which were fed with a diet of 0, 2, or 5% *H. cordata* and 15% fresh oil or OFO for 28 days. After administration of OFO, it was observed that there was a significant decrease in polyphenol content in plasma which increased in the faces showing an apparent decrease in absorption of polyphenol. On treatment with *H. cordata*, the polyphenol content in plasma improved, which may be due to the presence of higher polyphenol concentration in the aqueous extracts of *H. cordata*.[23]

Anti-inflammatory activity

Essential oil from *H. cordata* was reported to exhibit anti-inflammatory activity by a mechanism of action similar to that of non-steroidal anti-inflammatory drugs (NSAIDs). They inhibited the release of lipopolysaccharide (LPS)-induced prostaglandin E_2 (PGE_2) from mouse peritoneal macrophages (IC_{50} value: 44.8 μg/mL). Moreover, the inhibitory activity of *H. cordata* essential oil elicited a dose-dependent inhibition of cyclooxygenase-2 (COX-2) enzyme activity (IC_{50} value: 30.9 μg/mL). *H. cordata* essential oil was also found to elicit reduction in LPS-induced COX-2 messenger ribonucleic acid (mRNA) and protein expression, but did not affect COX-1 expression. NSAID and specific COX-2 inhibitor NS398 functioned similarly in LPS-induced mouse peritoneal macrophages.[24]

Water extracts of *H. cordata* exhibits anti-inflammatory activity on lipoteichoic acid (LTA)-induced inflammation in dermal fibroblasts by blocking the tumor necrosis factor-α (TNF-α) pathway. *H. cordata* (20 μg/mL) suppressed the level of LTA-induced TNF-α, mRNA and LTA-induced COX-2 protein by up to 40% and 52% respectively. Moreover, TNF-α-induced COX-2 expression was also down-regulated by *H. cordata* treatment up to 65%.[25]

Ethanolic extract of whole plant of *H. cordata* (10 μg/mL for 24 h) showed marked effect in treating mast cell-induced inflammatory diseases by a significant decrease in chemotactic index (63%) of human mast cells (HMC-1) in response to stem cell factor by inhibiting the nuclear factor-kappa B (NF-κB) activation.[26]

Anti-inflammatory activity of *H. cordata* injection (HCI), which constituted a mixture of essential oil from *H. cordata*, aqueous solution of sodium chloride solution and tween-80 was reported in carrageenan induced inflammation in the rat pleurisy model and by xylene in the mice ear edema model. The fluid volume,

protein concentration, C-reactive protein and cell infiltration were attenuated by HCI at all doses and touched bottom at a dose of 0.54 mL/100 g. This drug was also effective in inhibiting xylene induced ear edema and the percentage of inhibition came to 50% at a test dose of 80 μL/20 g.[27] Another anti-inflammatory study on supercritical extract of *H. cordata* (HSE) in a carrageenan-air pouch model showed that HSE (200 mg/kg; p.o.) exerts anti-inflammatory effects by inhibiting both TNF-α-nitric oxide (NO) and COX-2-PGE_2 pathways.[28]

Anti-viral activity

The optimal dosage of HCI showed direct inhibitory activity on cell infection by pseudorabies herpesvirus using Vero cells (a monkey kidney cell line) and swine testis cells as a model. While at high dosage *H. cordata* alone caused cell apoptosis.[29]

Aqueous extract of *H. cordata* showed immunomodulatory and anti-severe acute respiratory syndrome (SARS) activities. *H. cordata* also stimulated the proliferation of mouse splenic lymphocytes significantly and dose-dependently. By flow cytometry, it was revealed that *H. cordata* increased the proportion of $CD4^+$ and $CD8^+$ T cells. Moreover, it caused a significant increase in the secretion of interleukin (IL)-2 and (IL)-10 by mouse splenic lymphocytes. In the anti-viral aspect, *H. cordata* exhibited significant inhibitory effects on SARS coronavirus (SARS-CoV) 3C-like protease ($3CL^{pro}$) and RNA-dependent RNA polymerase.[30]

A 4-5 dioxoaporphin namely norcepharadione B isolated from the n-hexane fraction of *H. cordata* was found to possess good inhibitory activity against the replication of HSV-1.[31]

In particular, quercetin 7-rhamnoside (Q7R), a flavonoid present in *H. cordata*, has been reported to elicit anti-viral activities against porcine epidemic diarrhea virus (PEDV), which is the predominant cause of severe enteropathogenic diarrhea. Q7R actively inhibited PEDV replication with a 50% inhibitory concentration (IC_{50}: 0.014 μg/mL). The 50% cytotoxicity concentration (CC_{50}) of Q7R was over 100 μg/mL and the derived therapeutic index was 7142. Therefore, Q7R could be considered to be a lead compound for development of anti-PEDV drugs, which may be used to arrest the early stage of PEDV replication.[32]

Quercetin 3-rhamnoside (Q3R) from *H. cordata* possessed strong inhibitory effects on influenza A/WS/33 virus by reducing the formation of a visible cytopathic effect. Moreover, Q3R also inhibited virus replication in the initial stage of virus infection by indirect interaction with virus particles.[33]

One of the finding claimed that aqueous extract of *H. cordata* possess anti-viral activity against dengue virus serotype 2 (DEN-2), strain 16681. *H cordata* (10-100 mg/mL) was found to exhibit significant reduction in intracellular DEN-2 RNA production correlating with the decrease in dengue protein expression after pre- and post-incubation with HepG2 cells. Moreover, in the direct blocking mode, the extract bound with DEN-2 strongly inhibited the intracellular viral RNA replication with an effective dose (EC_{50}) of 0.8 mg/mL. Concentrations as low as 10-40 mg/mL of *H. cordata* extract also exhibited protective effect on virion release from infected monkey kidney cell line (LLC-MK2) cells.[34] Hot water extracts of *H. cordata* blocked HSV-2 infection through inhibition of NF-κB activation by the presence of major water extractable flavonoids quercetin or isoquercitrin at 10 μM.[35]

Anti-obesity effect

Administration of an aqueous extract of leaves of *H. cordata* (1 g/kg; p.o.) significantly inhibited the corn oil-induced increase in plasma triglyceride levels in mice. It also inhibited the oleic acid and glycerol induced increase in the levels of plasma non-esterified fatty acids and glycerol, respectively. Moreover, an anti-obesity effect of *H. cordata* leaf extract has also been reported in mice with high-fat-diet-induced obesity.[36]

Anti-bacterial activities

Water extract of *H. cordata* showed the anti-bacterial effects against *murine salmonellosis*. The anti-bacterial activity of *H. cordata* water extract was also examined in a *Salmonella enterica* serovar (*Salmonella typhimurium*) and was found to increase in a dose-dependent manner at concentrations from 25 to 100 mg/mL during 8-h incubation. Water extract of *H. cordata* also affected RAW 264.7 cells including morphologic changes and bacterial uptake, but there was no significant difference in bacterial replication in RAW 264.7 cells. With *H. cordata* water extract alone, NO production by RAW 264.7 cells did not increase, but when RAW 264.7 cells were infected by *S. typhimurium*, with or without extract, NO production with extract was 2-fold higher than that without extract. Treatment with aqueous extract of *H. cordata* did not affect inducible nitrous oxide synthase (iNOS) mRNA expression by RAW 264.7 cells, but when RAW 264.7 cells with extract were infected by *S. typhimurium*, iNOS mRNA expression was increased during 8-h incubation. Furthermore, water extract of *H. cordata* showed virulence reduction effects in *S. typhimurium*-infected BALB/c mice. After a lethal dose of *S. typhimurium*, the mortality rate in the extract untreated group was 100% at 7^{th} day, but at the doses 25, 50 and 100 μg/mL of extract groups were survived until 11, 17 and 23 days respectively. These data suggest that *H. cordata* water extract is stable and beneficial in the treatment of bacterial infection including intracellular replicating pathogens and may solve anti-microbial misuse and overuse.[37] Houttuynin (decanoyl acetaldehyde), a β-dicarbonyl compound, is reported as a major anti-bacterial constituent in the volatile oil of *H. cordata*.[38]

Effects on xenobiotic-metabolizing enzyme system of rodents

One of the finding on *H. cordata* claimed that the OFO feeding produced a significant increase in phase I and II enzyme systems, including the content of CYP450 and microsomal protein. The oil was also reported to play a significant role in activities of nicotinamide adenine dinucleotide phosphate reductase,

ethoxyresorufin O-deethylase (EROD), pentoxyresorufin O-dealkylase, aniline hydroxylase (ANH), aminopyrine demethylase (AMD) and quinone reductase (QR) (Phase-II enzyme) in Sprague-Dawley rats. In addition, the activities of EROD, ANH and AMD decreased and QR increased after feeding with *H. cordata* in OFO-fed group. Feeding with *H. cordata* diet also resulted in better regulation of the xenobiotic-metabolizing enzyme system.[39]

Anti-cancer activity

It is reported that *H. cordata* induced apoptotic cell death in human primary colorectal cancer cells through a mitochondria-dependent signaling pathway. *H. cordata* at 250 μg/mL showed chromatin condensation in the treated cells. Moreover, *H. cordata* increased reactive oxygen species production and decreased the mitochondrial membrane potential ($\Delta\Psi$ (m)) in examined cells. Mitochondria-dependent apoptotic signaling pathway was shown to be involved as determined by the increase in the levels of cytochrome c, Apaf-1 and caspase-3 and -9. The decrease in the level of $\Delta\Psi$ (m) was associated with an increase in the BAX/BCL-2 ratio which led to activation of caspase-3 and -9.[40]

Six bioactive alkaloids, aristolactam B, piperolactam A, aristolactam A, norcepharadione B, cepharadione B and splendidine were isolated by bioactivity-guided fractionation of a methanolic extract of the aerial part of *H. cordata*. All the isolates exhibited moderate cytotoxicity against the five human cancer cell lines (A-549, SK-OV-3, SKMEL-2, XF-498 and HCT-15) examined *in vitro*. Among them, splendidine was found to exhibit significant activity against each cell line and aristolactam B exhibited selective activity against XF-498 (central nerve system cell) (ED_{50}, 0.84 μg/mL).[18]

Anti-allergic activity

Aqueous extracts of *H. cordata* (10 or 100 mg/kg; p.o.) show a significant effect on mast cell-mediated anaphylactic reaction, which is involved in many allergic diseases such as asthma and allergic rhinitis. *H. cordata* aqueous extract inhibited the compound 48/80-induced systemic anaphylaxis in mice. It also inhibited the local allergic reaction, PCA, activated by anti-DNP IgE antibody in rats. Compound 48/80-induced mast cell degranulation and colchicine-induced deformations of RPMC were also reduced by the *H. cordata* extract. Moreover, the extract dose-dependently inhibited histamine release and calcium uptake of RPMC induced by compound 48/80 or anti-DNP IgE. Aqueous extract of *H. cordata* increased the level of intracellular cAMP and inhibited significantly the compound 48/80-induced cAMP reduction in RPMC.[21]

Ethanolic extract of *H. cordata* showed beneficial therapeutic effects on the T helper 2-mediated or allergic skin disorders. Ethanolic extract inhibited the expression of IL-4 and (IL)-5 in response to phorbol 12-myristate 13-acetate (PMA) and calcium ionophore (CaI) in Jurkat T cells and the HMC-1 line, HMC-1. IL-4-5 and TNF-α (TNF-γ)-induced thymus activation regulated chemokine (TARC) production was also blocked by ethanolic extract of *H. cordata* in skin fibroblast CCD-986 sk cells. Stimulants included in PMA, phytohemagglutinin and CaI, increased the mRNA level of CC chemokine receptor 4 (CCR4), a receptor of TARC, in Jurkat T cells and the ethanolic extract weakly blocked the increased mRNA level. However, the stimulants and *H. cordata* ethanolic extract had no effect on the CCR4 protein level. The ethanolic extract also inhibited the TARC-induced migration, as well as basal migration of Jurkat T cells.[41] It has been also reported that water extract of *H. cordata* suppressed anaphylactic reaction and IgE-mediated allergic response through inhibition of cytokines and multiple events of FcεRI-dependent signaling cascades in mast cells.[42]

Anti-diabetic activity

H. cordata water extract was also reported to exhibit significant decrease in the urinary protein, urinary albumin, monocyte chemo-attractant protein expression level and renal connective tissue growth factor (CTGF). It also showed a significant improvement in insulin resistance after giving 8 weeks of treatment to streptozotocine (STZ) induced type II diabetic mellitus rats.[43,44]

A recent study has shown that the volatile oil from *H. cordata* restored the alterations in blood glucose, insulin, adiponectin and CTGF levels in diabetic rats, induced by the combination of a high-carbohydrate and high-fat diet and STZ injection, which may be attributed to the reduced insulin resistance, adiponectin and CTGF levels.[45]

Anti-oxidant activity

Methanolic extract of *H. cordata* in an *in vitro* model has shown to possess free radical scavenging activity using 2, 2-diphenyl-1-picrylhydrazyl (DPPH), ferric reducing anti-oxidant power and trolox equivalent anti-oxidant capacity assays.[46] Anti-oxidant activity of *H. cordata* is mainly attributed to the presence of chlorogenic acids and its derivatives, catechin and procyanidin B, which were also characterized using on-line liquid chromatography-electrospray ionization mass spectrometer coupled with DPPH assay.[47]

One of the finding showed anti-oxidant activity of fermentation product of five indigenous plants *Phyllanthus emblica* Linn, *Morinda citrifolia* Linn, *H. cordata* Thunb. *Terminalia chebula* Retz and *Kaempferia parviflora* Wall. On oxidative stress in Wistar rats with STZ-induced type II diabetes. Fermentation product at the dose level 2 and 6 mL/kg body weight/day for 6 weeks significantly ($P < 0.05$) decreased the diabetes-associated oxidative stress to a large extent through the inhibition of lipid peroxidation.[48]

Dietary effects

A recent investigation has reported that methanolic extract of *H. cordata* powder (1 g/kg p.o.) increased growth performance, dry matter, nitrogen digestibility, white blood cell concentration, meat longissimus muscle area and thiobarbituric acid reactive substances value in finishing pigs.[49]

PHYTOCHEMISTRY

Phytochemical investigations on plant *H. cordata* up to 2012 have reported number of phytoconstituents present in the plant. Various types of chemical constituents such as aristolactams, 5,4-dioxoaporphines, oxoaporphines, amides, indoles, ionones, flavonoids, benzenoids, steroids and different volatile oils have been isolated from *H. cordata*. Houttuynoside A[31] and houttuynamide A[31] have also been isolated from this plant. Among the isolated compounds, some have been evaluated for their anti-oxidant and anti-tyrosinase activity. Cepharadione B showed strong inhibitory activity against tyrosinase with an IC_{50} value of 170 mM. Quercitrin, quercetin-3-*O*-β-D-galactop yranoside showed excellent DPPH radical-scavenging property with IC_{50} values of 31 and 63 mM, respectively.[31] Table 1 and Figure 1 demonstrate detailed information regarding the phytoconstituents with their specific classes isolated from *H. cordata*.

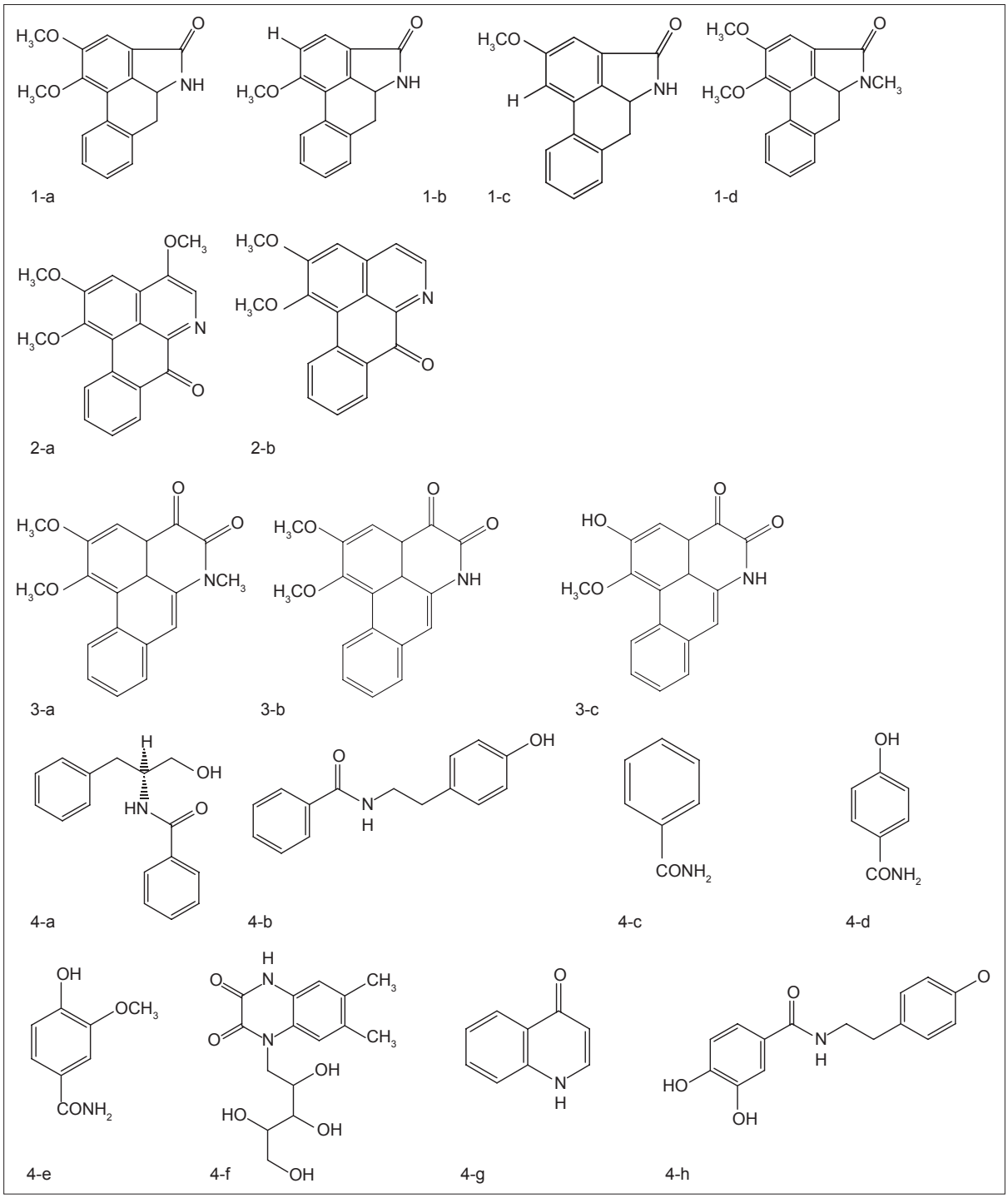

Figure 1: Phytoconstituents isolated from *Houttuynia cordata*

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CONCLUSION

According to Florae Reipublicae Popularis Sinicae and Flora Sichuanica, *H. cordata* Thunb. (Yuxingcao in Chinese) is the only species in the genus *Houttuynia*.[87,88] Its medicinal importance is well-described in Chinese system of medicine in fever, to

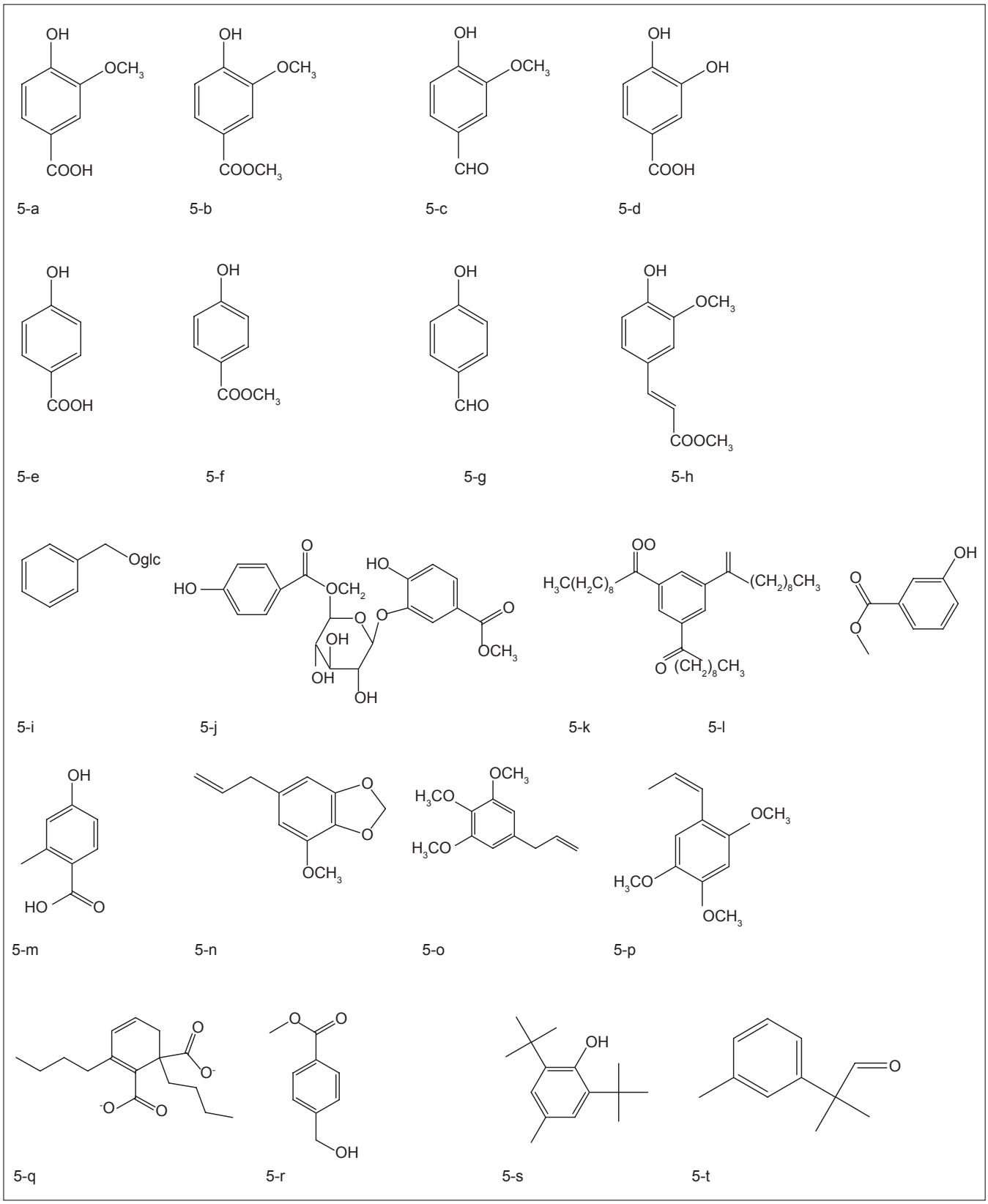

Figure 1: Phytoconstituents isolated from *Houttuynia cordata*

ease malnutrition, clearing of body toxins, anti-bacterial and in treatment of lung carbuncles. In addition, the plant is widely used as vegetable in North-Eastern parts of India and China and has been identified as one of the most potential medical and edible plant genetic resources by the Chinese State Health Department. Thus, the information provided in the present review may act as

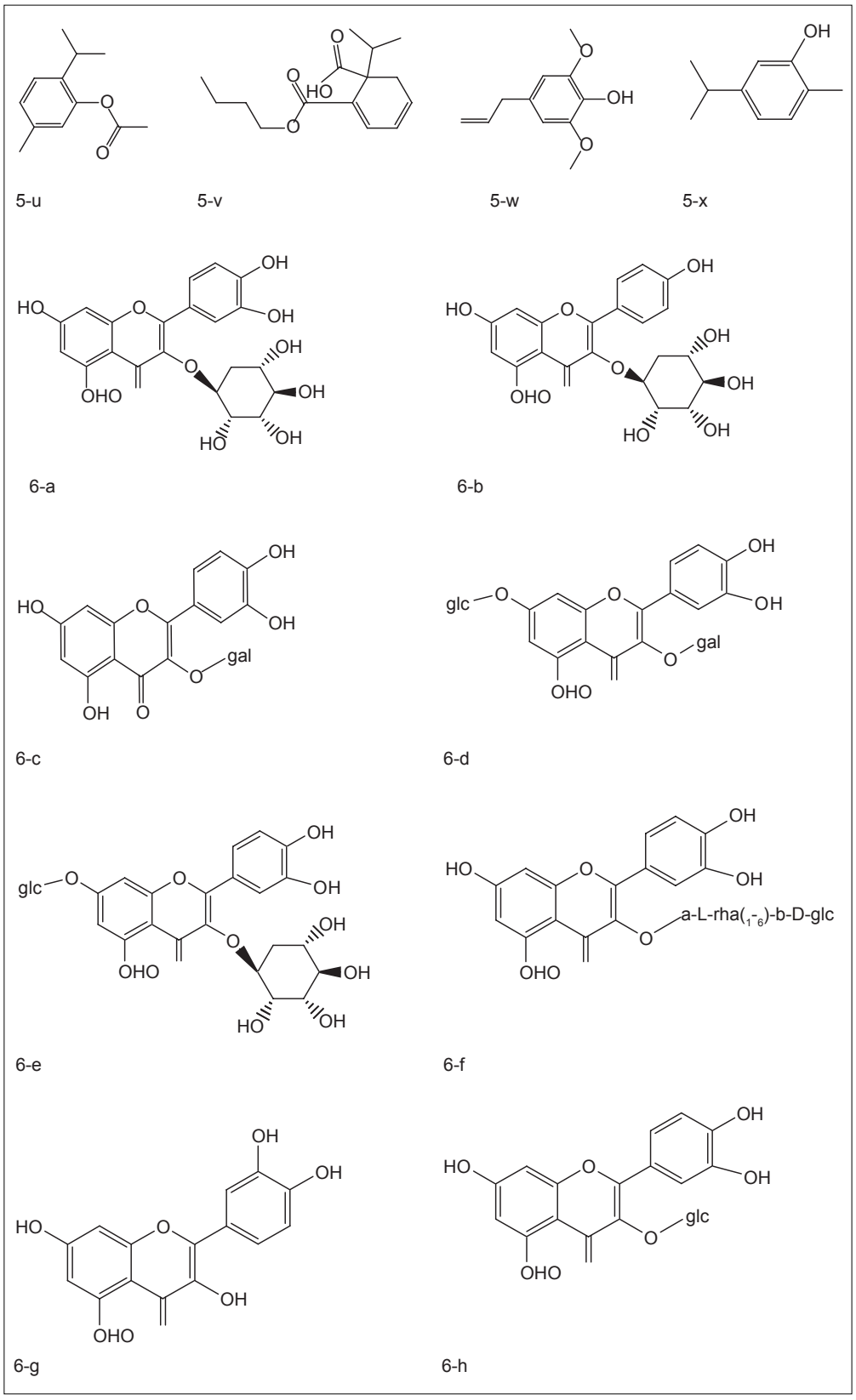

Figure 1: Phytoconstituents isolated from *Houttuynia cordata*

a contributing factor to the fact that at least 25% of all modern medicines are derived, either directly or indirectly, from medicinal plants, primarily through the application of modern technology to traditional knowledge.[1]

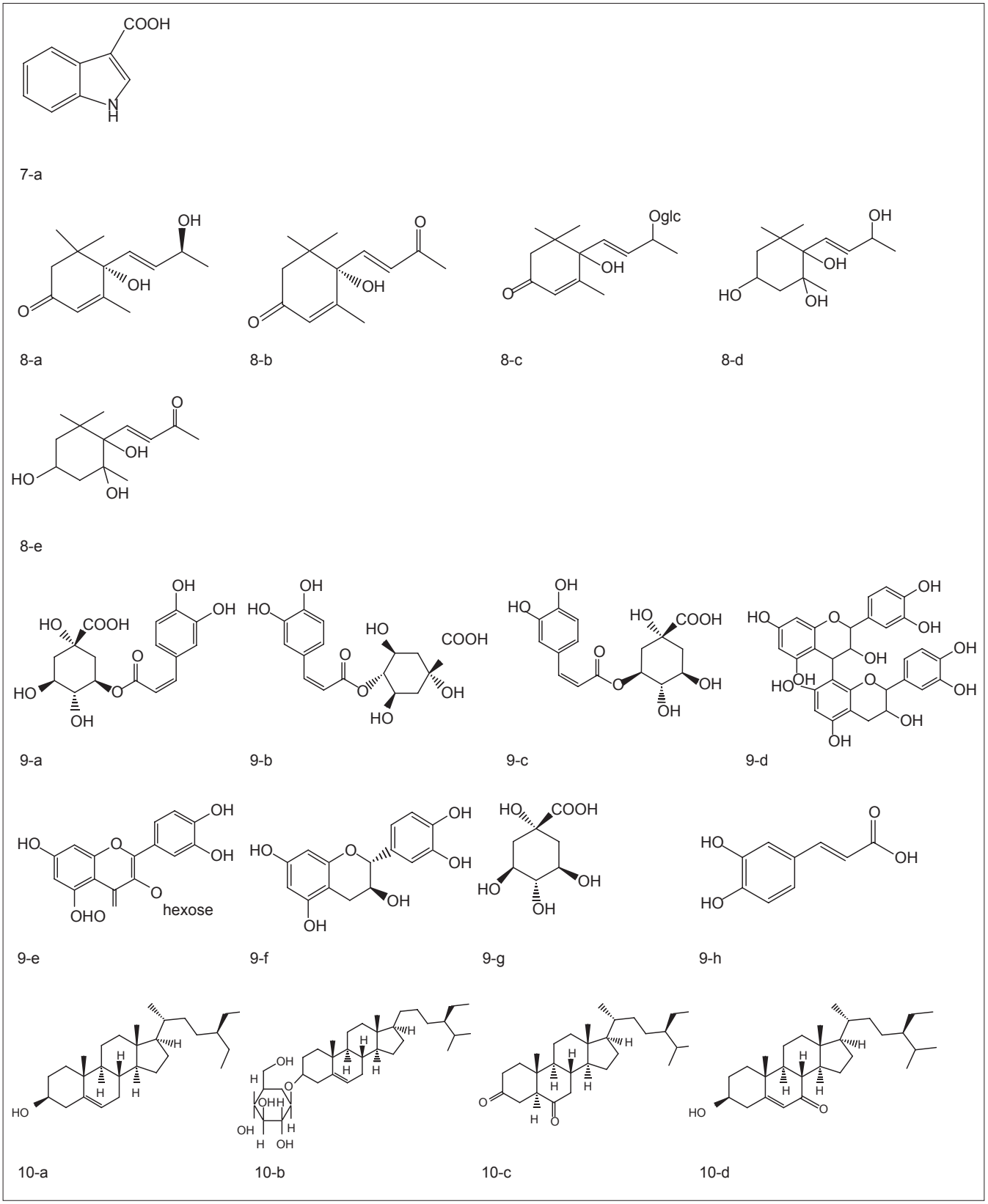

Figure 1: Phytoconstituents isolated from *Houttuynia cordata*

H. cordata offers an overall greater therapeutic value. The plethora of activities reported for the extracts, fractions and compounds isolated from *H. cordata* provide promising evidence for future research, which could achieve an important place in the world of modern drugs. Isolation on a large scale, chemical transformations and synthesis of the active compounds will

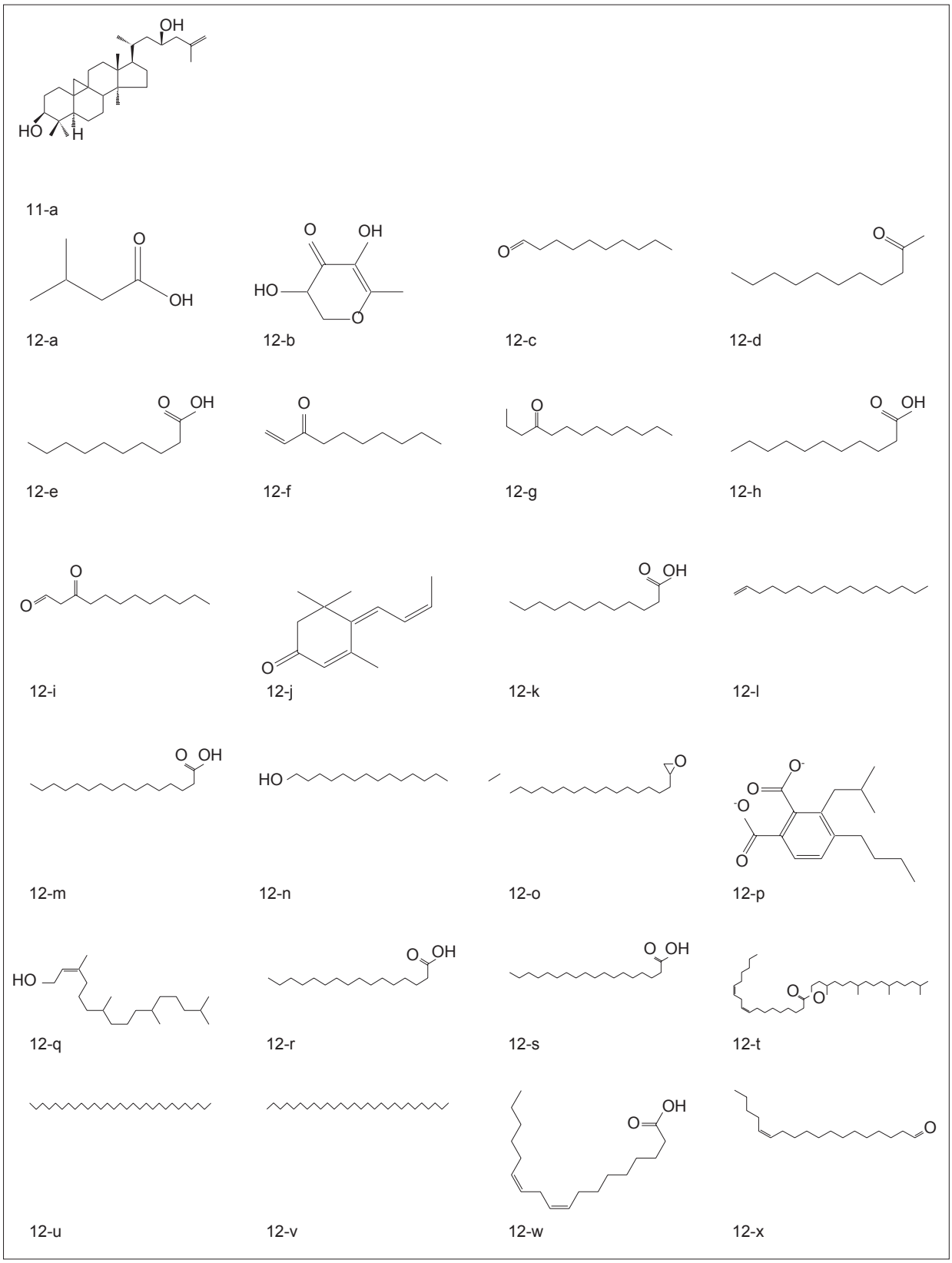

Figure 1: Phytoconstituents isolated from *Houttuynia cordata*

definitely enhance their pharmacological value. The provided information will also help in developing pharmacophores of many isolates that have not yet been identified and will also help in performing clinical trials using various active compounds against a variety of diseased conditions. Thus, the present review will elaborate the significance of *H. cordata* in human health-care system and will promote natural product research to its optimum height.

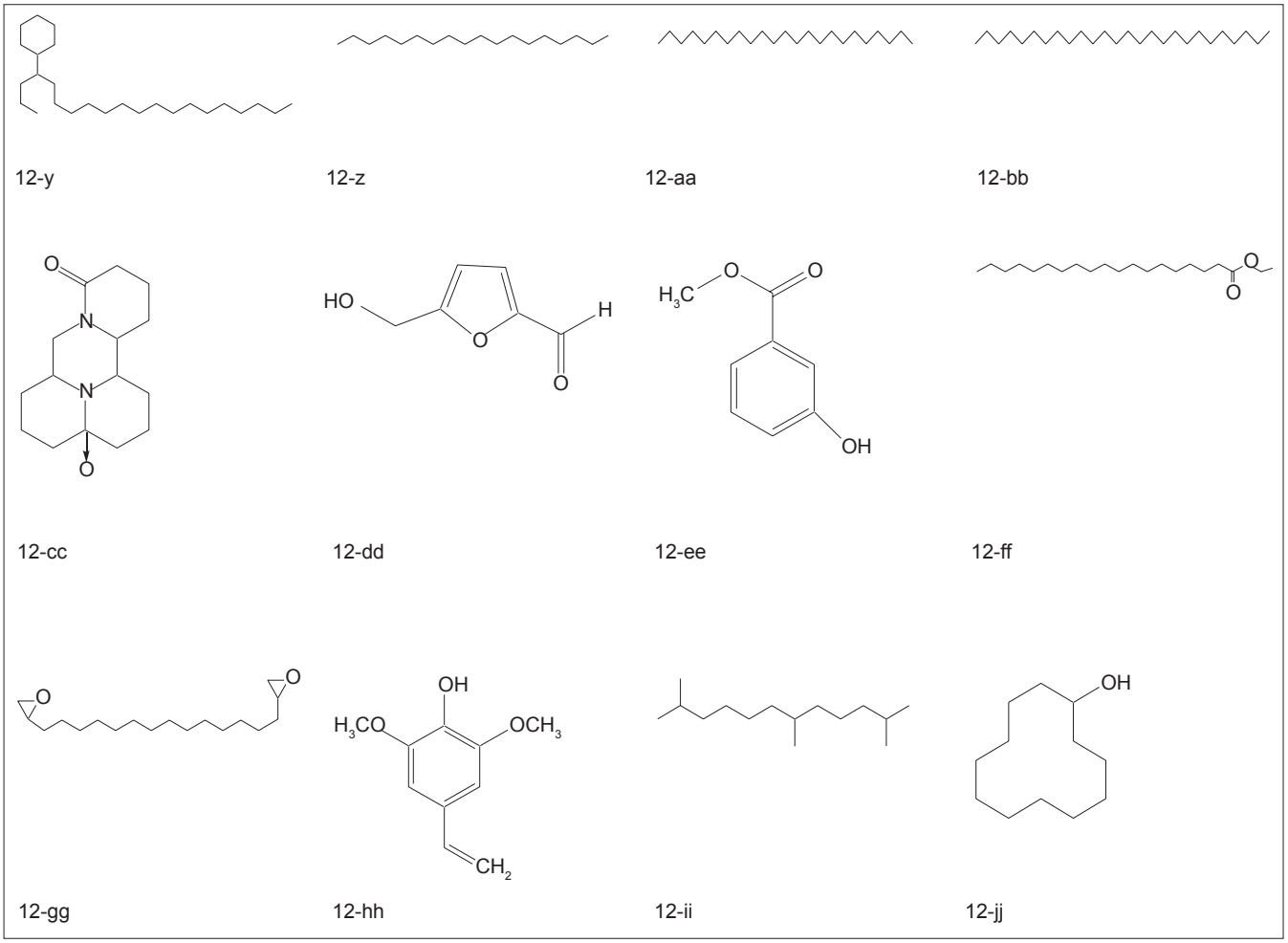

Figure 1: Phytoconstituents isolated from *Houttuynia cordata*

Table 1: List of phytoconstituents isolated from *H. cordata* till year 2012

Si No.	Phytoconstituents	Part of plant used for isolation	Reference
1	Aristolactams		
	a. aristolactam B II (Cepharanone B)	Dried aerial parts	a. [18,50]
	b. Aristolactam A II	Dried aerial parts	b. [18,50]
	c. Piperolactam A	Dried aerial parts	c. [18,50]
	d. Caldensin	Whole plant	d. [31,51]
2	Oxoaporphines		
	a. Splendidine	Dried aerial parts	a. [22]
	b. Lysicamine/oxonuciferine	Whole plant	b. [52]

Table 1: Contd...

Si No.	Part of plant used for isolation	Part of plant used for isolation	Reference
3	5,4-Dioxoaporphines		
	a. Cepharadione B	Dried aerial parts	a. [18,50]
	b. Norcepharadione B		b. [18,53]
	c. Noraritolodione		c. [22,53]
4	Amides		
	a. *N*-(1-hydroxymethyl-2-phenylethyl) benzamide	Whole plant	a. [54]
	b. *N*-(4-hydroxyphenylethyl) benzamide		b. [55]
	c. Phenyl carboxamide		c. [56]
	d. 4-Hydroxybenzamide		d. [57]
	e. 4-Hydroxy-3-		e. [58]

Contd...

Table 1: Contd...

Si No.	Part of plant used for isolation	Part of plant used for isolation	Reference
	methoxybenzamide		
	f. 6,7-Dimethyl-1-ribitol-1-yl-1, 4-dihydroquinoxaline-2,3-dione		f. [59]
	g. (1*H*)-quinolinone		g. [60]
	h. Houttuynamide A		h. [31]
5	Benzenoids		
	a. Vanillic acid	Whole plant	a. [31,61]
	b. Methyl vanillate		b. [31,62]
	c. Vanillin		c. [31,62]
	d. Protocatechuic acid		d. [31,63]
	e. 4-Hydroxybenzoic acid		e. [64]
	f. Methylparaben		f. [65]
	g. *p*-Hydroxybenzaldehyde		g. [67]
	h. *Cis*- and *trans*-methyl ferulate		h. [31,68]
	i. Benzyl-β-D-glucopyranoside		i. [31,69]
	j. Houttuynoside A		j. [31]
	k. 1,3,5,-Tridecanoylbenzene		k. [66]
	l. Methyl-3-hydroxybenzoate		l. [70]
	m. Methylaparaben		m. [66]
	n. Myristicin		n. [71]
	o. Elemicine		o. [71]
	p. α-Asarone		p. [71]
	q. 1,3-Dibutylphthalate		q. [70,72]
	r. Methyl-4-hydroxymethylbenzoate		r. [72,73]
	s. 2,6-Bis-(1,1-dimethyl)-4-methylphenol		s. [72]
	t. m-Tolyl-dimethylacetaldehyde		t. [72,73]
	u. Thymylacetate		u. [72]
	v. Butyl-2-isopropyl phthalate		v. [70,73]
	w. 2,6-Dimethoxy-4-(2-propenyl) phenol		w. [70]
	x. 2-Methyl-5-(1-methylethyl) phenol		x. [72]
6	Flavonoids		
	a. Quercitrin	Dried aerial parts	a. [18,74]
	b. Afzelin		b. [75,76]
	c. Hyperin		c. [76]
	d. Quercetin-3-O-β-D-galacto pyranosyl-7-O-β-D-glactopyra noside		d. [75,76]
	e. Quercetin-3-O-α-L-rhamno pyranosyl-7-O-β-D-glucopyran oside		e. [76]
	f. Rutin		f. [77,74]
	g. Quercetin		g. [78,31]
	h. Isoquercitrin		h. [79]
7	Indoles		
	a. Indole-3-carboxylic acid	Whole plant	a. [31,80]
8	Ionones		
	a. Vomifoliol	Whole plant	a. [66]
	b. Dehydrovomifoliol		b. [31,81]
	c. Reseoside		c. [31,82]
	d. 6-(9-Hydroxy-but-7-ethyl)-1, 1,5-trimethylcyclohexane-3,5,6-triol		d. [31,83]
	e. 7-(3,5,6-Trihydroxy-2,6, 6-trimethylcyclohexyl)-byt-3-en-2-one		e. [31,84]
9	Phenolic compound		
	a. Chlorogenic acid	Dried aerial part	[47]
	b. Crypto-chlorogenic acid		
	c. Neo-chlorogenica acid		
	d. Procynanidin B		
	e. Catechin		
	f. Quinic acid		
	g. Caffeic acid		
10	Steroids		
	a. β-Sitosterol	Rhizome	a. [61,77]
	b. β-Sitosteryl glucoside		b. [85]
	c. 5-α-Stigmastane-3,6-dione		c. [66]
	d. 3-Hydroxy-β-sitost-5-en-7-one		d. [66]
11	Triterpenoids		
	a) Cycloart-25-ene-3b, 24-diol	Whole plant	a. [31,86]
12	Volatile oil		
	a. 3-Methyl-butanoic acid	Whole plant	[70]
	b. 2,3-Dihydro-3,5-dihydroxy-6 methyl- 4*H*-pyran-4-one		
	c. Decanal		
	d. 2-Undecanone		
	e. *n*-Decanoic acid		
	f. 1-Decen-3-one		
	g. 4-Tridecanone		
	h. Undecanoic acid		
	i. Decanoyl acetaldehyde		
	j. Megastigmatrienone		
	k. Dodecanoic acid		
	l. 1-Hexadecene		
	m. *n*-Hexadecanoic acid		
	n. Pentadecanol		
	o. Hexadecyl-oxirane		
	p. Butyl-2-methylpropylphthalate		
	q. 3,7,11,15-Tetramethyl-2-hexadecen-1-ol		
	r. Palmitic acid		
	s. Octadecanoic acid		
	t. Phytol, (*Z*, *Z*) 9,12-octadecadienoic acid		
	u. Nonacosane		
	v. Octacosane		
	w. Linoleic acid		
	x. (*Z*)-13-octadecenal		
	y. (1-Propylheptadecyl) cyclohexane		
	z. Octadecane		
	aa. Tricosane		
	bb. Hexacosane		
	cc. *N*-oxide matrine		
	dd. 5-(Hydroxymethyl)-2-furancarboxalder		
	ee. 3-Hydroxy-benzoate methyl		
	ff. Nonadecanoate ethyl		
	gg. Tettadecyl oxirane		
	hh. 2,6-Dimethhoxy-4-(2-propenyl)-phenol		
	ii. 2,6,11-Timethyl-dodecane		
	jj. Cyxlododecanol		

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