Review 述评与综述

An update on *Murraya koenigii* Spreng: a multifunctional Ayurvedic herb

Priyanka Gupta, Alok Nahata, Vinod K. Dixit
Department of Pharmaceutical Sciences, Dr. Hari Singh Gour University, Sagar 470003, India

Abstract: *Murraya koenigii* Spreng (Rutaceae), a medicinally important herb of Indian origin, has been used for centuries in the Ayurvedic system of medicine. Leaves, fruits, roots and bark of this plant are a rich source of carbazole alkaloids. These alkaloids have been reported for their various pharmacological activities such as antitumor, antiviral, anti-inflammatory, antidiarrhoeal, diuretic and antioxidant activities. Apart from these activities, the plant is reported to possess a wide spectrum of biological activities. Phytochemistry and pharmacology of this plant make a demand of an exhaustive review of its potential as a valuable therapeutic agent for the treatment and management of various ailments frequently affecting humans. The present review gives a detailed description of the phytochemical, pharmacological, clinical and pre-clinical works carried out on this medicinal herb and also throws light on its therapeutic potential.

Keywords: Rutaceae; *Murraya*; medicine, Ayurvedic; plant extracts; review

Ayurveda is a traditional Indian medicinal system practiced for thousands of years. Herbal medicines are being used by nearly 80% of the world population, primarily in developing countries for primary healthcare[1]. Medicinal plants or the isolated bioactive constituents form one of the major sources of raw materials for drugs in preventive and curative applications[2]. Public, academic and government interest in traditional medicines is growing exponentially due to the increased incidence of the adverse drug reactions and economic burden of the modern system of medicine[3]. Crude drugs in many cases are found to be more potent than the pure drugs, the reason may be due to the synergistic action of the other components present which not only enhance the biological activity of the drug but simultaneously lower the toxic effect.

Selection of scientific and systematic approach for the biological evaluation of herbal formula-

Open Access 开放获取

DOI: 10.3736/jcim20110803
http://www.jcimjournal.com

Gupta P, Nahata A, Dixit VK. An update on *Murraya koenigii* Spreng: a multifunctional Ayurvedic herb. *J Chin Integr Med*. 2011; 9(8): 824-833.
Gupta P, Nahata A, Dixit VK. 印度传统药用植物可因氏越橘的研究综述. 中西医结合学报. 2011; 9(8): 824-833.

Received March 5, 2011; accepted May 5, 2011; published online August 15, 2011.
Full-text LinkOut at PubMed. Journal title in PubMed: *Zhong Xi Yi Jie He Xue Bao*.

基金项目: Research fellowships were provided by the University Grants Commission of India and All India Council for Technical Education, New Delhi, India.
Correspondence: Vinod K. Dixit, PhD, Professor; Tel: +91-94-25647546; E-mail: dixitvk2011@rediffmail.com, aloknahata@gmail.com

ISSN 1672-1977. Published by JCIM Press, Shanghai, China.

tions based on their use in the traditional systems of medicine forms the basis for an ideal approach in the development of new drugs from plants. One such plant is *Murraya koenigii* Spreng (Family Rutaceae). It is commonly known as curry-leaf tree and is a native of India, Srilanka and other South Asian countries. Leaves of *M. koenigii* are rich in minerals, vitamin A and vitamin B, and are a rich source of carbohydrates, proteins, amino acids and alkaloids[4, 5].

Of the 14 global species belonging to the genus *Murraya*, only two are available in India, namely, *M. koenigii* (L.) Spreng. and *M. paniculata* (L.) Jack (*M. exotica* (L.))[6]. Of the two, the former is more popular due to its large spectrum of medicinal properties and also because of the use of its leaves for centuries as a natural flavoring agent in various curries and food items[7].

The plant has been used in traditional Indian systems of medicine for a variety of ailments[8-10]. The leaves, bark and root of the plant are used in indigenous medicine as a tonic, stomachic, stimulant and carminative. An infusion of the roasted leaves is used to stop vomiting. The green tender leaves are eaten raw for the cure of dysentery. A decoction of the leaves is sometimes given with bitters as a febrifuge and the leaves have been claimed to be used with mint in the form of chutney to check vomiting. It has also been used as an antiperiodic and many a time the powdered dry leaf, mixed with honey and juice of betel nut, is recommended in the Ayurvedic system of medicine[4].

1 Habit and habitat

The plant *M. koenigii* is an aromatic and more or less deciduous shrub or a small tree found throughout India up to an altitude of 1 500 m commonly in forests often as gregarious undergrowths. The species is native to India. It commonly occurs in the foothills of Himalaya, Assam, Sikkim, Kerala, Tamil Nadu, Andhra Pradesh and Maharashtra[11]. It is also found in evergreen and deciduous forests of peninsular India, often as underwood[12].

2 Morphological characteristics

2.1 Stem An aromatic and more or less deciduous shrub or a small tree up to 6 m in height and 15 to 40 cm in diameter[13]. The main stem is dark green to brownish with numerous dots on it. Its bark can be peeled off longitudinally, exposing the white wood underneath.

2.2 Leaves Leaves have a green color and characteristic odour and taste. Exstipulate, bipinnately compound, 30 cm long, each bearing 24 leaflets having reticulate venation; leaflets lanceolate, 4.9 cm long, 1.8 cm broad, having 0.5 cm long petiole[14].

2.3 Flowers Round to oblong, 1.4 to 1.6 cm long, 1 to 1.2 cm in diameter; weight 880 mg; volume 895 μL; fully ripe fruits, black with a very shining surface; pulp, wistaria blue; the number of fruits per cluster varying from 32 to 80.

2.4 Seed One in each fruit, 11 mm long, 8 mm in diameter, with spinach green color.

3 Phytochemical profile

Several compounds have been isolated from different morphological parts of the plant. The alkaloids[15] and essential oils[16] are the most studied phytoconstituents of the plant. Apart from them, terpenoids, phenolics, minerals, protein, fat, carbohydrate, fibre, carotene, nicotinic acid, vitamin C etc. are also present in *M. koenigii* leaves.

4 Traditional uses

The leaves are fragrant, strongly aromatic, spicy, bitter, acrid, cooling and weakly acidic in taste. The essential oils impart intense characteristic flavor to the plant parts. Fresh leaves, dried leaf powder and essential oils are extensively used for flavoring soups, curries, chutneys, sausages, fish and meat dishes, pickles, butter milk preparations, egg preparations, curry powder blends, seasonings, ready-to-eat and many modern and other food preparations[17]. The essential oil is used in soap industry, cosmetics industry and aromatherapy.

The whole plant is considered to be a tonic and stomachic. Roots and bark are stimulant and are applied externally for skin eruptions and poisonous bites. It is used as a carminative agent for treating piles, influenza, fever, itching, dropsy, bronchial asthma, eruptions, diarrhoea, body aches, fresh cuts, kidney pains and vomiting[18-30]. Green leaves are febrifuge and used in dysentery.

It is traditionally used as antiemetic, antidiarrhoeal, febrifuge and blood purifier. It has been reported to possess antifungal, antibacterial, anthelmintic, antineoplastic, nitric oxide-scavenging, anti-hypercholesteremic and antioxidant activities. Antimicrobial, antitumor, pancreatic amylase-inhibitory, antioxidative, cytotoxic, depressant, anti-trichomonal, antihypertensive, anti-treponemal, antispasmodic, anti-amoebic, and antidiabetic activities have been reported for the extracts. It is used for the treatment of inflammatory disorders like asthma by interfering in the release and/or action of mediators such as histamine, serotonin, prostaglandins and leukotrienes, etc.

Curry leaves boiled in coconut oil till they are reduced to a blackened residue form an excellent hair tonic in retaining the natural pigmentation and also stimulating hair growth. South Indian women have mixed the leaves with fenugreek for centuries, and applied as a paste to keep hair long, black and gleaming. Pesticidal activities of curry leaves have also been reported.

5 Pharmacological profile

5.1 Antidiarrhoeal activity Two bioactive carbazole alkaloids, namely, kurryam and koenimbine obtained from fractionated n-hexane extract of the seeds of *M. koenigii* exhibited significant inhibitory activity against castor oil-induced diarrhoea and prostaglandin E_2-induced enteropooling in rats. These compounds also produced a significant reduction in gastrointestinal motility in the charcoal meal test in Wistar rats[27].

5.2 Antibacterial activity Aqueous extract of *M. koenigii* was tested for antibacterial activity by well diffusion method on nutrient agar medium against human pathogenic bacteria. It showed inhibition of bacterial growth. The protein designated as APC (antioxidant protein from curry leaves) effectively inhibited *Escherichia coli*, *Staphylococcus aureus*, *Vibrio cholerae*, *Klebsiella pneumoniae*, *Salmonella typhi* and *Bacillus subtilis*[28].

The alcoholic extract exhibited significant antibacterial activity as compared with petroleum ether extract and standard drug tetracycline[29]. The antibacterial studies conducted by using methanolic extract confirmed its effectiveness against *S. typhi* and *E. coli* at 100 μg/mL and 200 μg/mL, respectively[30].

5.3 Hepatoprotective effect The tannins and the carbazole alkaloids from the aqueous extract exhibited hepatoprotective activity with respect to the different parameters studied and maintained normal morphology even after ethanolic challenge to the cells which was comparable to the protection offered by the standard drug L-ornithine-L-aspartate[31].

The acetone extract of dried bark powder showed prominent protection of liver cells as compared with the control group and other solvents in CCl_4-induced liver damage[32]. The aqueous extract at doses of 200 and 400 mg/kg produced significant inhibition of gastric lesion induced by non-steroidal anti-inflammatory drugs and pylorus ligation-induced ulcer. The extract reduced ulcerative lesion, gastric volume and free and total acidity but raised the pH value of gastric juice in pylorus ligation model. The results obtained suggested that the extract possesses significant antiulcer activity[33].

5.4 Apoptosis in human leukemia cells *M. koenigii* has been found to induce apoptosis in human myeloid cancer cell (HL-60). Concentration of 10 mmol/L mahanine caused a complete inhibition of cell proliferation and a induction of apoptosis in a time-dependent manner. Mahanine-induced cell death was characterized with the changes in nuclear morphology, DNA fragmentation, activation of caspase-like activities, poly (ADP-ribose) polymerase cleavage, and release of cytochrome *c* into cytosol and stimulation of reactive oxygen species generation. The overall results suggested that mahanine down-regulates cell survival factors by activation of caspase-3 through mitochondrion-dependent pathway, and disrupts cell cycle progression[34].

Another study reported that mahanine, purified from the leaves of *M. koenigii*, has a dose- and time-dependent antiproliferative activity in acute lymphoid (MOLT-3) and chronic myeloid (K562) leukemic cell lines and in the primary cells of leukemic and myeloid patients, with minimal effect on normal immune cells including CD34 (+) cells[35].

5.5 Antitrichomonal activity Carbazole alkaloids and their derivatives from *M. koenigii* leaves showed antitrichomonal activity against *Trichomonas gallinae*. Girinimbine and girinimbilol with IC_{50} values of 1.08 and 1.20 mg/mL were the most active. Acetylation of girinimbilol and mahanimbilol improved their activities to 0.60 and 1.08 mg/mL[36].

5.6 Anti-inflammatory activity Ethanolic extract of *M. koenigii* (EEMK) (300 and 400 mg/kg) showed antihistaminic actions in the histamine-aerosol protocol. The mast cell stabilization and antihistaminic effects of EEMK were suggested to be the probable mechanisms for its anti-inflammatory action[37]. The ethanolic extract (250 mg/kg) showed significant anti-inflammatory effects as compared with petroleum ether and chloroform extracts in acute carrageen-induced paw edema method and yeast-induced hyperpyrexia method,

respectively[38].

The methanol extract of leaves showed significant ($P<0.001$) reduction in carrageenan-induced paw edema in comparison with aqueous extracts. Petroleum ether and hexane extracts showed no reduction in paw edema[39].

9,12-octadecadienoic acid, a compound isolated from the methanolic extracts of leaves was reported to induce 85% reduction in paw edema at a dose of 150 μg/mL in reference to the standard anti-inflammatory drug aspirin which showed 68.62% reduction[40].

The methanol extract showed significant ($P<0.001$) reduction in carrageenan-induced paw edema and analgesic activity evidenced by increase in the reaction time by Eddy's hot plate method and percentage increase in pain in formalin test[41].

5.7 Anthelmintic activity Ethanolic and aqueous extracts from *M. koenigii* leaves were investigated for their anthelmintic activity against *Pheretima posthuma*. Both the extracts exhibited significant anthelmintic activity at concentration of 100 mg/mL[42]. The alcoholic extract produced more significant anthelmintic activity than petroleum ether extract[29].

5.8 Immunomodulatory activity The methanolic extract of *M. koenigii* showed significant increase in phagocytic index by rapid removal of carbon particles from blood stream. The extract also increased the antibody titre against ovalbumin and protection towards cyclophosphamide-induced myelosuppression in albino mice[43].

Oral administration of the aqueous extract of leaves at doses of 250 and 500 mg/kg significantly enhanced the delayed-type hypersensitivity reaction induced by ovalbumin. The extract also potentiated the production of circulating antibody titre significantly in response to ovalbumin[44].

5.9 Antidiabetic activity Aqueous and methanolic extracts of leaves and fruits of *M. koenigii* were evaluated for antidiabetic activity in alloxan-induced diabetic rats. Plasma insulin showed significantly high levels on the 43rd and 58th days of treatment in aqueous and methanol extracts of *M. koenigii*-treated groups[45, 46]. Significantly reduced fasting blood sugar, triglycerides, low-density lipoprotein, very low-density lipoprotein levels and increased high-density lipoprotein level were noted on administration of mahanimbine at doses of 50 and 100 mg/kg intraperitoneally[47]. Fruit juice decreased blood glucose level significantly at the 10th and 15th days of administration in alloxan-induced diabetic mice[48].

Freeze dried leaves of *M. koenigii* lowered blood glucose level in normal and diabetic rats at oral administration of variable doses of 100, 200, 300 and 400 mg/kg. A fall of 41.5% in normal, 34.3% in sub-diabetic and 37.9% in mild-diabetic rats was observed with the dose of 300 mg/kg after 6 h of oral administration[49].

Aqueous extract of leaves led to lowering of blood glucose level in normal as well as in diabetic rabbits. The maximum fall of 14.68% in normal and 27.96% in mild diabetic animals was observed after 4 h of oral administration at a dose of 300 mg/kg[50].

Feeding of diet containing various doses of curry leaves (5%, 10% and 15%) to normal rats for 7 d as well as mild diabetic (blood glucose levels>175 mg/dL induced by alloxan 35 mg/kg intraperitoneally) and moderate diabetic rats (blood glucose levels > 250 mg/dL induced by streptozotocin 60 mg/kg intraperitoneally) for 5 weeks showed varying hypoglycemic and antihyperglycemic effects. In normal rats, feeding of 5%, 10% and 15% diet caused a maximal reduction in blood sugar from 13.1%, 16.3% and 21.4% to 3.2%, 5.58%, 8.21%, respectively[51].

The levels of glucose, glycosylated hemoglobin, insulin, thiobarbituric acid reactive substances (TBARS), enzymatic and non-enzymatic antioxidants were altered in diabetic rats, which reverted back to near control levels after treatment with extract of *M. koenigii*. These results suggested that *M. koenigii* treatment exerts a therapeutically protective effect in diabetes by decreasing oxidative stress and pancreatic β-cell damage[52].

A total of 63 extracts from 21 different plants were screened to study their pancreatic lipase activity *in vitro*. All three extracts (dichloromethane, ethanolic and methanolic) of *M. koenigii* leaves exhibited antilipase activity greater than 80%[53]. Aqueous extract of leaves of *M. koenigii*, *Psidium guajava*, *Catharanthus roseus* at dose of 500 mg/kg body weight showed beneficial effects in various physiological or histological parameters altered during diabetic manifestations and these effects were found to be comaparable to glibenclamide[54].

M. koenigii and *Brassica juncea* showed significant hypoglycemic action by increase in the concentration of hepatic glycogen and glycogenesis, as evident from the increased activity of glycogen synthetase, and decrease in glycogenolysis and gluconeogenesis as evident from the decreased activity of glycogen phosphorylase and gluconeogenic enzymes[55].

Streptozotocin-induced diabetic rats showed increases in blood glucose and glycosylated hemoglobin and a concomitant decrease in the levels of insulin and liver glycogen, increased activities of lactate dehydrogenase, glucose-6-phosphate, fructose-1, 6-diphosphatase and glycogen phosphorylase and decreased activities of hexokinase and pyuvate kinase (a glycogen synthase). These alterations were restored to near normal in the liver and kidney after treatment with ethanolic extract of *M. koenigii* leaves (200 mg/kg per day) for 30 d[56].

The body weight gain, plasma total cholesterol (TC) and triglyceride (TG) levels were signifi-

cantly reduced by dichloromethane and ethyl acetate extracts of *M. koenigii* when given orally at a dose of 300 mg/kg per day to the high-fat diet-induced obese rats for 2 weeks. Mahanimbine when given orally (30 mg/kg per day) also significantly lowered the body weight gain as well as plasma TC and TG levels[57].

Aqueous and 50% methanol leaf extract-treated diabetic mice were found to lower TC, TG, and phospholipids than diabetic mice. Rising of glutathione and superoxide dismutase enzyme activities compared with diabetic mice showed antioxidant property of the extracts. Anti-inflammatory response was evident by interleukin-2, 4 and 10, and tumor necrosis factor-α expression. In addition, the reduction of apoptosis in pancreatic cells was found in the extract-treated diabetic mice[58].

5.10 Nephroprotective activity Aqueous extract of leaves produced a significant dose-dependant decrease in serum urea and creatinine levels ($P<0.001$), and a marked increase in the levels of plasma antioxidant capacity ($P<0.01$) in diabetic rats, compared with the control (non-diabetic) subjects. Histological studies of the kidneys of these animals showed comparable tissue regeneration by the aqueous extract[59].

5.11 Antioxidant and free radical-scavenging activities The alcohol-water (1∶1) extract of curry leaves showed the highest antioxidant and free radical-scavenging activity. It reduced cytochrome *c* and ferric ion levels, chelated ferrous ions and inhibited ferrous sulfate: ascorbate-induced fragmentation and sugar oxidation of DNA[60]. Anti-peroxidative effect of alcoholic extract of *M. koenigii* has been studied in rat liver homogenate. Ferrous sulphate-treated group, produced 405.69 unit of TBARS, which gradually decreases from 400.09 to 125.66 nmol/100 mg protein in a dose-dependent manner in the presence of *M. koenigii*[10].

Five carbazole alkaloids, namely, euchrestine B (1), bismurrayafoline E (2), mahanine (3), mahanimbicine (4), and mahanimbine (5) were isolated from dichloromethane extract of *M. koenigii*. It was assumed that compounds 1 and 3 contributed to the high oil stability index (OSI) value of the dichloromethane extract of *M. koenigii*. The 1-1-diphenyl-2 picrylhydrazyl (DPPH) radical-scavenging activity for these carbazoles was in the order ascorbic acid>2>1, 3 and alpha-tocopherol> butylated hydroxytoluene>4 and 5[61].

In a study conducted on *M. koenigii*, *Centella asiatica*, *Amaranthus* species and *Trigonella foenum-graecum*, the total antioxidant activity was found to be highest in *M. koenigii* (2 691.78 μmol of one gram ascorbic acid sample) and least in *C. asiatica* (623.78 μmol of one gram ascorbic acid sample). The extract concentration causing 50% inhibition of DPPH (IC_{50}) was determined (*M. koenigii*<*C. asiatica*<*Amaranthus sp.*<*T. graecum*). The maximum DPPH-scavenging activity and reducing power was exhibited by *M. koenigii*[62].

The oleoresin of curry leaves, obtained by using acetone, was evaluated for its antioxidant activity using a β-carotene/linoleic acid model system, showed maximum activity of 83.2% at 100 mg/L. The methanol and water extracts showed activities of 16.7% and 11.3%, respectively, at the same concentration and volatile oil showed negligible (<10%) activity at 100 mg/L concentration. Mahanimbine and koenigine were identified for maximum antioxidant activity. Koenigine also showed a high degree of free radical-scavenging activity[63].

Some medicinal plants including *M. koenigii* were evaluated for nitric oxide-scavenging activity using sodium nitroprusside as a nitric oxide donor *in vitro*. All the evaluated extracts exhibited a dose-dependent nitric oxide-scavenging activity[2]. The elevated level of blood glucose, glycosylated haemoglobin and TBARS observed in diabetic rats were significantly altered compared with the control, which reverted back but did not reach the normal levels after treatment with *M. koenigii* leaves (300 and 500 mg/kg) for 15 d in diabetic rats. The ethanolic extract possessed potent antioxidant properties which were attributed to the presence of biologically active ingredients such as carbazole alkaloids, glycoside, triterpenoids and phenolic compounds[64].

5.12 Antiasthmatic activity Extract of *M. koenigii* was reported to have significant antiasthmatic effect in adult Wistar albino rats and guinea pigs. The probable mechanism for the antiasthmatic action was assumed to be antihistaminic, anticholinergic and mast cell membrane stabilization[65].

5.13 Antifungal activity The petroleum ether and alcoholic extracts of *M. koenigii* leaves have been reported to possess antifungal activity against *Asperigillus niger* and *Candida albicans*. The alcoholic extract exhibited significant antifungal activity, comparable to the standard drug tetracycline[29]. The extracts and essential oil of leaves were tested for antifungal activity. Zone of inhibition was measured by using the disc diffusion plate method. Distilled water extract has no antifungal activity. Acetone extract was most active against *A. niger*, benzene extract was most active against *Alternaria solani* and *Helminthosporium solani*. Ethanolic extract was most active against *Penicillium notatum*. The essential oil also exhibited moderate antifungal activity[66].

5.14 Anti-osteoporotic activity Isolated compound of *M. koenigii* was reported for anti-osteoporotic activity. A new carbazole alkaloid 8,8′-biskoenigine was a symmetrical dimer of the carbazole alkaloid koenigine and showed antiosteoporotic activity in the cathepsin B model with IC_{50} of 1.3 μg/mL[67].

5.15 Anticholinesterase propertry Ethanolic extract (300 and 500 mg/kg per oral) of *M. koenigii*

leaves (MKL) was evaluated for its memory enhancement potential. The result of the study indicated that administration of MKL for 15 d produces significant dose-dependant improvement of memory. The results also indicated to reduce the brain cholinesterase activity and total cholesterol levels[68].

5.16 Anti-amnesic activity Diet rich in *M. koenigii* leaves produced significant dose-dependent improvement in the memory scores of young and aged mice and significantly reduced the amnesia induced by scopolamine (0.4 mg/kg, intraperitoneally) and diazepam (1 mg/kg, intraperitoneally). Also, brain cholinesterase activity and total cholesterol levels were reduced by the MKL diets[69].

5.17 Wound-healing activity Aqueous extract of leaves showed marked reduction in wound area in comparison with the control group from 4th day onwards in albino rats by excision wound model. The result obtained indicated that aqueous extract of *M. koenigii* accelerates the wound-healing process by decreasing the surface area of the wound[70].

5.18 Anticancer activity The effects of column (SU Ⅰ, SU Ⅱ, SU Ⅲ) extracts of *M. koenigii* in *in vitro* (short term incubation method, SU Ⅰ, SU Ⅱ, SU Ⅲ) and *in vivo* (Dalton's ascitic lymphoma (DAL), SU Ⅱ) anticancer models have been evaluated in male Swiss albino mice. DAL cells were injected intraperitoneally (10^6 cells) to the mice. After treatment with SU Ⅱ, a significant decrease in the cancer cell number and tumor weight was observed in tumor-bearing mice. These observations are suggestive of the protective effect of extract in DAL[71].

5.19 Antipyretic activity The ethanolic extract of leaves of *M. koenigii* was investigated for antipyretic activity in rats using yeast-induced pyrexia model. Ethanolic extract at a single dose of 300 mg/kg produced significant antipyretic activity ($P<0.01$) in albino rats as compared with the standard drug paracetamol[72].

5.20 Haematological studies Whole curry leaf and mustard given to rats at doses equal to normal human intake did not cause any adverse effect on food efficiency ratio, red blood cell count, white blood cells, total count, differential counts or on the levels of blood constituents, like serum electrolytes, blood urea, haemoglobin, total serum protein, albumin-globulin ratio, fibrin level, glycosylated haemoglobin and the activity of aspartate aminotransferase, alanine aminotransferase and alkaline phosphatase in serum. No histopathological changes were observed in the liver of rats fed with curry leaf and mustard[73].

5.21 Radioprotective activity Adult Swiss albino mice were injected intraperitoneally with 100 mg/kg of methanolic extract of *M. koenigii* for 5 consecutive days and exposed to 4 Gy gamma radiation 30 min after the last injection. The extract itself increased the glutathione and enzymes levels, whereas radiation significantly reduced all values. Pretreatment with the extract reduced lipid peroxidation rate induced by radiation. The result demonstrated that *M. koenigii* leaves possess good antioxidant activity *in vitro* and are able to protect against radiation-induced depletion in cellular antioxidants[74].

The methanolic extract showed protection against gamma radiation and cyclophosphamide-induced chromosomal damage in Swiss albino mice at a single dose of 100 mg/kg body weight[75].

5.22 Other functions

5.22.1 Skin protection *M. koenigii* was studied for sun protection. On the basis of this study it was suggested that it can be used to maintain the natural pigmentation of the skin or can be used as an adjuvent in other formulations to enhance the activity. Curry leaf oil cream showed the low sun protection factor (2.04 ± 0.02), so the cream can be used in maintaining the natural skin pigmentation or it can be used as additives in other formulations to enhance the activity[76].

5.22.2 Insecticidal and seed-protective property *M. koenigii* has shown promising signs of seed protection and insecticidal properties[26].

5.22.3 Corrosion inhibition The inhibition of the corrosion of mild steel in hydrochloric acid and sulphuric acid solutions by the extract of *M. koenigii* leaves has been studied. The results obtained showed that the extract of the leaves could serve as an effective inhibitor of corrosion of mild steel in hydrochloric and sulphuric acid media. The inhibition was assumed to occur via adsorption of the inhibitor molecules on the metal surface[77].

6 Formulations

6.1 Gluteala Ayurvedic Herbal Drink Gluteala Ayurvedic Herbal Drink is a herbal preparation consisting of curry leaves (*M. koenigii*), Takli (*Premna serratifolia*), Gurikapuri (*Garcinia cambogia*), Kurchi bark (*Holarrhena antidysenterica*), Nelli (*Phyllanthus embilica*) and Indian beech (*Pongamia glabra*). It is highly effective in reducing excess body fat, preventing unnatural fettering of specific areas of the body such as the waist hips, thighs, shoulders and hands, efficiently controlling harmful cholesterol and ridding the body of aches and pains and helping alleviate pain caused by arthritis[78].

6.2 Orthokan Massage Oil Orthokan Massage Oil is a formulation consisting of *Sesamum indicum* oil, *Pinus longifolia* oil, *Madhuca indica* oil, *Ricinus cummunis* oil, *Celastrus paniculatus* oil, *Dryobalanops camphora* oil, *Eucalyptus globulus* oil, *Vitex negundo* and *M. koenigii*, etc. It is a pure herbal formula which provides relief in arthritis, rheumatism, gout, paralysis, low back pain, rickets, promotes intelligence and removes

swelling, frozen shoulder and other neuro-muscle pain[79].

Another herbal preparation "Ayur" which is fat-free, could reduce weight and cholesterol and consists of *A. sativum*, *C. indica*, *Garcinia gummi gutta*, *Boerrhavia diffusa*, *C. longa*, *M. koenigii*, and *Raphanus sativus*[80].

6.3 Consitap Consitap is an Ayurvedic herbal drink, containing *Ipomoea turpethum*, *M. koenigii*, *Terminalia chebula*, *P. embilica* and *Cassia obovata*. It could prevent gasses from causing abdominal aches, increase the appetite and ameliorate body functions and flows[81].

7 Conclusion

M. koenigii is a traditional Indian Ayurvedic herb. Apart from being a useful food supplement in curries and chutneys, the herb possesses immense therapeutic potential. The therapeutic usefulness of the herb can be easily understood from the present review. Review of the phytochemistry and pharmacology of this plant makes it a suitable potential candidate for clinical trials so that a valuable therapeutic agent for the treatment and management of various ailments frequently affecting humans can be brought into clinical practice.

8 Acknowledgments

Two of the authors, Priyanka Gupta and Alok Nahata are grateful to University Grants Commission of India and All India Council for Technical Education, New Delhi, India, respectively for providing research fellowships.

9 Competing interests

The authors declare that they have no competing interests.

REFERENCES

1 Kamboj VP. Herbal medicine. Curr Sci. 2000; 78(1): 35-39.

2 Baliga MS, Jagetia GC, Rao SK, Babu K. Evaluation of nitric oxide scavenging activity of certain spices *in vitro*: a preliminary study. Nahrung. 2003; 47(4): 261-264.

3 Hamilton AC. Medicinal plants, conservation and livelihoods. Biodivers Conserv. 2004; 13(8): 1477-1517.

4 Kong YC, Ng KH, But PP, Li Q, Yu SX, Zhang HT, Cheng KF, Soejarto DD, Kan WS, Waterman PG. Sources of the anti-implantation alkaloid yuehchukene in the genus *Murraya*. J Ethnopharmacol. 1986; 15(2): 195-200.

5 Tee ES, Lim CL. Carotenoid composition and content of Malaysian vegetables and fruits by the AOAC and HPLC methods. Food Chem. 1991; 41(3): 309-339.

6 Flora of West Bengal. Vol 1. Kolkata: Botanical Survey of India. 1997: 386.

7 Purthi JS. Spices and condiments. New Delhi: National Book Trust. 1976: 108.

8 Chevallier A. The encyclopedia of medicinal plants. London: Dorling Kindersley Publisher. 1996.

9 Sivarajan VV, Balachandran I. Ayurvedic drugs and their plant sources. New Delhi: Oxford & IBH Publishing. 1994: 199.

10 Gupta V, Sharma M. Protective effect of *Murraya koenigii* on lipid peroxide formation in isolated rat liver homogenate. Int J Pharma Bio Sci. 2010; 1(3): 1-6.

11 Lal RK, Sharma JR, Khanuja SPS, Naqvi AA, Sharma S. Diversity pattern in curry neem (*Murraya koenigii*). J Med Arom Plant Sci. 2003; 25(1): 13-18.

12 Bhattacharjee SK. Handbook of medicinal plants. 4th ed. Jaipur: Pointer Publishers. 2004.

13 Satyavati GV, Gupta AK, Tandon N, Seth SD. Medicinal plants of India. Vol 2. New Delhi: Indian Council of Medical Research. 1987: 289-299.

14 Parmar C, Kaushal MK. *Murraya koenigii*. In: Parmar C, Kaushal MK. Wild fruits. New Delhi: Kalyani Publishers. 1982: 45-48.

15 Nayak A, Mandal S, Banerji A, Banerji J. Review on chemistry and pharmacology of *Murraya koenigii* Spreng (Rutaceae). J Chem Pharm Res. 2010; 2(2): 286-299.

16 Chowdhury JU, Bhuiyan MNI, Yusuf M. Chemical composition of the leaf essential oils of *Murraya koenigii* (L.) Spreng and *Murraya paniculata* (L.) Jack. Banglad J Pharmacol. 2008; 3(2): 59-63.

17 Rao BRR, Rajput DK, Mallavarapu GR. Chemical diversity in curry leaf (*Murraya koenigii*) essential oils. Food Chem. 2011; 126(3): 989-994.

18 Rana VS, Juyal JP, Rashmi, Blazquez MA. Chemical constituents of the volatile oil of *Murraya koenigii* leaves. Int J Aromather. 2004; 14(1): 23-25.

19 Kumar VS, Sharma A, Tiwari R, Kumar S. *Murraya koenigii* (curry leaf): a review. J Med Arom Plant Sci. 1999; 21(4): 1139-1141.

20 Purohit SS, Sharma AK, Prajapati ND, Kumar T. A handbook of medicinal plants: a complete source book. 2nd ed. Jodhpur: Agrobios (India). 2009: 352-353.

21 Iyer UM, Mani UV. Studies on the effect of curry leaves supplementation (*Murraya koenigi*) on lipid profile, glycated proteins and amino acids in non-insulin-dependent diabetic patients. Plant Foods Hum Nutr. 1990; 40(4): 275-282.

22 Nutan MTH, Hasnat A, Rashid MA. Antibacterial and cytotoxic activities of *Murraya koenigii*. Fitoterapia.

1998; 69(2): 173-175.

23 Chakrabarty M, Nath A, Khasnobis S, Chakrabarty M, Konda Y, Harigaya Y, Komiyama K. Carbazole alkaloids from *Murraya koenigii*. Phytochemistry. 1997; 46(4): 751-755.

24 Ponnusamy S, Ravindran R, Zinjarde S, Bhargava S, Ravi Kumar A. Evaluation of traditional Indian antidiabetic medicinal plants for human pancreatic amylase inhibitory effect *in vitro*. Evid Based Complement Alternat Med. Epub 2010 Sep 23.

25 Adebajo AC, Olayiwola G, Verspohl EJ, Iwalewa EO, Omisore NOA, Bergenthal D, Kumar V, Kolawole AS. Evaluation of the ethnomedical claims of *Murraya koenigii*. Pharm Biol. 2004; 42(8): 610-620.

26 Gandhi N, Pillai S, Patel P. Efficacy of pulverized *Punica granatum* (Lythraceae) and *Murraya koenigii* (Rutaceae) leaves against stored grain pest *Tribolium castaneum* (Coleoptera: Tenebrionidae). Int J Agric Biol. 2010; 12(4): 616-620.

27 Mandal S, Nayak A, Kar M, Banerjee SK, Das A, Upadhyay SN, Singh RK, Banerji A, Banerji J. Antidiarrhoeal activity of carbazole alkaloids from *Murraya koenigii* Spreng (Rutaceae) seeds. Fitoterapia. 2010; 8 (1): 72-74.

28 Ningappaa MB, Dhananjayaa BL, Dineshaa R, Harshaa R, Srinivas L. Potent antibacterial property of APC protein from curry leaves (*Murraya koenigii* L.). Food Chem. 2010; 118(3): 747-750.

29 Khuntia TK, Panda DS. Evaluation of antibacterial, antifungal and anthelmintic activity of *Murraya koenigii* Spreng. Pharma Sci Monit. 2011; 2(2): 105-110.

30 Shivkanya J, Shilpa P, Sangita K, Neeraj F. Pharmacognostical studies and antibacterial activity of the leaves of *Murraya koenigii*. Phcog J. 2009; 1(3): 211.

31 Sathaye S, Bagul Y, Gupta S, Kaur H, Redkar R. Hepatoprotective effects of aqueous leaf extract and crude isolates of *Murraya koenigii* against *in vitro* ethanol-induced hepatotoxicity model. Exp Toxicol Pathol. 2010 May 18. [Epub ahead of print]

32 Pande MS, Gupta SPBN, Pathak A. Hepatoprotective activity of *Murraya koenigii* Linn bark. J Herb Med Toxicol. 2009; 3(1): 69-71.

33 Patidar DK. Anti-ulcer activity of aqueous extract of *Murraya koenigii* in albino rats. Int J Pharma Bio Sci. 2011; 2(1): 524-529.

34 Roy MK, Thalang VN, Trakoontivakorn G, Nakahara K. Mechanism of mahanine-induced apoptosis in human leukemia cells (HL-60). Biochem Pharmacol. 2004; 67 (1): 41-51.

35 Bhattacharya K, Samanta SK, Tripathi R, Mallick A, Chandra S, Pal BC, Shaha C, Mandal C. Apoptotic effects of mahanine on human leukemic cells are mediated through crosstalk between Apo-1/Fas signaling and the Bid protein and via mitochondrial pathways. Biochem Pharmacol. 2010; 79(3): 361-372.

36 Adebajo AC, Ayoola OF, Iwalewa EO, Akindahunsi AA, Omisore NO, Adewunmi CO, Adenowo TK. Anti-trichomonal, biochemical and toxicological activities of methanolic extract and some carbazole alkaloids isolated from the leaves of *Murraya koenigii* growing in Nigeria. Phytomedicine. 2006; 13(4): 246-254.

37 Parmar S, Gangwal A, Sheth N. Mast cell membrane stabilization and anti-histaminic actions — possible mechanism of action of anti-inflammatory action of *Murraya koenigii*. J Curr Pharm Res. 2010; 2(1): 21-25.

38 Darvekar VM, Patil VR, Choudhari AB. Anti-inflammatory activity of *Murraya koenigii* Spreng on experimental animals. J Nat Prod Plant Resour. 2011; 1(1): 65-69.

39 Mathur A, Prasad GBKS, Dua VK. Anti-inflammatory activity of leaves extracts of *Murraya koenigii* L. Int J Pharma Bio Sci. 2011; 2(1): 541-544.

40 Mathur A, Verma SK, Singh SK, Prasad GBKS, Dua VK. Investigation of the antimicrobial, antioxidant and anti-inflammatory activity of compound isolated from *Murraya koenigii*. Int J Appl Biol Pharm Technol. 2011; 2(1): 470-477.

41 Gupta S, George M, Singhal M, Sharma GN, Grag V. Leaves extract of *Murraya koenigii* Linn for anti-inflammatory and analgesic activity in animal models. J Adv Pharm Technol Res. 2010; 1(1): 68-77.

42 Sharma US, Sharma UK, Singh A, Sutar N, Singh PJ. *In vitro* anthelmintic activity of *Murraya koenigii* Linn. leaves extracts. Int J Pharma Bio Sci. 2010; 1(3): 1-4.

43 Shah AS, Wakade AS, Juvekar AR. Immunomodulatory activity of methanolic extract of *Murraya koenigii* (L) Spreng. leaves. Indian J Exp Biol. 2008; 46(7): 505-509.

44 Shah AS, Juvekar AR. Immunostimulatory activity of aqueous extract of *Murraya koenigii* (Linn.) Spreng. leaves. Indian J Nat Pro Resour. 2010; 1(2): 450-455.

45 Vinuthan MK, Girish Kumar V, Ravindra JP, Jayaprakash, Narayana K. Effect of extracts of *Murraya koenigii* leaves on the levels of blood glucose and plasma insulin in alloxan-induced diabetic rats. Indian J Physiol Pharmacol. 2004; 48(3): 348-352.

46 Lawal HA, Atiku MK, Khelpai DG, Wannang NN. Hypoglycaemic and hypolipidaemic effect of aqueous leaf extract of *Murraya koenigii* in normal and alloxan-diabetic rats. Niger J Physiol Sci. 2008; 23(1-2): 37-40.

47 Dineshkumar B, Mitra A, Mahadevappa M. Antidiabetic and hypolipidemic effects of mahanimbine (carbazole alkaloid) from *Murraya koenigii* (Rutaceae) leaves. Int J Phytomed. 2010; 2(1): 22-30.

48 Tembhurne SV, Sakarkar DM. Hypoglycemic effects of fruit juice of *Murraya koenigii* (L) in alloxan induced diabetic mice. Int J PharmTech Res. 2009; 1(4): 1589-1593.

49 Chatterji S, Singh RK, Shukla S, Yadav DK, Watal G. Glycemic effect of freeze dried *Murraya koenigii* — an evidence based study. Int J Pharma Bio Sci. 2010; 1(2): 1-9.

50 Kesari AN, Gupta RK, Watal G. Hypoglycemic effects of *Murraya koenigii* on normal and alloxan-diabetic rabbits. J Ethnopharmacol. 2005; 97(2): 247-251.

51 Yadav S, Vats V, Dhunnoo Y, Grover JK. Hypoglycemic and antihyperglycemic activity of *Murraya koenigii* leaves in diabetic rats. J Ethnopharmacol. 2002; 82(2-3): 111-116.

52 Arulselvan P, Subramanian SP. Beneficial effects of *Murraya koenigii* leaves on antioxidant defense system and ultra structural changes of pancreatic β-cells in experimental diabetes in rats. Chem Biol Interact. 2007; 165(2): 155-164.

53 Birari R, Roy SK, Singh A, Bhutani KK. Pancreatic lipase inhibitory alkaloids of *Murraya koenigii* leaves. Nat Prod Commun. 2009; 4(8): 1089-1092.

54 Prasad SK, Kulshreshtha A, Qureshi TN. Antidiabetic activity of some herbal plants in streptozotocin induced diabetic albino rats. Pak J Nutr. 2009; 8(5): 551-557.

55 Khan BA, Abraham A, Leelamma S. Hypoglycemic action of *Murraya koenigii* (curry leaf) and *Brassica juncea* (mustard): mechanism of action. Indian J Biochem Biophys. 1995; 32(2): 106-108.

56 Arulselvan P, Subramanian S. Effect of *Murraya koenigii* leaf extract on carbohydrate metabolism studied in streptozotocin induced diabetic rats. Int J Biol Chem. 2007; 1(1): 21-28.

57 Birari R, Javia V, Bhutani KK. Antiobesity and lipid lowering effects of *Murraya koenigii* (L.) Spreng leaves extracts and mahanimbine on high fat diet induced obese rats. Fitoterapia. 2010; 81(8): 1129-1133.

58 Paul S, Bandyopadhyay TK, Bhattacharyya A. Immunomodulatory effect of leaf extract of *Murraya koenigii* in diabetic mice. Immunopharmacol Immunotoxicol. 2011 Mar 14. [Epub ahead of print]

59 Yankuzo H, Ahmed QU, Santosa RI, Akter SF, Talib NA. Beneficial effect of the leaves of *Murraya koenigii* (Linn.) Spreng (Rutaceae) on diabetes-induced renal damage *in vivo*. J Ethnopharmacol. 2011; 135(1): 88-94.

60 Ningappaa MB, Dineshaa R, Srinivasa L. Antioxidant and free radical scavenging activities of polyphenol-enriched curry leaf (*Murraya koenigii* L.) extracts. Food Chem. 2008; 106(2): 720-728.

61 Tachibana Y, Kikuzaki H, Lajis NH, Nakatani N. Antioxidative activity of carbazoles from *Murraya koenigii* leaves. J Agric Food Chem. 2001; 49(1): 5589-5594.

62 Gupta S, Prakash J. Studies on Indian green leafy vegetables for their antioxidant activity. Plant Foods Hum Nutr. 2009; 64(1): 39-45.

63 Rao LJM, Ramalakshmia K, Borsea BB, Raghavana B. Antioxidant and radical-scavenging carbazole alkaloids from the oleoresin of curry leaf (*Murraya koenigii* Spreng.). Food Chem. 2007; 100(2): 742-747.

64 Tembhurne SV, Sakarkar DM. Protective effect of *Murraya koenigii* (L) leaves extract in streptozotocin induced diabetic rats involving possible antioxidant mechanism. J Med Plant Res. 2010; 4(22): 2418-2423.

65 Parmar S, Gangwal A, Sheth N. Evaluation of anti-asthmatic activity of a polyherbal formulation containing four plant extracts. J Curr Pharm Res. 2010; 2(1): 40-44.

66 Mishra MK, Sahu RV, Goojar M, Prajapati N, Pathak K. Anti-fungal potential of leave extracts of *Murraya koenigii*. Int J Res Ayurveda Pharm. 2010; 1(2): 549-552.

67 Wang YS, He HP, Shen YM, Hong X, Hao XJ. Two new carbazole alkaloids from *Murraya koenigii*. J Nat Prod. 2003; 66(3): 416-418.

68 Tembhurne SV, Sakarkar DM. Beneficial effects of ethanolic extract of *Murraya koenigii* (Linn) leaves in cognitive deficit aged mice involving possible anticholinesterase and cholesterol lowering mechanism. Int J PharmTech Res. 2010; 2(1): 181-188.

69 Vasudevan M, Parle M. Antiamnesic potential of *Murraya koenigii* leaves. Phytother Res. 2009; 23(3): 308-316.

70 Patidar DK, Yadav N, Nakra V, Sharma P, Bagherwal A. Wound healing activity of *Murraya koenigii* leaf extract. Int J Compr Pharm. 2010; 4(9): 1-2.

71 Muthumani P, Venkatraman S, Ramseshu KV, Meera R, Devi P, Kameswari B, Eswarapriya B. Pharmacological studies of anticancer, anti inflammatory activities of *Murraya koenigii* (Linn) Spreng in experimental animals. J Pharm Sci Res. 2009; 1(3): 137-141.

72 Patel VR, Patel MG, Patel RK. Anti-pyretic activity of the ethanolic extract of the powdered leaves of *Murraya koenigii* (L.) Spreng. J Pharm Res. 2009; 2(4): 731-732.

73 Khan BA, Abraham A, Leelamma S. Haematological & histological studies after curry leaf (*Murraya koenigii*) & mustard (*Brassica juncea*) feeding in rats. Indian J

Med Res. 1995; 102: 184-186.
74 Deepa I, Devi PU. Radioprotective activity of *Murraya koenigii* (L.) on cellular antioxidants in Swiss albino mice. J Pharm Res. 2009; 2(3): 495-501.
75 Goswami RB, Khare P, Singh S, Goswami N, Thomas P, Devi PU, Pathak AK. Studies on antigenotoxic effect of *Murraya koenigii* leaves. Int J Pharma Recent Res. 2010; 2(21): 65-68.
76 Patil RB, Kale S, Badiyani DM, Yadav AV. Determination of *in-vitro* sun protection factor (SPF) of *Murraya koenigii* L. (Rutaceae) essential oil formulation. Indian J Pharm Educ Res. 2010; 44(4): 375-379.
77 Quraishib MA, Singha A, Singha VK, Yadavb DK, Singh AK. Green approach to corrosion inhibition of mild steel in hydrochloric acid and sulphuric acid solutions by the extract of *Murraya koenigii* leaves. Mater Chem Phys. 2010; 122(1): 114-122.
78 Amazon Health Care. Gluteala Ayurvedic herbal drink. [2011-02-15]. http://www.amazonhealthcare.com/products/body_care/gluteala_ayurvedic_herbal_drink.html.
79 Herbal Ayurveda Remedies. Orthokan massage oil. [2011-02-15]. http://herbalayurvedaremedies.com/product_info.php?cPath=31&products_id=67.
80 SBM Ayur Care. SBM fat free-lose weight & cholesterol naturally. [2011-02-15]. https://www.sbmayurcare.com/health-supplement/sbm-fat-free-lose-weight-cholesterol-naturally/.
81 Amazon Health Care. Consitap Ayurvedic herbal drink. [2011-02-15]. http://www.amazonhealthcare.com/products/body_care/consitap_ayurvedic_herbal_drink.html.

印度传统药用植物可因氏越橘的研究综述

Priyanka Gupta, Alok Nahata, Vinod K. Dixit
Department of Pharmaceutical Sciences, Dr. Hari Singh Gour University, Sagar 470003, India

摘要: 可因氏越橘又名调料九里香(*Murraya koenigii*,芸香科,九里香属),是一种常用的药用植物,在印度阿育吠陀医学中有数百年的使用历史。这种植物的叶子、果实、根及树皮均富含咔唑生物碱。已有的很多研究报道这些生物碱具有多种药理活性如抗肿瘤、抗病毒、抗炎、止泻、利尿、抗氧化等。除了这些药理活性,该植物还具有多种多样的生物活性。可因氏越橘作为一种能够治疗多种疾病的有价值的药用植物,有关其植物化学及药理学的研究数量众多,因此有必要对其作一系统的综述。本文对有关可因氏越橘的植物化学、药理学、临床及基础研究进行了系统的整理,以期更全面地发掘其作为药用植物的价值。

关键词: 芸香科; 九里香属; 医学,印度传统; 植物提取物; 综述