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ORIGINAL ARTICLE

Centella asiatica (L.) Urb.: Ethnomedicinal uses and their scientific validations

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ABSTRACT

The medicinal uses of *Centella asiatica* goes back to pre-historic times. Discovery of any new drug from a plant can benefit a lot if ethnomedicinal uses of the plant from various sources are documented and compared, and relevant scientific studies are conducted on the plant's pharmacological properties. In this review, we have attempted to compile a list of ethnomedicinal uses of *Centella asiatica* and have searched the scientific literature for reported constituents from the plant, which can scientifically validate the plant's traditional uses for cure of many ailments. The study clearly demonstrates that the various constituents present in different parts of the plant and the reported pharmacological properties agree well, and as such, validate many of the traditional uses of this plant. Numerous ethnomedicinal studies are published every year without any discussion of the chemical constituents of the medicinal plants reported, and scientific validations of their traditional medicinal uses. It is believed that the present approach of study of a medicinal plant can prove more valuable in not only identifying which diseases the plant may prove beneficial for but also provide a rational basis for any plant's given traditional uses, and lead to the discovery of new drugs.

Key words: *Centella asiatica*, ethnomedicine, scientific validation, constituents.

Introduction

Indigenous medicinal practices of various communities throughout the world have always proved to be an excellent route to discovery of many important modern drugs (Balick and Cox, 1996; Gilani and Rahman, 2005). Although the advent of allopathic medicine somewhat diminished the importance of traditional medicinal systems, yet these medicinal systems have in recent years, staged a come-back. This has happened due to a number of factors. First, allopathic medicine cannot cure all ancient and quite a number of emerging modern diseases like diabetes. Second, many allopathic medicines have developed drug-resistant vectors. Third, adverse reactions have been observed with a number of allopathic medicines. Even common over the counter pain-killing drugs like aspirin and paracetamol can develop gastric ulceration or hepatotoxicity from prolonged usage or over-dose. Fourth, many rural and remote areas of the world lack allopathic doctors and modern health-care facilities making modern medicine become out of reach of the population. Fifth, and last of all, people still believe in traditional medicine out from either habit or from finding such medicines beneficial.

As a result, recent years are witnessing an upsurge in observations and documentation of traditional medicinal practices, as evidenced through the number of ethnomedicinal papers published in various scientific journals, proliferation of books on home remedies, and renewed public interest as manifested by visits to traditional medicinal practitioners. The plethora of ethnomedicinal papers published, however, lacks one important aspect. This is discussing the comparative ethnomedicinal uses of a given plant in various traditional medicinal practices of the world, along with a description of the plant's reported constituents and their pharmacological effects, and whether such pharmacological properties justify or validate the plant's traditional use. This is important, for otherwise, ethnomedicinal papers lose most of any practical significance. Conversely, such discussion can add an important dimension to further scientific research on the plant thus leading to possible safe therapeutic use of the plant in alleviating symptoms and curing diseases.

Centella asiatica (L.) Urb. (Apiaceae/Umbelliferae) is a plant that has been used from pre-historic times to cure a number of maladies. It is a small, herbaceous annual plant and is native to India, Sri Lanka, Bangladesh, northern Australia, Indonesia, Iran, Malaysia, Melanesia, Papua New Guinea, and other parts of Asia. It has uses in traditional African medicine, traditional Chinese medicine, and the ancient Ayurvedic system of medicine in

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India, which dates back at least 3,500 years ago. It also has uses in the Unani system of traditional medicine in India, which began from the Greeks and was later developed by the Arabs. In Unani medicine, the plant is known as 'braahmi'. A number of its bio-active constituents have been characterized. The plant is known as 'thankuni' in Bengali, 'Indian pennywort' in English, 'gotu kola' in Sinhala, 'mandukaparni' in Sanskrit (Ayurveda), 'Hydrocotyle asiatique' in French, and 'Asiatischer Wassernabel' in German. Accepted synonyms of the plant include *Hydrocotyle asiatica* L., *Hydrocotyle lunata* Lam., *Centella coriacea* Nannfd., *Centella cordifolia* (Hooker fil.) Nannfd., *Centella dusenni* Nannfd., *Centella floridana* (C. et R.) Nannfd., *Centella repanda* (Pers.) Small., *Centella triflora* (R. et P.) Nannfd., and *Centella uniflora* (Col.) Nannfd. The full classification of the plant is shown in Table 1 (below).

Considering the diversified uses of the plant for treatment of a diverse variety of ailments in many traditional medicinal systems of the world, the objective of the present review was to compare such ethnomedicinal uses with reported bio-active constituents of the plant, and determine whether the traditional uses of the plant can be validated scientifically, considering reported pharmacological activities of the various plant constituents.

Table 1: Systematic classification (Taxonomy) of *Centella asiatica*.

Classification	Name
Kingdom	Eukaryota
Subkingdom	Embryophyta
Division	Spermatophyta
Subdivision	Angiospermae
Class	Dicotyledoneae
Subclass	Rosidae
Superorder	Aralianae
Order	Araliales (Umbelliflorae)
Family	Apiaceae or Umbelliferae
Subfamily	Hydrocotyle
Genus	Centella
Species	Centella asiatica

Methodology:

The authors first carried out a computer-aided search of the literature stored in various medical data banks. In addition, relevant information was also searched on the Internet. All publications containing original data and an adequate detailed description of methodology were considered in the present review. Data collected by the corresponding author in his previous field studies in Bangladesh with folk and tribal medicinal practitioners was also used in this review for comparative analysis of ethnomedicinal uses. Ethnomedicinal data collected on the uses of this plant for treatment of diverse diseases in traditional medicinal systems was compared with reported constituents of the plant and their reported relevant pharmacological activities or properties. On the basis of this comparison, it was determined whether traditional medicinal uses of the plant are scientifically validated or not. Moreover, the on the basis of the latter data combined with the first set of data it was determined whether the plant could serve single or multiple therapeutic purposes.

Results and Discussion

The major ethnomedicinal uses of the plant appears to be to alleviate gastrointestinal disorders like dysentery, constipation, stomach problems, indigestion and loss of appetite, and to enhance memory or to serve as nerve stimulant. Altogether twenty three ethnomedicinal uses were collected from the available literature, of which six dealt with the plant's use in gastrointestinal disorders, and four uses were linked to memory or uses associated with brain functions like stimulation of nerve or for treatment of mental retardation. However, the uses of the plant were quite diverse overall, for the plant was used for treatment of headache, toothache, cuts and wounds, leucorrhea, skin disorders (like eczema, carbuncle), hemorrhoids, as antidote to poison, urinary troubles and leucorrhea, pneumonia, syphilis, liver problems (like jaundice), sexual weakness in males, fever, sun stroke, rickets, cardiovascular disorders, leprosy, tuberculosis, asthma, and varicocele. Altogether, 12 ethnomedicinal reports were from India, 3 from Nepal, 6 from Bangladesh, and 2 from Africa. Thus the major ethnomedicinal uses of the plant seemed to be centered in the Indian sub-continent. The results are shown in Table 2.

Some other traditional uses of the plant have been referenced but have not been added in Table 2. For instance, traditional healers in Java and other Indonesian islands, as well as in the island of Madagascar have been reported to use the plant for therapeutic purposes (Madaus, 1938; Kiessewetter, 1964; Kartnig, 1988). The use of the plant in Chinese traditional medicine has also been documented (Kan, 1986).

Table 2: Ethnomedicinal uses of *Centella asiatica* (L.) Urb. (Apiaceae/Umbelliferae).

Serial Number	Tribe/people and location	Ailment(s) treated	Part of plant used with formulation, if any	References
1	People of Kasaragod district, Kerala State, India	To improve memory, headache.	Extract from leaves and whole plants taken orally to improve memory and used topically to treat headache.	Unnikannan *et al*., 2012.
2	People of Kedarnath Wildlife Sanctuary, Western Himalaya, India	Dysentery, constipation.	Leaf.	Singh and Rawat, 2011.
3	Tribal people of Tirunelveli Hills, Southern India	Wounds.	Flowers of *Ixora coccinea* L. (Rubiaceae) are mixed with leaves of *Coldenia procumbens* L. (Boraginaceae), *Centella asiatica* and stem bark of *Madhuca longifolia* Koen. (Sapotaceae) and boiled with water. The decoction thus obtained is topically applied along with coconut oil to wounds.	Ayyanar and Ignacimuthu, 2009.
4	Newar community of Pharping village of Kathmandu district, Nepal	Antidote to poison, cuts and wounds, urinary trouble.	Whole plant juice.	Balami, 2004.
5	Meche people of Jhapa District, Eastern Nepal	Heating and tenderness of limb skin.	Whole plant extract (30-50 ml) is taken for 30 or more days.	Rai, 2004.
6	Manipuri people of Manipur State, India	Stomach treatment, to improve brain power.	About 100g of fresh leaves and stems is taken once early in the morning for stomach treatment. Extracted juice (1/2 glass) is mixed with yolk of an egg and 1-2 teaspoon of honey to improve brain power in young learners.	Yumnam *et al*., 2012.
7	Malasars tribe of Velliangiri holy hills, India	Leucorrhea, eczema.	Not reported.	Ragupathy *et al*., 2008.
8	Local people of the lowlands of Konta Special Woreda, Ethiopia	Not reported.	Not reported.	Bekalo *et al*., 2009.
9	People of Buldhana District of Maharashtra State, India.	Mental retardation.	Powder of entire plants mixed in cow's ghee is boiled slightly and filtered. It is stored in a red bottle for one day in sunlight. Ten drops of it in one cup of cow's fresh milk is advised twice daily for a month.	Dushing and Patil, 2010.
10	People of Dolpa District, Nepal.	To stimulate nervous system, pneumonia, skin diseases, toothache, indigestion, dysentery.	Fresh leaf is used to stimulate nervous system. Plant extract is taken for pneumonia, skin diseases, toothache, and indigestion. Leaf paste is used to treat dysentery.	Kunwar and Adhikari, 2005.
11	Chakma communities of Chittagong Hill Tracts, Bangladesh.	Syphilis, ulcer.	Whole plant juice is taken.	Khisha *et al*., 2012.
12	Tai-Khamyang people of Sivasagar District, Assam, India.	Carbuncle hemorrhoids.	For treatment of carbuncle, paste of *Centella asiatica* and *Bonnaya reptans* (Roxb.) Spreng. (Scrophulariaceae) is mixed with leaves and tender leaf buds of *Psidium guajava* L. (Myrtaceae) and a little amount of *Nicotiana tabacum* L. (Solanaceae) and is warped over the affected area with a banana leaf and tied with a soft cloth for the whole night. For treatment of hemorrhoids, resin of *Artocarpus lakoocha* Roxb. (Moraceae) is mixed with crushed leaves of *Centella asiatica* and meat of fire roasted *Channa punctatus* (fish species). Three tablets are prepared from the mixture and are taken one by one at any time of the day.	Sonowal and Barua, 2011.
13	Manavalakuruchi people of Kanyakumari District, Tamil Nadu State, India.	Fever, sun stroke.	Whole plant.	Britto *et al*., 2010.
14	People of Bansoa, West Cameroon, Africa.	Varicocele [widening of the veins along the cord that holds up a man's testicles (spermatic cord)].	Dried and powdered whole plant is swallowed with water.	Noumi *et al*., 2011.

15	Kol, Gond and Mawasi tribes of Chitrakoot region, Madhya Pradesh, India.	Rickets (softening and weakening of the bones due to lack of vitamin D).	Leaf juice is given to children once daily for one month.	Sikarwar *et al*., 2008.
16	People of NR Pura taluk in Chikmagalur District of Karnataka State, India.	Cardiovascular problems, stomach disorders.	For cardiovascular problems, leaf infusion of *Centella asiatica* with flowers of *Nyctanthes arbor tristis* L. (Oleaceae) and onion bulb [*Allium cepa* L. (Liliaceae)] is administered orally. For stomach disorders, leaf extracts of *Centella asiatica* and *Mimosa pudica* L. (Fabaceae) are mixed with lemon juice and taken orally on an empty stomach.	Prakasha *et al*., 2010.
17	Lushai tribe of North Cachar District of Assam, India.	Leprosy, tuberculosis, asthma.	Crushed whole plant parts are used.	Sajem and Gosai, 2010.
18	Folk medicinal practitioners and Khasia tribal medicinal practitioners of Sylhet District, Bangladesh.	Gastric disorders, liver troubles.	Juice obtained from macerated leaves and stems is orally administered.	Shaheen *et al*., 2010.
19	Folk medicinal practitioners of Fullbari village, Bogra District, Bangladesh.	Leucorrhea.	Juice obtained from macerated whole plant is orally administered.	Hossan *et al*., 2010.
20	Folk medicinal practitioners of Sylhet Division, Bangladesh.	Indigestion, appetite stimulant.	Juice from whole plant is orally taken.	Rahmatullah *et al*., 2010.
21	Soren clan of the Santal tribe in Rajshahi District, Bangladesh.	Sexual weakness in males.	1g roots of *Eclipta alba* (L.) Hassk. (Asteraceae) is mixed with leaves of *Centella asiatica*, 1g roots of *Abroma augusta* L.f. (Sterculiaceae), roots of *Bombax ceiba* L. (Bombacaceae) and boiled in water. Fruits of *Croton tiglium* L. (Euphorbiaceae) and powdered seed husks of *Plantago ovata* Forssk. (Plantaginaceae) are then mixed with the decoction, and the decoction taken with ripe bananas, sugar and cow milk.	Rahmatullah *et al*., 2012.
22	Hodi tribe of Bangladesh.	Jaundice.	Juice obtained from macerated leaves of *Centella asiatica* is taken with roots of *Costus speciosus* daily in the morning on an empty stomach till cure.	Rahmatullah *et al*., 2011.
23	Baiga tribe of Amarkantak Biosphere Reserve, India	Syphilis, mental disorder, skin disease.	Not reported.	Kapale, 2012.

The role of *Centella asiatica* in improving cognitive and other functions of the brain has been supported by a wealth of scientific evidence. Extracts of the plant reportedly improved cognition and reduced oxidative stress in rats (Veerendra Kumar and Gupta, 2002). Leaf powder has been shown to have anti-oxidant effect in brain regions of pre-pubertal mice *in vivo*, and ameliorate 3-nitropropionic acid-induced oxidative stress in mitochondria *in vitro* (Shinomol and Muralidhara, 2008). Neuroprotective effect of the plant has been observed against intracerebroventricular colchicine-induced cognitive impairment and oxidative stress (Kumar *et al*., 2009), and D-galactose-induced cognitive impairment, oxidative stress and mitochondrial dysfunction (Kumar *et al*., 2011). The anti-oxidant property of the plant has further been evaluated in relation to its memory enhancing ability (Meena *et al*., 2012). Treatment with the plant during postnatal period has been found to enhance learning and memory in mice (Rao *et al*., 2005). Leaf extract treatment during the growth spurt period has been shown to enhance hippocampal CA3 neuronal dendritic and amygdaloid neuronal dendritic arborization (regions concerned with learning and memory) in rats (Mohandas Rao *et al*., 2006; Gadahad *et al*., 2008; Mohandas Rao *et al*., 2009). Treatment with fresh leaf extract has been demonstrated to enhance learning ability and memory retention power in rats (Rao *et al*., 2007). A positive modulation of cognition and mood in healthy elderly human volunteers has been observed following administration of the plant (Wattanathorn *et al*., 2008).

Extract of the plant has the possibility of proving beneficial in Alzheimer's patients because it has been shown to enhance phosphorylation of cyclic AMP response element binding protein (CREB) in neuroblastoma cells expressing amyloid beta peptide, a component of amyloid plaques in association with Alzheimer's disease (Xu *et al*., 2008). It is to be noted that in Alzheimer's disease, amyloid beta peptide decreases the phosphorylation of CREB by protein kinase A (PKA) is significantly inhibited leading to possible cognitive impairment during the progress of the disease (Vitolo *et al*., 2002). In fact, extract of the plant reportedly decreased amyloid beta levels in hippocampus of Alzheimer's disease animal model (Dhanasekaran *et al*.,

2009). Extract of the plant has been shown to improve behavioral deficits in a mouse model of Alzheimer's disease (Soumyanath *et al*., 2012).

One of the active principles in the plant, which contributes to improvement in brain functions, seem to be asiatic acid. Asiatic acid derivatives have been shown to enhance cognitive performance partly by improving acetylcholine synthesis (Kim *et al*., 2004). Treatment of Sprague-Dawley rats resulted in significantly dose-dependently improved memory (Nasir *et al*., 2011). The compound has been shown to attenuate glutamate-induced cognitive deficits in mice and apoptosis in SH-SY5Y cells, a human-derived cell line isolated from a four year-old female with neuroblastoma (Xu *et al*., 2012). Memory loss and cognitive impairment as well as behavioral deficit can be a consequence of anxiety and depression. Asiaticoside, another component of the plant has been shown to impart anxiolytic activity (Wijeweera *et al*., 2006). An alcoholic extract of the plant has been reported to have tranquilizing effects and the active component has been shown to a triterpene component of the plant, brahmoside. The extract has further been shown to have sedative, anti-depressant and potentially cholinomimetic activities (Sakina and Dandiya, 1990).

A number of potentially important components of possible therapeutic values and important pharmacological effects have been described for the plant (Brinkhaus *et al*., 2000). These compounds include terpene acetate, germacrene, beta-caryophyllene, p-cymol, and pinene (from essential oil); the flavone derivatives – quercetin glycoside, kaempferol in its free and glycoside form (3-glucosyl kaempferol and 7-glucosyl kaempferol); sesquiterpenes – beta-elemene, bicycloelemene, trans-farnesene, ermacrene D; triterpenic steroids – stigmasterol and beta-sitosterol; triterpenic acids – asiatic acid, 6-hydroxy asiatic acid, madecassic acid, madasiatic acid, betulinic acid, thankunic acid and isothankunic acid; and triterpenic acid sugar esters like asiaticosides A and B, braminoside, brahmoside, brahminoside, thankuniside and isothankuniside. Rhizomes, particularly are rich in various bio-active components like the mono-terpenes – 1,8-cineole, limone, pinene, borneol, camphene, terpenine-4-ol, borneol acetate, carveol I, carveol II, citronellol acetate, p-cymene, p-cymenol, geraniol acetate, linalool, myrcene, nerol acetate, sabines, and terpineolenes; diterpenes like galanal A and B, galanalactone, (E)-8(17),12-labdiene-15,16-dial, and (E)-8(17)-epoxylabd-12-en-15,16-dial; sesquiterpenes like bergamotene, bisabolene 2, trans-farnesene, caryophyllenol I, caryophyllene oxide, caryophyllenol II, curcumin, copaene; sesquiterpenes – humulene, santalene, and sesquiphellandrene; alkenes – n-heptadecene; alkanes – pentadecane and tridecane; phenyl-propanoids – chavicol, chavicol acetate, 1'-acetoxychavicol acetate, 1'-hydroxychavicol acetate, 4-hydroxy-trans-cinnamaldehyde, 3,4-dimethoxy-trans-cinnamyl alcohol, 4-methoxy-trans-cinnamyl alcohol, trans-coniferyl diacetate, trans-para-coumaryl diacetate, eugenol acetate, 1'-acetoxyeugenol acetate, and eugenol methylether. Other reported compounds include 3-glucosyl quercetin, betulic acid, bicycloelemene, brahmic acid, campesterol, camphor, centellic acid, centellinic acid, centellose, centelloside, centoic acid, elaidic acid, germacrene-D, hydrocotyline, indocentoic acid, isobrahmic acid, isothankunic acid, lignoceric acid, medicassic acid, oxyasiaticoside, and vellarine (Duke, 1992).

Ursane- and oleanane-type triperne oligoglycosides, centellasaponins B, C, and D and sceffoleoside has been isolated from aerial parts of the plant (Matsuda *et al*., 2001). Aerial parts further reportedly yielded ursolic acid lactone, ursolic acid, pomolic acid, 2alpha,3alpha-dihydroxyurs-12-en-28-oic acid, 3-epimaslinic acid, asiatic acid, corosolic acid, and rosmarinic acid (Yoshida *et al*., 2005). Methanolic extract of aerial parts yielded 3,5-di-O-caffeoyl quinic acid, 1,5-di-O-caffeoyl quinic acid, 3,4-di-O-caffeoyl quinic acid, 4,5-di-O-caffeoyl quinic acid and chlorogenic acid together with asiaticoside, kaempferol, quercetine, kaempferol-3-O-beta-D-glucoside, and quercetin-3-O-beta-D-glucoside (Satake *et al*., 2007). Centellin, asiaticin, and centellicin has also been reported from aerial parts of the plant (Siddiqui *et al*., 2007). Other chemical compounds reported from the plant include docosyl ferulates, bayogenin, 3beta-6beta-23-trihydroxyolean-12-en-28-oic acid, 3beta-6beta-23-trihydroxyurs-12-en-28-oic acid and D-gulonic acid (Yu *et al*., 2007).

Extract of the plant has been shown to have beneficial effects in various chemical or stress-induced ulceration in animal models, like cold restraint stress ulcer (Ravokatra *et al*., 1974; Chatterjee *et al*., 1992), ethanol-induced gastric mucosal lesions (Cheng and Koo, 2000), and physical and chemical factors-induced gastric ulceration (Sairam *et al*., 2001). The active factor for healing at least acetic acid-induced gastric ulceration and phenylchinolincarbonic acid-induced gastric lesions appear to be asiaticoside (Catania, 1960; Cheng *et al*., 2004). The anti-bacterial activity of *Centella asiatica* has been demonstrated against a number of enteric pathogens, showing that the plant may prove useful in treatment of diarrhea and dysentery (Mamtha, 2004). The presence of flavonoids and tannins in the plant may also contribute to its anti-diarrheal effect. Flavonoid type of compounds can inhibit the development of fluids that result in diarrhea by targeting of the intestinal cystic fibrosis trans-membrane conductance regulator (Schuier *et al*., 2005). Rosmarinic acid, a constituent of the plant, and also isolated from *Anchusa azurea* Mill., reportedly demonstrated anti-inflammatory and anti-ulcer activities (Kuruuzum-Uz *et al*., 2012).

The analgesic and anti-inflammatory properties of *Centella asiatica* has been described, thus validating its ethnomedicinal uses for treatment of headache and toothache (Somchit *et al*., 2004). Ayurveda, the ancient Indian traditional medicinal system of India, describes the plant as being good, particularly for treating wounds,

leprosy, and for various mental disorders. The plant is also used in the folk medicine of Malay Peninsula, Java and Madagascar for treating wounds; in China it is used historically for various psychotropic applications. The official Chinese and European Pharmacopoeia lists the plant for treatment of fever, heat stroke, ulcerations, diarrhea, and traumatic diseases. The British Herbal Pharmacopoeia of 1983 recommends using the plant as a mild diuretic and anti-rheumatic. In Ayurvedic Pharmacopoeia of India, the dried plant is used in 'raktapitta' (hemorrhagic diseases), 'kustha' (leprosy), 'meho' (polyurea), 'kasa' (cough), 'jvara' (fever), 'aruchi' (loss of appetite, anorexia), 'pandu' (anemia), 'sotha' (edema), and 'raktadosa' (poisoning of blood) (Bhavna and Jyoti, 2011). The anti-leprotic property of the plant has been attributed to asiaticoside (Barbosa-Filho *et al*., 2007).

In Unani medicine, the plant is said to be useful for treatment of skin disorders like eczema (Jamil *et al*., 2007). The essential oil from *Hyptis suaveolens* (L.) Poit leaves have been found to be effective against pathogenic *Aspergillus* species, including species which can cause cutaneous aspergillosis, and aspergillar onychomycosis (Moreira *et al*., 2010). The active constituents have been reported to be gamma-elemene, beta-pinene, trans-beta-caryophyllene, and germacrene. Some of these components have been found in essential oil from *Centella asiatica*, suggesting that the plant may prove useful in treatment of skin disorders, particularly caused by various fungi. Anti-bacterial activity has been reported with the essential oil from *Monticalia greenmaniana* (Hieron) C. Jeffrey containing germacrene against *Staphylococcus aureus*, *Enterococcus faecalis*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumonia* (Cárdenas *et al*., 2012). The essential oil from Acanthospermum hispidum DC. containing beta-caryophyllene and germacrene D has been found to be inhibitory to pathogenic strains of *Staphylococcus aureus* and *Enterococcus faecalis* (Alava *et al*., 2012). Pinene and germacrene were among the constituents of essential oil from the leaves of *Annona vepretorum* with anti-microbial activity (Costa *et al*., 2012). Germacrene was also among the constituents of essential oil of *Salvia reuterana* Boiss showing anti-microbial activity (Ghomi *et al*., 2012).

Extract of the plant containing total triterpenoid fraction has been shown to help patients with varicose venous disorders like hemorrhoids and varicose vein (Arpaia *et al*., 1990). According to the Siddha system of Indian medicine, leaves have been traditionally used for treatment of syphilis. In Ayurveda, the plant is also used for treatment of tertiary syphilis and tuberculosis (Tiwari *et al*., 2011). It has been reported that leaf juice of the plant following administration decreased systolic blood pressure and heart rate in hypertensive rats. Additionally, the juice significantly increased cutaneous blood flow as well as regional cerebral blood flow in both normal and hypertensive rats, suggesting that the plant may prove useful in treatment of cardiovascular disorders (Muangnongwa, 2004). Cardiac glycosides present in the plant (Singh *et al*., 2012) explain its use for treatment of cardiovascular disorders (as observed in the present study), and for treatment of congestive heart failure and cardiac arrhythmia (Krishnaiah *et al*., 2009). The anti-hyperlipidemic effect of ursolic acid, a component of the plant, has been observed in isoproterenol-induced myocardial ischemic mice (Radhiga *et al*., 2012).

Varicocele is a hypogonadism of testicular origin caused by the varicose dilation (varix) of the veins of the spermatic cord, and can be a cause of male infertility. Asiatic acid present in the plant can be used for treatment of this disease, for the compound acts on the connective tissue in the biosynthesis of collagen (Paris and Hurabielle, 1981).

Our review clearly demonstrates two things. The first is that virtually all ethnomedicinal uses of *Centella asiatica* can be scientifically validated on the basis of scientific research on the properties of the various bioactive components of the plant. This fact highlights the importance of ethnomedicinal surveys to further scientific research in the quest for discovery of newer and better medicines. The second is that the possible therapeutic uses of the plant are yet to be totally explored considering that the plant contains numerous chemicals of potential therapeutic significances. To cite a few instances, ursolic acid (which is present in the plant) or its derivatives have been found useful in the potential treatment of epilepsy (Kazmi *et al*., 2012). The anti-depressant like effect of ursolic acid [mediated through the activation of dopamine D(1) and D(2) receptors], isolated from *Rosmarinus officinalis* L. has been observed in mice (Machado *et al*., 2012). Pomolic acid, another constituent of the plant, (also isolated from *Licania pittieri* Prance) has been shown to be a competitive antagonist of ADP-induced aggregation of human platelets and can form a new generation of non-nucleotide anti-platelet drugs (Alvarado-Castillo *et al*., 2012). The anti-cancer properties of pomolic acid have been shown in MCF7 human breast cancer cells (Youn *et al*., 2012). The modulatory efficacy of rosmarinic acid on premalignant lesions and anti-oxidant status in 1,2-dimethylhydrazine-induced rat colon carcinogenesis has been reported (Karthikkumar *et al*., 2012).

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