1735-2657/08/71-107-114
IRANIAN JOURNAL OF PHARMACOLOGY & THERAPEUTICS

IJPT 7:107-114, 2008

MINI REVIEW

Medicinal Uses and Pharmacological Actions of Five Commonly Used Indian Medicinal Plants: A Mini-Review

MUNIAPPAN AYYANAR and SAVARIMUTHU IGNACIMUTHU

For author affiliations, see end of text.

Received July 11, 2007; Revised June 2, 2008; Accepted June 9, 2008

This paper is available online at *http://ijpt.iums.ac.ir*

ABSTRACT

Man depends heavily on various plant species for his survival. Indian traditional system of medicine is based on empirical knowledge of the observations and the experience over millennia and more than 5000 plants are used by different ethnic communities in India. During the last few decades there has been an increasing interest in the study of medicinal plants and their traditional use in different parts of India. The present communication constitutes a review on the medicinal properties, ethnomedicinal uses and pharmacological activities of five common medicinal plants (*Acalypha indica* L., *Achyranthes aspera* L., *Adhatoda vasica* Medicus, *Coriandrum saticum* and *Centella asiatica*) used in Indian traditional medicine. These plants are known to contain various active principles of therapeutic value and to possess biological activity against a number of diseases.

Keywords: *India, Medicinal plants, Pharmacology, Phytochemistry, Traditional medicine*

Many of today's synthetic drugs originated from the plant kingdom, and only about 200 years ago our pharmacopoeia was dominated by herbal medicines [1]. The largest research fields, as defined by the number of publications describing bioactive plant-derived compounds in the last few years, are anti-tumour drugs, antibiotics, drugs active against tropical diseases, contraceptive drugs, anti-inflammatory drugs, immunomodulators, kidney protectors and drugs for psychiatric use [2]. Herbal drugs are being proved as effective as synthetic drugs with lesser side effects [3]. Current estimates suggest that, in many developing countries, a large proportion of the population relies heavily on traditional practitioners and medicinal plants to meet primary health care needs. Although modern medicine may be available in these countries, herbal medicines have often maintained popularity for historical and cultural reasons [4]. WHO encourages countries to provide safe and effective traditional remedies and practices in public and private health services and it also published two monographs on medicinal plants with information on pharmacopoeial summaries for quality assurance: botanical features, distribution, identity tests, purity requirements, chemical assays, and active or major chemical constituents, clinical applications, pharmacology, contraindications, warnings, precautions, potential adverse reactions, and posology, etc.

The Indian flora is extensively utilized as source of many drugs mentioned in the traditional systems of medicine. During the last few decades there has been an increasing interest in the study of medicinal plants and their traditional use in different parts of India. Indian medicinal plants are widely used by all sections of the population and it has been estimated that over 7500 species of plants are used by several ethnic communities. India possesses more than 500 tribal communities and even today, tribals and certain local communities in India practice herbal medicine to cure a variety of diseases and disorders [5]. During the last few decades there has been an increasing interest in the study of medicinal plants and their traditional use in different parts of India. There are many reports on the use of plants in traditional healing by either tribal people or indigenous communities of India.

The focus of this review is to provide informations on the medicinal properties, ethnomedicinal uses and pharmacological activities of five medicinal plants (*Acalypha indica*, *Achyranthes aspera*, *Adhatoda vasica*, *Coriandrum saticum* and *Centella asiatica*) commonly used in Indian traditional medicine. These plants are known to contain various active principles of thera-

peutic value and to possess biological activity against a number of diseases. No comprehensive account on these plants is available as a review except for *Adhatoda vasica* [6]. NCBI (Pubmed) and Medbioworld databases were used for the collection of pharmacological activities. As well as, ethnomedicinal information was extracted from the book on Dictionary of Indian Folk Medicine and Ethnobotany [7] and some related publications which are published on the ethnobotanical aspects. The medicinal properties and plant characteristics were collected from the published books on Indian Medicinal Plants and Indian Materia Medica.

ACHYRANTHES ASPERA L. (Prickly Chaff-Flower, Amaranthaceae)

An erect and much branched diffuse herb found throughout India along roadsides and waste places. The plant is acrid, bitter, thermogenic, expectorant, revulsive, carminative, digestive, stomachic, laxative, anodyne, depurative, anthelmintic, diuretic, linthontripic, sudorific, demulcent, haematinic and anti-inflammatory [7,8]. The plant is an indigenous medicinal plant of Asia, South America, and Africa and is commonly used by traditional healers for the treatment of fever, especially malarial fever, dysentery, hypertension, diabetes [9] and asthma [10]. The ash of the plant yields a large quantity of potash and it is used in asthma and cough. The whole plant is reported to be useful in indigenous system of medicine for the treatment of renal dropsy, bronchial affections and leprosy [7].

The leaves have been used for centuries in ethnomedicine for varied medicinal purposes [11]. Since time immemorial, it is in use as folk medicine. It holds a reputed position as medicinal herb in different systems of medicine in India. For example the various ethnic communities in India used the different parts of this plant to treat cold, cough, dysentery, eye complaints, headache, liver complaints, piles, rheumatism, scabies, burns, skin diseases, poison bites, toothache, stomachache spleen enlargement, pneumonia and kidney troubles [7,8,12-14].

Pharmacological activities of Achyranthes aspera

Chakraborthy et al [9] have assessed the leaves for chemopreventive activity and suggested that, the leaf extract and the non-alkaloid fraction were valuable anti-tumor promotors in carcinogenesis. Gokhale et al [15] reported that the ethanolic extracts of the plant possessed anti-inflammatory and anti-arthritic properties and supported the rationale behind the use in treating inflammatory conditions as claimed in the traditional Indian system of medicine. The anti-inflammatory activity of an alcohol extract of the plant was further evaluated by Vetrichelvan and Jegadeesan [16] on carrageenin-induced hind paw oedema and cotton pellet granuloma models in albino male rats. The aqueous and methanolic extracts of the whole plant showed significant dose-related hypoglycaemic effect in normal as well as diabetic rabbits [17].

The composite extract of root of this plant possessed an immobilizing factor that probably reduced motility by causing sperm non-viability by disrupting the membrane architecture of the sperm cell and it proved that the plant possessed potential contraceptive spermicidal activity in vitro [18]. Decoctions of the plant have cardiovascular toxicity [19]; saponin isolated from the plant has cardiac stimulant activity [20] and extract of the whole plant have abortifacient property [21].

The leaves of this plant played a role in changes in serum thyroid hormone concentrations and glucose levels in male rats and they concluded that the leaf extract of this plant can be both prothyroidic and antiperoxidative in nature and may be used for the treatment of hypothyroidic subjects after standardization of the dose [22]. Immunomodulatory activity of the plant on the elicitation of antigenspecific murine antibody response was reported by Vasudeva et al [23]. The methanolic extract of leaves of the plant have anti-fertility activity and increased pituitary and uterine wet weights in ovarectimized rats, which might be exploited to prevent unwanted pregnancy and control the ever-increasing population explosion [24]. Vasudeva and Sharma [25] studied the ethanolic extract of the root for anti-fertility activity in proven fertile female albino rats and showed that, the extract possessed both anti-implantation and abortifacient activity and also exhibited estrogenic activity tested in immature ovarectimized animals.

Ethanolic extract of the plant also reduced sperm counts, weight of epididymis, serum level of testosterone and testicular activity of 3-beta-hydroxysteroid dehydrogenase, while motility of the sperm and activity of the HMG CoA reductase were not affected [26]. The cholesterol level in the testis, incorporation of labelled acetate into cholesterol, 17-ketosteroids in urine and hepatic and fecal bile acids were also increased and the results suggested that the plant caused reproductive toxicity in male rats by suppressing the synthesis of androgen.

ACALYPHA INDICA L. (Indian Acalypha, Euphorbiaceae)

An erect, annual herb found profusely throughout the plains of India as a weed. The plant is bitter, acrid, expectorant, purgative, emetic, gastrointestinal irritant and diuretic. It has been reported to be useful in treating pneumonia, asthma, rheumatism and the decoction of the leaves is useful in scabies, earache, syphilitic ulcers and snakebites [7,8]. A drug named Anna Pavala Sindhooram (APS), used in Sidha system of Indian medicine for the prevention and reversal of the atherosclerotic disease was prepared in combination of nine plants as ingredients including *Acalypha indica* [27]. Tribal communities in India used various parts of this plant for the treatment of diseases such as asthma, cough, dog bite, rheumatism, earache, scabies, scorpion bites snake bites and sting of centipedes, burns and eczema [7,8,12-14]. In homoeopathy, the plant is used to treat severe cough, haemoptysis and incipient phthisis, gastrointestinal and respiratory problems [28]

Pharmacological activities of Acalypha indica

The ethanol leaf extract was found to significantly reduce the viper venom induced necrotic and haemorrhagic lesions and this proves that the plant possesses potent snake venom neutralizing properties [29]. 10% w/v of the extract of whole plant shows wound healing activity in rats [30]. Hiremath et al tested the four successive solvent extracts of the whole plant for postcoital antifertility activity in female albino rats. Among the four extracts tested at two different doses, the petroleum ether and ethanol extracts of the plant was found to be most effective in causing significant antiimplantation activity and the antifertility activity was reversible on withdrawal of the treatment of the extracts. The leaf extract of the plant showed significant antibacterial activity and highest inhibition zone was observed against *Aeromonos hydrophylla* and *Pseudomonos aeruginosa* [31].

ADHATODA VASICA MEDICUS (Malabar Nut/Vasaka, Acanthaceae)

It is a shrub growing throughout India especially in lower Himalayan ranges. The plant is antiperiodic, astringent, diuretic and purgative. It is a highly valued Ayurvedic medicinal plant used for the treatment of asthma, cough, bronchitis and tuberculosis [7,8] and the flowers, leaves and root are possessed antispasmodic property. The tubercular activities were reported by researchers' quite early [32,33]. It has been used as herbal medicine in treating a wide variety of diseases in India and the leaves of the plant are the main source of drug preparation. For example, the source of the drug 'vasaka', is well known in the indigenous system of medicine for its beneficial effects, particularly in bronchitis [34].

Traditionally, *A. vasica* has been used for the treatment of bronchial disorders such as acute and chronic cough, bronchitis and asthma, and also as an expectorant in the treatment of acute and chronic bronchial catarrh and broncho-pulmonary disease. The leaves as well as flowers, fruits and roots are extensively used for treating cold, whooping cough, asthma and as antihelmintic and the leaf juice is stated to cure diarrhoea, dysentry and glandular tumor. The various parts of the plant is used in Indian traditional medicine for the treatment of asthma, joint pain, lumber pain and sprains, cold, cough, eczema, malaria, rheumatism, swellings, venereal diseases [7,8,12-14]. In homoeopathy, the plant has been used in the treatment of cold, cough, pneumonia, spitting of blood, fever, jaundice, catarrh, whooping cough and asthma [28].

Pharmacological activities of Adhatoda vasica

The major data on traditional uses as well as ethnopharmacological and toxicological studies were reviewed by Claeson et al [6]. After that some more pharmacological studies have also been carried out in this plant. The leaf showed significant hepatoprotective effect on liver damage induced by D-galactosamine in rats [35]. The plant showed significant antitussive activity in guinea-pig and it may be due to the presence of the specific site of action of vasicinone and vasicinol (major alkaloids) which suppress coughing by its action on the cough center or its neuronal system in the medulla [36]. The radiomodulatory influence of ethanolic extract of leaf against radiation-induced hematological alterations in peripheral blood of Swiss albino mice was studied by Kumar et al [34] and they showed significant increase in the serum alkaline phosphatase activity and decrease in acid phosphatase activity.

Anti-tubercular activity of the extract of the plant was studied by Barry et al [32] and Gupta and Chopra [33]. Vasicine isolated from this plant showed significant role in the tuberculosis therapy [37]. Bromhexine and ambroxol are semi-synthetic derivatives of vasicine. The anti-inflammatory activity of the methanol extract of the non-alkaloid fraction, the saponins and the alkaloids was evaluated by the modified hen's egg chorioallantoic membrane test and the results showed, potent activity at a dose of 50 microg/pellet equivalent to that of hydrocortisone while the MeOH extract and the other fractions showed less activity [38] and unknown alkaloids isolated from the plant showed pronounced protection against allergen-induced bronchial obstruction in guinea pigs [39].

A structural analogue of vasicinone possessed potent antiallergic activity in mice, rats and guinea pigs [40]. Unknown alkaloids from this plant showed pronounced protection against allergen-induced bronchial obstruction in guinea pigs. Chronic toxicity study was carried out in vasicine isolated from this plant in rats and monkeys [41]. Methanolic extract of the plant showed 60-70% anti-implantation activity in female albino rats [42]. Extract of the plant showed minimum inhibition in the growth of fungi, *Microsporum gypseum*, *Chrysosporium tropicum* and *Trichophyton terrestre* [43].

Leaf of this plant showed 100% abortifacient activity in rats [44]. KanJang- an oral solution with a fixed combination of standardised extracts of *Echinacea purpurea*, *Adhatoda vasica* and *Eleutherococcus senticosus* has been used in the relief of symptoms associated with the common cold (coughing and irritability of the throat) with a well-established medical use comprising over 50 million human daily doses [45]. The major efficacy of this solution is mainly due to the presence of *A. vasica*. Other constituents of KanJang have been showed to have anti-stress effects, which might be occasioned partly by an endocrine and partly by an immunomodulatory mechanism of action.

CENTELLA ASIATICA L. (Indian Penny Wort, Apiaceae)

A perennial creeping herb found throughout India on moist soil, especially along bunds and canals. The plant is bitter, acrid, sweet, cooling, soporific, cardio tonic, nervic tonic, stomachic, carminative, antileprotic, diuretic and febrifuge. It is native to countries like Sri Lanka, Madagascar, South Africa and Malaysia. It has been used as a traditional herbal medicine in Asiatic countries for hundreds of years as a tonic in skin diseases and leprosy. It is used in the Ayurvedic system of

medicine to treat various diseases and it considered to be one of rejuvenator drugs and it is said to improve the texture of skin, enhance memory and prolong life. The whole plant has been showed to be beneficial in improving memory and is reported to improve the general mental ability of mentally retarded [46].

In India, it is called "Mandukaparani" and used in folk medicine for leprosy, lumps, syphilis, and tuberculosis and to improve mental function. Reports from different places have revealed that, this plant has been used for wound healing, memory improvement, treating mental fatigue, bronchitis, asthma, dysentery, leucorrhoea, kidney trouble, urethritis, antiallergic and anticancer purposes, curing leucorrhea and toxic fever [7, 8]. In homoeopathy, the plant is used in ulceration of womb, eczema, elephantiasis, ascariasis and in granular cerviitis [28]. Active constituents of the plant are used as components of many drugs and cosmetic preparations worldwide in the field of skin care. In addition, Madecassol and Blastoestimulina are the most known pharmaceutical products that contain constituents of this plant as active ingredients [47].

Pharmacological activities of Centella asiatica

Methanol extracts of Whole plant parts of this plant was studied for immunomodulatory activity and the results showed that significant increases in the phagocytic index and total WBC count were observed and the F ratio of the phagocytic index was also significant and the study indicated that the plant has promising immunomodulatory activity [48]. Cognitive-enhancing effect has been observed in rats following oral administration of an aqueous extract of *C. asiatica* and this effect was associated with an antioxidant mechanism in the central nervous system [49].

The plant has also been used to treat rheumatic disorders, which suggested that it may have anti-inflammatory effects [50]. Treatments with the extracts of *C. asiatica* during the early postnatal developmental stages in mice, when the higher brain centers are maturing, can produce long lasting beneficial effects on the mouse brain. Beneficial effects on cognitive functions are probably mediated through their effect on cholinergic system and by influencing the neuronal morphology [51].

Wijeeweera et al [52] reported that, several animal models of anxiety, provides strong support to the ayurvedic claim that the plant has anxiolytic activity and they suggest that this anxiolytic activity may be attributable in part to triterpene rich fractions within the plant extracts. Asiaticoside is clearly one of the active triterpenes, and is found in the plant in the largest amount, but there may be other active principles and some synergy between them and the whole plant activity may be important.

Jayashree et al [53] studied that the activities of anti-oxidant enzymes and anti-oxidant levels were found to be increased significantly in both the liver and kidney after oral treatment with crude methanolic extract of *C. asiatica* on lymphoma-bearing mice and it indicated that it exhibited an anti-oxidant property in cell line induced lymphoma-bearing mice. Effects of the water extract on the formation of azoxymethane (AOM)-induced aberrant crypt foci (ACF) and intestinal tumorigenesis in male F344 rats were investigated by Bunpo et al [54] and they showed the extract has a chemopreventive effect on colon tumorigenesis. Abdul Hamid et al [55] studied the antioxidative activity of various extracts from different parts of the plant including leaves, petioles and roots, using three types of solvents (ethanol, water and light petroleum) using a linoleic acid model system and the thiobarbituric acid test and the study showed that ethanol is the best solvent for extracting antioxidative compounds from different parts (roots, petioles and leaves) of the plant.

Roots exhibited higher antioxidative activity than either leaves or petioles with all types of solvent used. Adriamycin, also known as doxorubicin, a potent antitumor antibiotic used for the treatment of a variety of soft and solid human malignancies. *C. asiatica* could enhance myocardial antioxidants and significantly prevent the heart from adriamycin induced oxidative stress and it could offer a useful support to the adriamycin therapy by acting as a cardio protective agent and thus prevented the extent of cardiac damage [56].

The total phenolic compounds found in the leaf, root and petioles of *C. asiatica* are the major contributions to the antioxidant activities [57]. The whole plant extracts of *C. asiatica* was found to reduce gastric lesions induced by ethanol in both the ex-vivo and in-vivo models. The accelerated recovery of potential difference after ethanol incubation in extract treated gastric mucosa with a concomitant reduction in ulcer lesion areas suggested that *C. asiatica* extract protects the gastric mucosa by improving the integrity of the mucosal lining and it may due to its strengthening action on gastric mucosal lining and the suppression of damaging effects of free radicals [58]. Cheng et al [59] studied the healing effects of water extract of the plant and the active constituent of *C. asiatica*, asiaticoside on acetic acid induced gastric ulcers (kissing ulcers) in rats and they suggested that the potential use of *C. asiatica* and its active ingredient are used as anti-gastric ulcers drugs.

Shukla et al [60] also revealed that asiaticoside exhibits significant wound healing activity in normal as well as delayed healing models. In their experiment they studied in streptozotocin diabetic rats, where healing is delayed, topical application of 0.4% solution of asiaticoside over punch wounds increased hydroxyproline content, tensile strength, collagen content and epithelisation thereby facilitating the healing. Wang et al [61] isolated pectin from *C. asiatica* by anion-exchange and gel-filtration chromatography with TLC and GLC analysis. They showed that with deacetylation and carboxyl-reduction, the pectin and its degraded product showed immunostimulating activity to different extent in vitro and it indicated that the carboxyl and acetyl groups play important roles in the expression of immunological activity.

CORIANDRUM SATIVUM L. (CORIANDER, APIACEAE)

A glabrous, aromatic annula herb cultivated throughout India. The leaves are acrid, astringent, aromatic, analgesis, anti-inflammatory and styptic; fruits are aromatic, bitter, sweet, acrid, astingent, emollinet, thermogenic, anti-inflammatory, anthelmintic, stomachic, carminative, digestive, appetiser, constipating, diuretic, antipyretic,stimylant, expectorant and anodyne (Nadkarni; Warrier et al). Coriander is widely distributed and mainly cultivated for the seeds. The seeds contain an essential oil (up to 1%) and the monoterpenoid, linalool, is the main component [62]. Coriander seed is a popular spice and finely ground seed is a major ingredient of curry powder. The seeds are mainly responsible for the medical use of coriander and have been used as a drug for indigestion, against worms, rheumatism and pain in the joints [62]. In folk medicine, the seeds of coriander are used as an aromatic, carminative, stomachic, antispasmodic and against gastrointestinal complaints such as dyspepsia, flatulence and gastralgia. The seeds are also used as an ingredient in the laxative preparations to prevent stomach griping [7, 8]. In Morocco, coriander has been documented as a traditional treatment of diabetes, indigestion, flatulence, insomnia, renal disorders and loss of appetite, and as a diuretic and all parts of the plant are edible, but the fresh leaves and the dried seeds are the most common parts used in cooking [63]

Pharmacological activities of Coriandrum sativum

The seeds of coriander showed significant hypoglycemic activity by enhanced glycogenesis, glycolysis and decreased glycogenolysis and gluconeogenesis and may be due to increased utilization of glucose in liver glycogen synthesis and decreased degradation of glycogen to give blood sugar [64]). The biochemical effect of coriander seeds on lipid parameters in 1,2-dimethyl hydrazine (DMH) induced colon cancer in rats were studied by Chitra and Leelamma [65] and they showed that the concentrations of cholesterol and cholesterol to phospholipids ratio decreased while the level of phospholipid increased significantly in the DMH control group compared to the spice administered group. It proves that coriander plays a protective role against the deleterious effects in lipid metabolism in experimental colon cancer. The aqueous extract of seeds has anxiolytic effect and may have potential sedative and muscle relaxant effects [66].

Wangensteen et al [67] evaluated the extracts of different polarity from leaves and seeds of coriander and coriander oil for their antioxidant activity and they found between the total phenolic content in the extracts and antioxidant activity. They also observed that the coriander leaves showed stronger antioxidant activity than the seeds, and in both parts of coriander, the ethyl acetate extract contributed to the strongest activity and coriander have a potential natural antioxidant and thus inhibit unwanted oxidation processes. In the carotenoids fractions obtained from coriander etheric extract, b-carotene has been identified as the principal antioxidant component and the greater antioxidant effect of the whole coriander etheric extract in comparison to the component fractions suggests a possible synergistic effect [68]. They suggest that the coriander etheric extract could be considered as a promising source of bioactive substances. Melo et al [69] studied that the leaves and stem of coriander extracts contain phenolic acids and they are principle components responsible for the antioxidant activity.

Cortés-Eslava et al [70] investigated the antimutagenic activity of coriander juice against the mutagenic activity of 4-nitro-*o*-phenylenediamine, *m*-phenylenediamine and 2-aminofluorene using the Ames reversion mutagenicity assay with the *S. typhimurium* TA98 strain as indicator organism. In this study the plant cell/microbe coincubation assay was used as the activating system for aromatic transformation and plant extract interaction. They showed the aqueous crude coriander juice significantly decreased the mutagenicity of metabolized aromatic amines and the chlorophyll content in vegetable juice was monitored and its concentration showed a positive correlation with the detected antimutagenic effect.

The aqueous extract of the seeds of coriander has a significant decrease in serum progesterone levels and anti-implantation effect on rats [71]. Seeds of coriander confers a dose-dependent protection against gross damaging action of ethanol and other necrotizing agents on gastric mucosa of rats and the histopathological assessment also revealed that pretreatment with coriander prevented congestion, hemorrhage, edema, necrosis, inflammatory and dysplastic changes, erosions and ulcerations caused by the destructive stimuli in the gastric tissue in a dose-dependent manner [72]. The crude aqueous extract of seeds increased diuresis, excretion of electrolytes and glomerular filtration rate in a dose-dependent way and furosemide was more potent as a diuretic and saluretic [63].

Essential oils prepared from the seeds and immature leaves of coriander inhibit the growth of *Pseudomonas fragi*, *Escherichia coli*, *Salmonella typhimurium*, *Listeria monocytogenes*, *Staphylococcus aureus* and *Saccharomyces cerevisiae* in individual and mixed fractions such as essential oils of *Anethum graveolens* and *Eucalyptus dives* [73]. Eguale et al. [74] studied the *in vitro* anthelmintic activities of crude aqueous and hydroalcoholic extracts of the seeds of *coriander* on the egg and adult nematode parasite *Haemonchus contortus*. They showed better in vitro activity against adult parasites than the aqueous one and reduction in male worms was higher than female worms.

DISCUSSION AND CONCLUSION

Plants have formed the basis of sophisticated traditional medicine systems that have been in existence for thousands of years and continue to provide mankind with new remedies. From ancient literature to modern scientific records of traditional medicinal knowledge, there is evidence that plants supply the main medicinal source for peoples' healthcare in developing Asian

countries [75]. According to the WHO, 80% of the world's population primarily those of developing countries rely on plant-derived medicines for their healthcare needs [76].

Research on medicinal plants and the search for plant-derived drugs require a multidisciplinary approach with integrated projects, financial and technical support, and a very carefully planned strategy. The aims should consider demands in terms of public health, preservation of biodiversity and the technical qualification of each laboratory or research group involved [2]. Renewed interest in traditional pharmacopoeias has meant that researchers are concerned not only with determining the scientific rationale for the plant's usage, but also with the discovery of novel compounds of pharmaceutical value [77]. Drug discovery from medicinal plants continues to provide new and important leads against various pharmacological targets including cancer, HIV/AIDS, Alzheimer's, malaria, and pain. Several natural product drugs of plant origin have either recently been introduced to the United States market, including arteether, galantamine, nitisinone, and tiotropium, or are currently involved in late-phase clinical trials [78].

Thus, the review ascertains the value of a great number of plants used in tribal medicine, which could be of considerable interest in the development of new drugs. The curative properties of drugs are due to the presence of complex chemical substances of varied composition (present as secondary plant metabolites) in one or more parts of these plants. This type of research must be promoted as a means for developing countries to understand the potential use of their plant resources, as well as a means to better promote basic healthcare.

This review showed that, the different parts of *Acalypha indica*, *Achyranthes aspera*, *Adhatoda vasica*, *Coriandrum saticum* and *Centella asiatica* exhibited various pharmacological activities on the basis of their use in traditional medicine. The potent chemical compounds found in the above plants are exciting advance in the search for the novel drugs. These plants are also proven to be very valuable to the discovery and utilization of medicinal natural products. The potential for the development of leads from the above plants for example, wound healing activity (*Acalypha indica*), antimycobacterial activity (*Adhatoda vasica*), antidiabetic activity (*Coriandrum saticum* and *Centella asiatica*). It is also clear that much needs to be discovered, both as to the active ingredients and their biological effects. The information summarized here is intended to serve as a reference tool to researchers in the fields of ethnopharmacology.

REFERENCES

1. Ernst E. The efficacy of herbal medicine – an overview. *Fund Clin Pharmacol* 2005;19:405 – 409.
2. Rates SMK. Plants as source of drugs. *Toxicon* 2001;39:603 – 613.
3. Balasubramanian A, Ramalingam K, Krishnan S, Christina AJM. Anti-inflammatory activity of *Morus indica* Linn. *Iran J Pharmacol Ther* 2005;4:13-15.
4. WHO. Monographs on selected medicinal plants, Vol. I, World Health Organization, Geneva, 1996
5. Mahishi P, Srinivasa BH, Shivanna MB. Medicinal plant wealth of local communities in some villages in Shimoga District of Karnataka, India. *J Ethnopharmacol* 2005;98:307 - 312.
6. Claeson UP, Malmfors T, Wikman G, Bruhn JG. *Adhatoda vasica*: a critical review of ethnopharmacological and toxicological data. *J Ethnopharmacol* 2000;72:1–20.
7. Jain SK. Dictionary of Indian folk Medicine and Ethnobotany, New Delhi, Deep Publications. 1991.
8. Nadakarni AK. Indian Materia Medica, vol. I. Popular Prakashan, Bombay. 1976.
9. Chakraborty A, Brantner A, Mukainaka T, Nobukuni Y, Kuchide M, Konoshima T, Tokuda H, Nishino H. Cancer chemopreventive activity of *Achyranthes aspera* leaves on Epstein–Barr virus activation and two-stage mouse skin carcinogenesis. *Cancer Lett* 2002;177:1–5.
10. Singh V. Traditional remedies to treat asthma in the North West and Trans-Himalayan region in J. & K. state, *Fitoterapia* 1995;66:507–509.
11. Girach RD, Khan ASA. Ethnomedicinal uses of *Achyranthes aspera* leaves in Orissa (India). *Int J Pharmacog* 1992;30:113 – 115.
12. Kirtikar KR, Basu BD. Indian Medicinal Plants. International Book Distributors, Dehradun, India. 1935.
13. Chopra RN, Nayar SL, Chopra IC. Glossary of Indian medicinal plants. Publication and Information Directorate, Council of Scientific and Industrial Research, New Delhi, India, 1956.
14. Rastogi RP, Mehrotra BN. Compendium of Indian Medicinal Plants, Vol. I–V. Central Drug Research Institute, Lucknow and National Institute of Science Communication, New Delhi, India, 1990-1994.
15. Gokhale AB, Damre AS, Kulkarni KR, Saraf MN. Preliminary evaluation of anti-inflammatory and anti-arthritic activity of *S. lappa, A. speciosa* and *A. aspera*. *Phytomedicine* 2002;9:433–437.
16. Vetrichelvan T, Jegadeesan M. Effect of alcohol extract of *Achyranthes aspera* Linn. on acute and subacute inflammation. *Phytother Res* 2003;17:77 – 79.
17. Akhtar MS, Iqbal J. Evaluation of the hypoglycaemic effect of *Achyranthes aspera* in normal and alloxan0diabetic rabbits. *J Ethnopharmacol* 1991;31:49 – 57
18. Paul D, Bera S, Jana D, Maiti R, Ghosh D. In vitro determination of the contraceptive spermicidal activity of a composite extract of Achyranthes aspera and Stephania hernandifolia on human semen. *Contraception* 2006;73:284– 288.
19. Han ST, Un CC. Cardiac toxicity caused by *Achyranthes aspera*. Vet Hum Toxicol 2003;45:212 – 213.
20. Gupta SS, Bhagwat AW, Ram AK. Cardiac stimulant activity of the saponin of *Achyranthes aspera* (Linn). *Indian J Medical Res* 1972;60: 462 – 471.
21. Pakrashi A, Bhattacharya N. Abortifacient principle of *Achyranthes aspera* L. *Indian J Exp Biol* 1977;15:856 – 858.
22. Tahiliani P, Kar A. *Achyranthes aspera* elevates thyroid hormone levels and decreases hepatic lipid peroxidation in male rats. *J Ethnopharmacol* 2000;71:527–532.
23. Vasudeva RY, Govinda RD, Babu S, Rao RA. Immunomodulatory activity of *Achyranthes aspera* on the elicitation of antigen-specific murine antibody response. *Pharm Biol* 2002;40:175 - 178.
24. Shibesh W, Makonnen E, Zerihun L, Debella A. Effect of *Achyranthes aspera* L. on fetal abortion, uterine and pituitary weights, serum lipids and hormones. *Afr J Health Sci* 2002;6:108 – 112.
25. Vasudeva N, Sharma SK. Post-coital antifertility activity of *Achyranthes aspera* Linn. root. *J Ethnopharmacol* 2006;107:179 – 181.

26. Sandhyakumari,K, Baby RG, Indira M. Impact of feeding ethanolic extracts of *Achyranthes aspera* Linn. on reproductive functions in male rats. *Indian J Exp Biol* 2002;40:1307 – 1309.

27. Shanmugasundaram KR, Seethapathy PG, Shanmugasundaram ER. Anna Pavala Sindhooram – an antiatherosclerotic Indian drug. *J Ethnopharmacol* 1983;7:247 – 265.

28. Asolkar LV, Kakkar KK, Chakra OJ. Second supplement to Glossary of Indian Medicinal Plants with active principles, Part I. Publication and Information Directorate (CSIR), Dr. K.S. Krishnan MArg. New Delhi, India, 1992.

29. Shirwaikar A, Rajendran K, Bodla R, Dinesh kumar C. Neutralization potential of *Viper russelli russelli* (Russell's viper) venom by ethanol leaf extract of *Acalypha indica*. *J Ethnopharmacol* 2004;94:267–273.

30. Suresh Reddy J, Rajeswara Rao P, Reddy MS. Wound healing effects of *Heliotropium indicum*, *Plumbagozeylanicum* and *Acalypha indica* in rats. *J Ethnopharmacol* 2002;79:249–251.

31. Perumal Samy R, Ignacimuthu S, Patric Raja D. Preliminary screening of ethnomedicinal plants from India. *J Ethnopharmacol* 1999;66:235–240.

32. Barry VC, Conalty ML, Rylance HJR. Antitubercular effect of an extract of *Adhatoda vasica*. *Nature* 1955;176:119 – 120.

33. Gupta, KC, Chopra IC. Anti-tubercular action of *Adhatoda vasica* (N.O. Acanthaceae). *Indian J Exp Biol* 1954;42:355 – 358.

34. Kumar A, Ram J, Samarth RM, Kumar M. Modulatory influence of *Adhatoda vasica* Nees leaf extract against gamma irradiation in Swiss albino mice. *Phytomedicine* 2005;12:285–293.

35. Bhattacharyya D, Pandit S, Jana U. Hepatoprotective activity of *Adhatoda vasica* aqueous leaf extract on d-galactosamine-induced liver damage in rats. *Fitoterapia* 2005;76:223– 225.

36. Dhuley JN. Antitussive effect of *Adhatoda vasica* extract on mechanical or chemical stimulation-induced coughing in animals. *J Ethnopharmacol* 1999;67:361–365.

37. Grange JM, Snell NJC. Activity of bromhexine and ambroxol, semi-synthetic derivatives of vasicine from the Indian shrub *Adhatoda vasica*, against *Mycobacterium tuberculosis* in vitro. *J Ethnopharmacol* 1996;50: 49-53.

38. Chakraborty A, Brantner AH. Study of alkaloids from *Adhatoda vasica* Nees on their antiinflammatory activity. *Phytother Res* 2001;15:532 – 534.

39. Dorsch W, Wagner H. New antiasthmatic drugs from traditional medicine? *Int J Allergy Appl Immunol* 1991;94:262 – 265.

40. Paliwa JK, Dwivedi AK, Singh S, Gupta RC. Pharmacokinetics and in-situ absorption studies of a new anti-allergic compound 73/602 in rats. *Int J Pharm* 2000;197:213-220.

41. Pahwa GS, Zutshi U, Atal CK. Chronic toxicity studies with vasicine from *Adhatoda vasica* Nees. in rats and monkeys. *Indian J Exp Biol* 1987;25:467 – 470.

42. Prakash AO, Saxena V, Shukla S, Tewari RK, Mathur S, Gupta A, Sharma S, Mathur R. Anti-implantation activity of some indigenous plants in rats. *Acta Eur Fertil* 1985;16:441 – 448.

43. Quershi S, Rai MK, Agrawal SC. In vitro evaluation of inhibitory nature of extracts of 18-plant species of Chhindwara against 3-keratinophilic fungi. *Hindus Antibiot Bull* 1997;39:56 – 60.

44. Nath D, Sethi N, Singh RK, Jain AK. Commonly used Indian abortifacient plants with special reference to their teratologic effects in rats. *J Ethnopharmacol* 1992;36:147- 154.

45. Narimanian M, Badalyan B, Panosyan V, Gabrielyan E, Panossian A, Wikman G, Wagner H. Randomized trial of a fixed combination (KanJangs) of herbal extracts containing *Adhatoda vasica*, *Echinacea purpurea* & *Eleutherococcus senticosus* in patients with upper respiratory tract infections. *Phytomedicine* 2005;12:539–547.

46. Rao ASK, Rao K. Effect of Mandookaparni (Centella asiatica) on the general mental ability (Medhya) of mentally retarded children. Indian J Med Res 1973;8: 9– 16.

47. Randriamampionona D, Diallo B, Rakotoniriana F, Rabemantsoa C, Cheuk K, Corbisier A, Mahillon J, Ratsimamanga S, El-Jaziri M. Comparative analysis of active constituents in Centella asiatica samples from Madagascar: Application for *ex situ* conservation and clonal propagation. *Fitoterapia* 2007:78;482–489.

48. Jayathirtha M, Mishra SH. Preliminary immunomodulatory activities of methanol extracts of *Eclipta alba* and *Centella asiatica. Phytomedicine* 2004;11:361–365.

49. Kumar MHV, Gupta YK. Effect of different extracts of *Centella asiatica* on cognition and markers of oxidative stress in rats. *J Ethnopharmacol* 2002;79:253 – 260.

50. Howes MR, Houghton PJ. Plants used in Chinese and Indian traditional medicine for improvement of memory and cognitive function. *Pharmacol Biochem Behav* 2003;75:513–527.

51. Rao SB, Chetana M, Umadevi P. *Centella asia*tica treatment during postnatal period enhances learning and memory in mice. *Physiol Behav* 2005;86:449 – 457.

52. Wijeweera P, Arnason JT, Koszycki D, Merali Z. Evaluation of anxiolytic properties of Gotukola – (*Centella asiatica*) extracts and asiaticoside in rat behavioral models. *Phytomedicine* 2006;13:668–676.

53. Jayashree G, Muraleedhara GK, Sudarsla S, Jacob VB. Antioxidant activity of *Centella asiatica* on lymphoma-bearing mice. *Fitoterapia* 2003;74:431– 434.

54. Bunpo P, Kataoka K, Arimochi H, Nakayama H, Kuwahar T, BandoY, Izumic K, Vinitketkumnuen U, Ohnishi Y. Inhibitory effects of *Centella asiatica* on azoxymethane-induced aberrant crypt focus formation and carcinogenesis in the intestines of F344 rats. *Food Chem Toxicol* 2004; 42:1987–1997.

55. Abdul Hamid A, Shah Z, Muse R, Mohamed S. Characterisation of antioxidative activities of various extracts of *Centella asiatica* (L) Urban. *Food Chem* 2002;77:465–469.

56. Gnanapragasam A, Kumar Ebenezer K, Sathish V, Govindaraju P, Devaki T. Protective effect of *Centella asiatica* on antioxidant tissue defense system against adriamycin induced cardiomyopathy in rats. *Life Sci* 2004;76:585–597.

57. Zainol MK, Abd-Hamid A, Yusuf S, Muse R. Antioxidative activity and total phenolic compounds of leaf, root and petiole of four accessions of *Centella asiatica* (L.) Urban. *Food Chem* 2003;81:575–581.

58. Cheng CL, Koo MWL. Effects of *Centella asiatica* on ethanol induced gastric mucosal lesions in rats. *Life Sci* 2000;67: 2647–2653.

59. Cheng CL, Guo JS, Luk J, Koo MWL. The healing effects of *Centella* extract and asiaticoside on acetic acid induced gastric ulcers in rats. *Life Sci* 2004;74:2237–2249.

60. Shukla A, Rasik AM, Jain GK, Shankar R, Kulshrestha DK, Dhawan BN. In vitro and in vivo wound healing activity of asiaticoside isolated from *Centella asiatica*. *J Ethnopharmacol* 1999;65:1–11.

61. Wang XS, Liu L, Fang JN. Immunological activities and structure of pectin from *Centella asiatica*. *Carbohydr Polym* 2005;60:95–101.

62. Wichtl MW. Herbal drugs and phytopharmaceuticals. Stuttgart: Medpharm GmbH Scientific Publishers. 1994.

63. Aissaoui A, El-Hilaly J, Israili ZH, Lyoussi B. Acute diuretic effect of continuous intravenous infusion of an aqueous extract of *Coriandrum sativum* L. in anesthetized rats. *J Ethnopharmacol* 2008;115:89–95.

64. Chitra S, Leelamma S. *Coriandrum sativum* - mechanism of hypoglycemic action. *Food Chem* 1999;67:229–231.

65. Chitra S, Leelamma S. *Coriandrum sati*6*um* - effect on lipid metabolism in 1,2-dimethyl hydrazine induced colon cancer. *J Ethnopharmacol* 2000;71:457–463.

66. Emamghoreishi M, Khasaki M, Aazam MF. *Coriandrum sativum*: evaluation of its anxiolytic effect in the elevated plus-maze. *J Ethnopharmacol* 2005;96:365 – 370.

67. Wangensteen H, Samuelsen AB, Malterud KE. Antioxidant activity in extracts from coriander. *Food Chem* 2004;88:293–297.

68. Guerra NB, Melo EA, Filho JM. Antioxidant compounds from coriander (Coriandrum sativum L.) etheric extract. *J Food Compost Anal* 2005;18: 193–199.

69. Melo EA, Filho JM, Guerra NB. Characterization of antioxidant compounds in aqueous coriander extract (*Coriandrum sativum* L.). Lebensm.-Wiss. u.-Technol. 2005;38:15–19.

70. Cortés-Eslava J, Gómez-Arroyo S, Villalobos-Pietrini R, Espinosa-Aguirre JJ. Antimutagenicity of coriander (*Coriandrum sativum*) juice on the mutagenesis produced by plant metabolites of aromatic amines. *Toxicol Lett* 2004;153:283–292.

71. Al-Said MS, Al-Khamis KI, Islam MW, Parmar NS, Tariq M, Ageel AM. Post-Coital antifertility activity of the seeds of *Coriandrum sativum* in rats. *J Ethnopharmacol* 1987;21:165 – 173.

72. Al-Mofleh IA, Alhaider AA, Mossa JS, Al-Sohaibani MO, Rafatullah S, Oureshi S. Protection of gastric mucosal damage by *Coriandrum sativum* L. pretreatment in Wistar albino rats. *Environ Toxicol Pharmacol* 2006;22:64–69.

73. Delaquis PJ, Stanich K, Girard B, Mazza G. Antimicrobial activity of individual and mixed fractions of dill, cilantro, coriander and eucalyptus essential oils. *Int J Food Microbiol* 2002;74:101–109.

74. Eguale T, Tilahun G, Debella A, Feleke A, Makonnen E. In vitro and in vivo anthelmintic activity of crude extracts of *Coriandrum sativum* against *Haemonchus contortus. J Ethnopharmacol* 2007:110;428–433.

75. Pei SJ. Ethnobotanical approach of traditional medicine studies: Some experiences from Asia. *Pharm Biol* 2001;39:74 – 79.

76. Gurib-Fakim A. Review – Medicinal plants: Traditions of Yesterday and drugs of tomorrow. *Mol Aspects Med* 2006;27:1- 93.

77. Fennell CW, Lindsey KL, McGaw LJ, Sparg SG, Stafford GI, Elgorashi EE, Grace OM, van Staden J. Assessing African medicinal plants for efficacy and safety: pharmacological screening and toxicology. *J Ethnopharmacol* 2004;94:205-217.

78. Balunas MJ, Kinghorn AD. Drug discovery from medicinal plants. *Life Sci* 2005;78:431–441.

Current Author Addresses

Muniappan Ayyanar, Division of Biodiversity and Biotechnology, Entomology Research Institute, Loyola College, Nungambakkam, Chennai.

Savarimuthu Ignacimuthu, Entomology Research Institute, Loyola College, Chennai. E-mial: entolc@hotmail.com (Corresponding author)