REVIEW ARTICLE

Traditional uses, chemistry and pharmacological activities of *Leea indica* (Burm. f.) Merr. (Vitaceae): A comprehensive review

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Abstract

Plants have been used for various purposes of humans including medicinal purposes since time immemorial. Plants are an integral part of traditional medicine. *Leea indica* (Burm.f.) is a large shrub and belongs to the family Vitaceae. The plant *L. indica* is used traditionally in various countries of the world such as India, Malaysia, Thailand, Nepal, and Indonesia. The plant is used as a remedy for ailments such as diarrhea, dysentery, diabetes, bone fracture, body ache, fever, and wound treatment. Phytochemical groups such as alkaloids, flavonoids, terpenoids, glycosides, saponins, and steroids and compounds, namely, quercetin, gallic acid, lupeol, β-sitosterol, ursolic acid, mollic acid arabinoside, and mollic acid xyloside have been identified in various parts of the plant. Literature survey carried on biological activities of *L. indica* revealed that the plant showed bioactivities such as antimicrobial, antioxidant, cytotoxic, enzyme inhibitory, analgesic, hepatoprotective, hypoglycemic, hypolipidemic, and antidiarrheal activity. The observed bioactivities of the plant might be related to the presence of bioactive phytoconstituents as compounds such as gallic acid, quercetin, mollic acid arabinoside, and mollic acid xyloside are known to exhibit marked pharmacological activities.

Key words: Ethnomedicine, *Leea indica* (Burm.f.) Merr., Vitaceae, pharmacological activities, phytochemicals

INTRODUCTION

The term "ethnobotany" was proposed by Harshberger. Ethnobotany is a multidisciplinary science of interactions between people and plants. Plants are widely used to meet various needs of humans such as food, cloth, shelter, dyes, fuelwood, fodder, and medicine. Besides, plants have also found ritual uses. In recent years, the field of ethnobotany is on rise. Throughout the world, many plants with therapeutic values have been used to treat several human and veterinary diseases. Traditional medicinal practitioners, especially from rural areas, utilize plants singly or in certain formulations to treat various diseases. A majority of population in the world, especially those living in remote areas, rely on traditional medicine for meeting primary health care. Plants form an integral part of medicinal systems such as Unani, Sidda, Ayurveda, and traditional Chinese medicine. More emphasis is devoted on searching natural products with therapeutic values due to many adverse effects associated with the use of modern drugs.[1-10] Therapeutic values of plants lie in the presence of bioactive secondary metabolites such as alkaloids, terpenoids, and polyphenolic compounds including flavonoids distributed in various parts of plants. Compounds such as vincristine, vinblastine, taxol, quinine, digoxin, reserpine, nicotine, codeine, and morphine are from plant origin. Studies have shown that crude solvent extracts and purified components from plants exhibit a wide array of biological activities including anticancer activity.[11-19]

Leea indica (Burm.f.) Merr., [Figure 1] belonging to the family Vitaceae, is commonly known as Bandicoot berry in English, Chhatri in Sanskrit, and Hastipalash in Hindi. The

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Figure 1: *Leea indica* (Burm.f.) Merr. (Photograph by Vinayaka K.S)

plant is distributed in various parts of the world such as India, Malaysia, China, and Thailand. The plant is distributed in forests of tropical and subtropical India, from Himalayas to southward to the Peninsula. The plant is medicinally important and is widely used in indigenous systems of medicine. The root is antidiarrheal, antidysenteric, antispasmodic, cooling, and sudorific. The juice of young leaves is digestive. An ointment prepared from roasted leaves relieves vertigo.[20,21] The plant *L. indica* is a large perennial shrub with stout, soft-wooded stems, alternate leaves (2-3 pinnate, sometimes 1-pinnate), leaflets ovate or oblong-lanceolate, 25 cm × 10 cm, apex acuminate, margin irregularly serrate, base truncate, pinnately veined. Flowers are pale-green/greenish-white, bisexual, in large terminal compound corymbose cymes, bracts minute, calyx 5-lobed, petals 5, and spreading. Stamens 5 in number, stamina tube white in color, anthers are united in buds. Fruit is a berry, 8 mm across, globose, often 2–6 lobed, to 0.5 cm in diameter, purplish–black when ripe. Flowering occurs more or less throughout the year.[22,23] In a tropical lowland rainforest in Borneo (Danum Valley, Sabah, Malaysia), the stick insect *Dinophasma ruficornis* had restricted diet and fed on *L. indica*.[24] In this review, a detailed literature survey was carried out to collect information available on the traditional uses and chemistry and biological activities of *L. indica*. Literature survey was carried out by referring flora, journals, and search engines such as Google Scholar, PubMed, and Science Direct.

ETHNOBOTANICAL USES OF *L. INDICA*

Plants are the key components of traditional medicine. Ethnic communities in various parts of the world utilize several plants to treat a number of diseases/disorders. Traditional medicine based on plant is widely practiced in countries such as India, China, Sri Lanka, Pakistan, Thailand, and many African countries. Plant-based medicines are cheaper, often safer and are the only therapeutic agents for people from poor economic background and living in rural areas.[17,25,26] The plant *L. indica* has ethnomedicinal importance worldwide. Various parts of the plants, namely, leaves, roots, stem bark, inflorescence, and flowers in certain formulations such as paste and decoction are being in use for treating several ailments. Roots and leaves are predominantly used. The plant is used medicinally in several formulations to treat ailments such as fever, bone fracture, diarrhea, dysentery, body ache, head ache, malaria, rheumatism, asthma, and gastric ulcer. A brief detail on some of the uses of *L. indica* to treat diseases and disorders in India and in other parts of the world (namely, Nepal, Bangladesh, Malaysia, Indonesia, and Thailand) is presented in Table 1.

CHEMISTRY OF *L. INDICA*

Plants produce a number of primary and secondary metabolites. Metabolic pathways such as shikimic acid pathway and malonate/acetate pathways are involved in the synthesis of secondary metabolites, most of which are phenols or their oxygen-substituted derivatives. Most of the metabolites serve many functions such as defense against insects and herbivores and contribute color, flavor, and aroma to plants. Besides, many of the secondary metabolites produced by plants possess therapeutic values. Advancements made in chromatographic and spectral analyses such as column chromatography, high-performance thin-layer chromatographic (HPTLC), gas chromatography-mass spectrometry (GC-MS), high-performance column liquid chromatographic, infrared, and nuclear magnetic resonance led to the identification of several plant secondary metabolites.[4,54-58] Studies have shown that the plant *L. indica* contains a wide variety of phytochemicals which have been identified by several methods such as standard phytochemical tests, GC-MS analysis, HPTLC, and spectral analyses. Table 2 shows the chemicals/phytochemical groups detected in different parts of *L. indica* by various detection procedures.

BIOLOGICAL ACTIVITIES OF *L. INDICA*

The plant *L. indica* is shown to exhibit a range of biological activities such as antimicrobial, antioxidant, cytotoxic, larvicidal, hepatoprotective, antidiarrheal, thrombolytic, analgesic, sedative, and antimalarial activity. A brief detail on the biological activities exhibited by *L. indica* is presented.

Antibacterial Activity

The essential oil obtained from the flowers of *L. indica* was effective against Gram-positive and Gram-negative bacteria.[69] The ethanolic extract obtained from leaves of *L. indica* was shown to inhibit Gram-positive and Gram-negative bacteria in disk diffusion assay. It was observed that the extract inhibited Gram-positive bacteria to higher extent when compared to Gram-negative bacteria as revealed by lower MIC values.[61]

Table 1: Reported ethnobotanical uses of different parts of *L. indica*

Region	Part	Uses	Reference
Singhanakhon district, Songkhla Province, Thailand	Root	Fever	Neamsuvan *et al*.[27]
Kut Chum District, Yasothon Province, Thailand	Root	Diarrhea	Chuakul *et al*.[28]
Chittagong Hill Tracts, Bangladesh	Leaf	Joint pain	Khisha *et al*.[29]
Jalpaiguri district, West Bengal, India	Root	Bone fracture	Bose *et al*.[30]
Hassan district, Karnataka, India	Root	Sudorific, diarrhea, dysentery, colic	Kumar and Shiddamallayya[31]
Thrissur district, Kerala, India	Root	Diarrhoea, dysentery, hyperdipsia, ulcer, skin diseases	Deepa *et al*.[32]
Rajasthan, India	-	Body ache	Choudhary *et al*.[33]
Dindigul district, Tamil Nadu, India	Root	Dysentery	Shanmugam *et al*.[34]
Andaman and Nicobar Islands, India	-	Malaria, contraception, dysentery, fever, bone fracture, headache, pruritus, skin injuries	Chander *et al*.[35]
Sumatra, Indonesia	-	Abscess	Hariyadi and Ticktin[36]
Golaghat district, Assam, India	Fruit	Extracts used for purple dye	Barukial and Sarmah[37]
Visakhapatnam district, Andhra Pradesh, India	Tuber	Liver enlargement	Rao *et al*.[38]
Thrissur district, Kerala, India	Stem bark	Treatment of wound	Udayan *et al*.[39]
Kannur district, Kerala, India	Root, leaf	Diarrhea, dysentery and ulcer	Ranjith and Ramachandran[40]
Lubuk Ulu Legong, Kedah, Malaysia	Leaf	Diabetes	Mohammad *et al*.[41]
Ulu Kuang village, Malaysia	Leaf and shoot	Wound treatment	Azliza *et al*.[42]
Rajasthan, India	Inflorescence, tuber	Chest pain in children (inflorescence extract), allergy (tuber paste)	Swarnkar and Katewa[43]
Jessore District, Bangladesh	Leaf	Joint pain	Akter *et al*.[44]
Shimoga district, Karnataka, India	Leaf	Diarrhea and dysentery in cattle	Rajakumar and Shivanna[45]
Car Nicobar island, Nicobar, India	Leaf	Cuts and wounds	Verma *et al*.[46]
Kalakad Mundanthurai Tiger Reserve, Tamil Nadu, India	Leaf, flower	Rheumatism	Sutha *et al*.[47]
Kanyakumari district, Tamil Nadu, India	Root	Diarrhea	Sukumaran and Raj[48]
Banjar, South Kalimantan, Indonesia	Root	Asthma	Anshari *et al*.[49]
West Nepal	Leaf	Young leaves digestive; leaf useful in spleen problems	Kunwar *et al*.[50]
Northern Thailand	Root, stem	Diarrhea, hemorrhoid, gastric ulcer	Tangjitman *et al*.[51]
Eastern Himalaya	-	Fuelwood	Bhatt *et al*.[52]
Chittagong hill tracts, Bangladesh	Leaf	Sore, leprosy, eczema, itching, bone fracture, and sprain	Yusuf *et al*.[53]

L. indica: Leea. indica

Table 2: Chemicals/phytochemical groups detected in *L. indica*

Plant part	Method	Compounds identified	Reference
Leaf	GC-MS	Phthalic acid, palmitic acid, 1-eicosanol, solanesol, farnesol, three phthalic acid esters, gallic acid, lupeol, β-sitosterol, ursolic acid	Srinivasan *et al*.[59]
Leaf	Standard tests	Alkaloid, terpenoids, flavonoids, steroid, tannin	Emran *et al*.[60]
Leaf	Standard tests	Alkaloid, glycoside, cardiac glycoside, terpenoids, flavonoids, steroid, tannin	Rahman *et al*.[61]
Leaf	Chromatographic and spectral analyses	Triterpenoid glycosides, namely, mollic acid arabinoside and mollic acid xyloside	Wong *et al*.[21]
Fresh plant material	HPTLC	Quercetin, gallic acid	Patel *et al*.[62]
Leaf	Standard tests	Alkaloids, saponins, steroids, saponins, terpenoids	Harun *et al*.[63]
Stem	Standard tests	Saponins, steroids, terpenoids, tannins, cardiac glycosides, flavonoids	Harun *et al*.[63]
Root	Standard tests	Saponins, steroids, terpenoids, tannins, cardiac glycosides, flavonoids	Harun *et al*.[63]
Leaf	Standard tests	Alkaloids, flavonoids, steroids, glycosides, tannins	Tareq *et al*.[64]
Leaf	Standard tests	Alkaloids, flavonoids, tannins, sterols, glycosides, phenols, saponins	Ghagane *et al*.[65]
Stem bark	Standard tests	Alkaloids, flavonoids, glycosides, phenolic compounds	Mishra *et al*[66]
Leaf	Standard tests	Alkaloids, flavonoids, triterpenoids, sterols	Chander and Vijayachari[67]
Leaf	Standard tests	Saponins, tannins, alkaloids, steroids, flavonoids, cardiac glycosides, terpenoids	Dalu *et al*.[68]

L. indica: Leea. indica, HPTLC: High-performance thin-layer chromatographic, GC-MS: Gas chromatography-mass spectrometry

A herbal formulation, THR-SK009, containing *L. indica* (used for the treatment of wound or skin inflammation) was shown to exhibit inhibitory activity against drug-resistant bacteria.[70] The study carried out by Harun *et al*.[63] revealed the potential of dichloromethane extract of *L. indica* leaf, stem, and root to *Staphylococcus aureus* and *Staphylococcus epidermidis*. Tareq *et al*.[64] showed the inhibitory potential of methanolic extract of *L. indica* leaves against Gram-positive and Gram-negative bacteria. The study carried out by Chander and Vijayachari[67] and Chander and Vijayachari[71] showed the ineffectiveness of methanol extract of leaves of *L. indica* to inhibit Gram-positive and Gram-negative bacteria.

Antifungal Activity

Essential oil, obtained from flowers of *L. indica*, was effective in inhibiting molds, namely, *Penicillium notatum*, *Fusarium moniliforme,* and *Aspergillus niger*.[69] The study by Rahman *et al*.[61] revealed the antifungal potential (as revealed by poisoned food technique) of ethanolic extract of *L. indica* leaves to inhibit the growth of *Aspergillus flavus*, *Candida albicans,* and *Fusarium equiseti* by 38.09 ± 0.59, 22.58 ± 2.22, and 22.58 ± 2.22%, respectively. Ramesh *et al*.[72] evaluated the antifungal potential of leaf and bark extract of *L. indica* against molds, namely, *Colletotrichum capsici*, *Helminthosporium* sp., and *Curvularia* sp. Among extracts, marked inhibitory potential was shown by leaf extract. Among fungi, *Helminthosporium* sp. and *Curvularia* sp. were inhibited to the highest and least extent, respectively. Tareq *et al*.[64] showed the inhibitory potential of methanolic extract of *L. indica* leaves against pathogenic yeasts and molds. The study carried out by Chander and Vijayachari[67] and Chander and Vijayachari[71] showed the ineffectiveness of methanol extract of leaves of *L. indica* to inhibit *C. albicans* and *A. niger*, respectively.

Antiviral Activity

Ethanolic extract obtained from leaves of *L. indica* was shown to exhibit antiviral activity against herpes simplex virus type-1 with an MIC value of 0.05 mg/ml. The extract was ineffective against vesicular stomatitis virus.[73]

Antioxidant Activity

Studies have shown the potential of *L. indica* to exhibit free radical and antioxidant activity. Methanol extract of

L. indica was shown to exhibit marked scavenging activity against DPPH radicals.[74] The crude ethanol extract and hexane, ethyl acetate, and aqueous fractions of ethanol extract obtained from leaves of *L. indica* were evaluated for antioxidant activity by DPPH scavenging, superoxide radical scavenging, and reducing power assay. Aqueous fraction of ethanol extract was found to contain high phenolics and exhibited marked antioxidant activity when compared to other fractions.[75] The study carried out by Ghagane *et al*.[65] revealed the antioxidant activity of solvent extracts obtained from leaves of *L. indica* by DPPH, ferric reducing antioxidant power, and phosphomolybdenum assays. The antioxidant activity observed was in the order: Methanol extract > ethanol extract > aqueous extract. Table 3 presents the free radical scavenging and antioxidant potential of *L. indica* being revealed by other researchers.

Cytotoxic/Anticancer/Antitumor Activity

Methods such as brine shrimp lethality assay and MTT assay are routinely used to evaluate cytotoxic potential of plants. It is evident from the studies that crude solvent extracts and isolated compounds from *L. indica* exhibit *in vitro* and *in vivo* cytotoxic/antitumor activity. Hsiung and Kadir[78] investigated anticancer potential of ethanol extract and ethyl acetate, hexane, and water fraction *L. indica* leaves against various cell lines (Ca Ski, MCF 7, MDA-MB-435, KB, HEP G2, WRL 68, and Vero) by MTT assay. It was shown that the ethyl acetate fractions showed greatest cytotoxic effect against Ca Ski cervical cancer cells. Treatment of cells with the fraction showed typical apoptotic morphological changes such as DNA fragmentation and chromatin condensation. In another study, Wong *et al*.[21] isolated two cycloartane triterpenoid glycosides, namely, mollic acid arabinoside and mollic acid xyloside [Figure 2] from leaves of *L. indica* and subjected the compounds for cytotoxicity against Ca Ski cervical cancer cells. Mollic acid arabinoside and mollic acid xyloside inhibited the growth of Ca Ski cervical cancer cells with IC_{50} value of 19.21 μM and 33.33 μM, respectively. Raihan *et al*.[77] determined *in vivo* antitumor activity of leaf extract of *L. indica* in Ehrlich ascites carcinoma (EAC) bearing mice. It was found that the extract at the dose of 40 mg/kg/day significantly decreases tumor weight, increases lifespan, and reduces tumor cell growth rate in comparison to those of EAC bearing mice receiving no extract. The study of Emran *et al*.[60] revealed dose-dependent mortality of brine shrimps by ethanolic extract of leaves of *L. indica*. Paul and Saha[79] screened cytotoxicity of ethanolic extract of *L. indica* by brine shrimp lethality assay. The leaf extract displayed cytotoxicity against brine shrimps with an LC_{50} value of 2.47μg/ml. Reddy *et al*.[75] screened crude ethanol extract and solvent fractions, namely, hexane, ethyl acetate, and water fractions of leaves of *L. indica* for cytotoxicity activity against colon cancer cell lines, namely, HT-29, HCT-15, and HCT-116 by MTT assay. It was observed that the crude extract and solvent fractions did not exert any cytotoxicity against cell lines. Rahman *et al*.[61] screened cytotoxic potential of ethanol extract of *L. indica* by brine shrimp assay. The extract caused dose-dependent mortality of shrimps with an LC_{50} value of 2.65 μg/ml. More recently, Ghagane *et al*.[65] revealed cytotoxicity of *L. indica* leaves against two cancer cell lines, namely, DU-145 and PC-3 by MTT assay. Based on IC_{50} values, the degree of cytotoxicity of solvent extracts observed was in the order: Methanol extract > ethanol extract > aqueous extract. Moreover, the extracts were not effective against normal mice embryo fibroblast cells. The study carried out by Ali *et al*.[73] revealed ineffectiveness of ethanolic extract of leaves of *L. indica* to exhibit cytotoxicity against HeLa cells. The study by Avin *et al*.[80] revealed the modulation of neovessel formation in non-tumorigenic and tumorigenic conditions by crude ethanolic extract of *L. indica* by performing assays, namely, rVEGF165-induced *in vivo* CAM assay, rat corneal micropocket assay, and tumor-induced peritoneal angiogenesis assay. It was found that the crude extract of *L. indica* inhibited the sprouting vessels.

Thrombolytic Activity

Ethanol extract of *L. indica* leaves was screened for thrombolytic activity *in vitro* by clot lysis activity. The extract produced a significant clot lysis activity of 39.30 ± 0.96%.[81]

Antidiarrheal Activity

Tareq *et al*.[64] evaluated the antidiarrheal activity of methanolic extract of leaves of *L. indica* by castor oil-induced

Table 3: Free radical scavenging and antioxidant activity of *L. indica*

Part	Assay/technique	Reference
Leaf	Total antioxidant capacity, ferric reducing power, superoxide scavenging, iron chelating activity	Rahman *et al*.[61]
Leaf, bark	DPPH assay	Ramesh *et al*.[72]
Leaf	DPPH assay	Emran *et al*.[60]
Leaf	DPPH, superoxide, and hydroxyl radical scavenging assay	Sulistyaningsih *et al*.[76]
Leaf	DPPH assay, reducing power assay	Raihan *et al*.[77]
Stem, leaf, root	DPPH assay	Harun *et al*.[63]
Leaf	DPPH assay	Chander and Vijayachari[67]

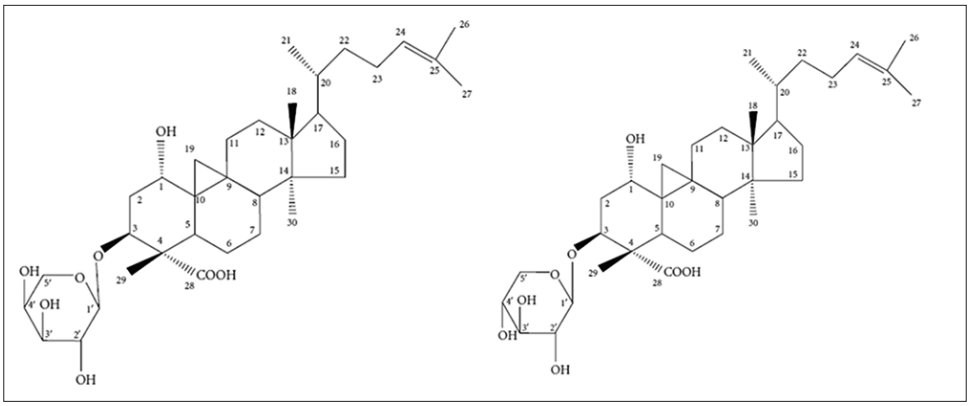

Figure 2: Mollic acid arabinoside (left) and mollic acid xyloside (right)

diarrhea in mice. The extract at the doses of 500 mg/kg and 250 mg/kg significantly reduced the total number of stool as well as increased the latency period of defecation in comparison to the control groups.

Hepatoprotective Activity

Ethanolic extract obtained from the stem bark of *L. indica* was shown to exhibit hepatoprotective activity against liver injury induced by paracetamol in rats. The treatment of animals with the extract at two doses, namely, 200 and 400 mg/kg body weight resulted in significant decrease in elevated level of serum marker enzymes, bilirubin, and triglycerides when compared to positive control group of rats.[66]

Enzyme Inhibitory Activity

The plant *L. indica* is reported to possess inhibitory activity against enzymes such as phosphodiesterase, pancreatic lipase, and glucosidase. In a study, Ado *et al*.[82] investigated lipase inhibitory activity of methanolic extract of *L. indica* leaves against porcine pancreatic lipase. It was observed that the extract was effective in inhibiting the activity of lipase by 48.5%. The study carried out by Temkitthawon *et al*.[83] indicated the potential of ethanol extract of *L. indica* root to inhibit the activity of phosphodiesterase activity measured using the SPA radioassay (with an IC_{50} value of 2.62 ± 0.25 µg/ml). Ridhwan[84] revealed the potential of *L. indica* root to strongly inhibit activity of α-glucosidase.

Antihyperglycemic Activity

Dalu *et al*.[68] evaluated hypoglycemic activity of alcoholic and hydroalcoholic extracts of *L. indica* leaves using glucose tolerance test and alloxan-induced diabetes model in rats. The extract administration significantly reduced blood glucose level indicating hypoglycemic activity of leaf extracts. The study of Patel *et al*.[85] also revealed the antidiabetic activity of methanol extract of *L. indica* leaves in alloxan-induced diabetic rats.

Hypolipidemic Activity

The administration of alcoholic and hydroalcoholic extracts of *L. indica* leaves in rats resulted in significant decrease in the level of triglycerides, total cholesterol, LDL, and VLDL and increased HDL indicating hypolipidemic activity of leaf extract.[68]

Sedative Activity

Raihan *et al*.[86] evaluated the sedative property of crude methanol extract of *L. indica* leaves by hole cross, open field, and thiopental sodium-induced sleeping time tests. It was shown that the leaf extract displayed a dose-dependent suppression of motor activity, exploratory behavior, and prolongation of thiopental induced sleeping time in mice in a dose-dependent manner.

Anxiolytic Activity

An elevated plus maze (EPM) test was performed to evaluate anxiolytic potential of crude methanol extract of *L. indica* leaves by Raihan *et al*.[86] The methanol extract at the dose of 400 mg/kg body weight, significantly increased the entries of mice into the open arms, and the time spent in the open arms of the EPM.

Wound Healing Activity

The study carried out by Azizi *et al*.[87] revealed the wound healing potential of ethanolic extract of *L. indica* in NIH 3T3 mouse fibroblast cells and RAW 264.7 mouse macrophage cells by scratch assay. It was found that the extract treatment triggered migration of cells at the site of the gap (the wound) being created by scratching the area of cells (0.5 mm width) indicating the potential of *L. indica* to heal the wound.

Analgesic Activity

Emran *et al*.[88] investigated the analgesic activity of leaf extract of *L. indica* by acetic acid writhing test and

formalin-induced licking response test. Oral administration of the extract significantly inhibited writhing response induced by acetic acid. The administration of extract also suppressed formalin-induced pain response in mice.

Larvicidal Activity

The leaf extract of *L. indica* was investigated for insecticidal activity against larvae (I to IV instar) of *Culex quinquefasciatus*. The leaf extract exhibited larvicidal effect which was more effective against earlier stages of larval development.[89]

Antimalarial Activity

The study of Abd Razak *et al*.[90] revealed the ineffectiveness of solvent extracts of *L. indica* leaf to exhibit antiplasmodial activity against *Plasmodium falciparum* K1 by HRP2-based assay. In another study, Sulistyaningsih *et al*.[76] investigated antimalarial activity of leaf extract of *L. indica* in male Balb/c mice. The leaf extract was found to decrease the parasitemia level by 3.50 ± 1.26% on the 4th day and yielded 24.85 ± 1.28% of suppression.

Biosynthesis and Biological Activity of Nanoparticles from *L. indica*

Few studies have been carried out on synthesis of nanoparticles from *L. indica*. The study of Rokhade and Taranath[91] revealed the synthesis of silver nanoparticles using aqueous extract of *L. indica* leaves. The nanoparticles exhibited synergistic antibacterial activity with antibiotic against Gram-positive and Gram-negative bacteria. In another study, Rokhade and Taranath[92] synthesized silver nanoparticles using fruit extract of *L. indica*. The nanoparticles showed synergistic antibacterial activity with antibiotic against Gram-positive and Gram-negative bacteria.

CONCLUSION

In the present review, an extensive literature review carried out to compile information related to ethnobotanical uses, chemistry and pharmacological activities of *L. indica* indicated that the plant is widely used in traditional medicine in India and other countries such as Thailand, Nepal, Indonesia, and Malaysia for the treatment of ailments or disorders such as diabetes, dysentery, wounds, body ache, bone fracture, and fever. Phytochemical groups such as alkaloids, terpenoids, flavonoids, terpenoids, tannins, steroids, and glycosides have been identified in the plant. Triterpenoid glycosides with cytotoxic activity have been isolated from the leaves of *L. indica*. The presence of these phytochemicals may be responsible for the observed biological activity such as antimicrobial, antioxidant, cytotoxic, enzyme inhibitory, analgesic, hepatoprotective, and antimalarial activity of the plant *L. indica*. The results of pharmacological activities being conducted support the traditional uses of the plant. A much detailed literature review carried out in this review indicated that the plant appears to be a suitable alternative for current chemotherapeutic agents which often possess many drawbacks such as high cost and side effects. However, more studies are required to identify therapeutic principles from the plant and their utilization for a remedy against several dreadful diseases due to agents such as pathogens and free radicals.

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