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A Comprehensive Review on *Lantana camara*: An Important Medicinal and Ornamental Plant

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Abstract

In the present era researchers are focusing on medicinal plant research throughout the world as medicinal plants are important and cheap source of drugs and have a long history. Most of the remedies in the traditional system were taken from plants due to lack of technology and using plants as medicines were proven to be useful. *Lantana camara* L. is an important medicinal and aromatic plant belonging to family Verbenaceae. The plant is a rich source of medicinal compounds and that is the reason it has been used for the treatment of various ailments i.e. malaria, cough, fever cold and cough etc. Several essential phytochemicals have been isolated from *L.camara* L. and the plant was reported to possess important compounds including triterpenoids, flavonoids, alkaloids, saponins, steroids and tannins. Moreover, it is also known as an essential oil producing plant and the essential oil is available in the market known as Lantana oils. Thus due to the above mentioned economic as well as medicinal properties of *Lantana camara* L. Here we report a comprehensive review on the ethnobotany, phytochemistry, pharmacology and toxicology of *Lantana camara* L. This review will serve as a baseline for researchers working in the field of genomics and molecular studies of medicinal plants.

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1. Introduction

The genus *Lantana camara* L. is an important medicinal, ornamental as well as essential oil producing plant from family Verbenaceae and termed by Linnaeus in 1753. It is mainly composed of seven species with six species reported from South America and one from Ethiopia [1]. It is innate to South America but some of the taxas can be found in almost 50 countries of the world and in some countries it can be cultivated as well [2]. It is also known as red sage and is used as popular ornamental plant in gardens [3]. *L. camara* grows in tropical, subtropical and temperate regions at a high altitude upto 2000 m [4]. The plant has woody stem with several different colours of flowers i.e. red, white, pink as well as the plant contain spines or prickles [1]. The genus consists of 650 cultivars but the majority is related with the *L.camara* complex. It is also considered as a noxious weed globally [5]. Moreover, it is stated that the ash of *L.camara* contain manganese and potassium which are useful for coconut trees [2]. Few reports consider it as a poisonous plant for humans as well as animals [6,7]. Traditionally, *L. camara* have been used as a medication to treat various diseases such as cancer, tumors, tetanus, cuts, eczema, measles, chicken pox, fevers, rheumatism and asthma [8–11]. *L.camara* possess therapeutic potential because it is a rich source of various bioactive components including steroids, triterpenoids, oligosaccharides, iridoide glycosides, naphthoquinones and phenylpropanoid glycosides [12–14] .

Different important phytochemicals have been isolated form *L.camara* including ursolic acid, oleanolic acid, linaroside, lantanoside, verbascoside, camarinic acid, phytol and umuhengerin and their biological activities including anticancer, antibacterial, antioxidant, , antiulcer and nemeticidal have been well studied [11,12,15,16]. Additionally, it is also known as one of the best as well as easily obtainable materials for the isolation of EOs branded as *Lantana* oils [17]. These important EOs obtained from L.*camara* from different localities have been reported [15,18,19] and there important biological activites including antioxidant [20], antibacterial [21] as well as anti-inflammatory [22] have been reported . However, up to date almost 41 sequences including (rps3, atpB, ccsA, rpoC1, rpoC2, FT, GLO1,rpl32 and rbcL) have been deposited in the NCBI Genbank database [23] and recently the genome of *L.camara* is also reported [24] . Looking at the medicinal and economic importance of *L. camara* there is a need of a comprehensive review for gathering all the information about its pharmacology, toxicology, and phytochemistry. This review will serve as a baseline for further molecular studies of *L.camara*.

2. Scientific Classification and Plant Description

Family: Verbenaceae
Scientific name: Lantana camara
Kingdom: Plantae
Order: Lamiales

Lantana camara is an erect vigorous shrub which can grow up to 4 meters in height. The leaf is 2-10 cm long and 2-6 cm wide and is ovate or ovate oblong shaped. Leaves are green and tough with fine hairs and have a pungent odour and it have ability to climb upto 15 meters with the help of support. It can easily grow in favorable conditions and flowers usually appear in the month of March and August. The color of the fruit is green and drupaceous with two nutlets. Mature plants produce upto 2000 seeds annually. The roots of *L.camara* are very strong having a main taproot with many small side roots [25].

3. Phytochemistry

L.camara is a medicinal plant and due to this property all parts of the plant were studied for chemical compounds. The leaf extracts were found to have majority of chemical constituents including Triterpenoids, alkaloids, flavonoids, tannins, saponins, glycosides [19,20,26–28]. In spite of leaves phytochemical studies of *L.camara* stem and fruit was also performed [26]. They reported tannins, saponins, flavonoids, and terpeniods from stem and fruit. The following compounds were reported by GC/MS analysis of the fruit in n-Hexane fraction [26] (Table.1).

Table1: GC-MS analysis of of *L. camara* fruit

Sr#	Compound Name	Chemical Formula
1	Pentadecanoic acid, 14-methyl-,methyl ester	$C_{17}H_{34}O_2$
2	2-pentadecyn-1-ol	$C_{15}H_{28}$
3	Tetradecanoic acid	$C_{14}H_{28}O_2$
4	Benzene,(1,1-dimethylbutyl)-(1,1-dimethylbutyl)benzene,2-Methyl-2-phenylpentane	$C_{12}H_{18}$
5	Nonadecane, 2-methyl-	$C_{20}H_{42}$
6	cis-□-Bergamotene	$C_{15}H_{24}$
7	Heptadeanoic acid	$C_{17}H_{34}O_2$
8	2(4H)-Benzofuranone, 5,6,7,7a-tetrahydro-4,4,7a-trimethyl, (R)	$C_{11}H_{16}O_2$
9	6-Methyl-2-tridecanone	$C_{14}H_{28}O$
10	Turmerone 2-Methyl-6-(4-methyl-1,3-cyclohexadien-1-yl)-2-hepten-4-one	$C_{15}H_{22}O$
11	2- Decenal (E)	$C_{10}H_{18}O$
12	Octadecanoic acid	$C_{18}H_{36}O_2$
13	Glutaraldehyde	$C_5H_8O_2$
14	Hexadecanoic acid, 15-methyl-,methyl ester	$C_{18}H_{36}O_2$
15	Curlone	$C_{15}H_{22}O$
16	4-Hexadecen-6-yne, (z)	$C_{16}H_{28}$

It was described that the root of the plant contain important bioactive compound ‘Oleanolic acid’ and its isolation procedure has been patented [29–32]. *L.camara* is also known as a rich source of essential oils and is available in the market named as Lantana oils [17,33]. A list of essential oils chemical constituents isolated from various organs of *L.camara* reported from different countries of the globe are summarized in **(Table.2)**.

Table 2: A list of major constituents of *L. camara* essential oils reported from different countries of the world.

Sr #	Countries	Compounds (%)	References
1	**Saudi Arabia**	cis-3-hexen-1-ol, 1-octen-3-ol, spathulenol, caryophyllene oxide, 1-hexanol, **β-caryophyllene**, spathulenol, c-cadinene and trans-b-farnesene.	[19]
2	**Congo**	**β-Caryophyllene**, α-humulene, bicyclogermacrene.	[34]
3	**Iran**	**β-Caryophyllene**, sabinene, bicyclogermacrene, α-humulene, 1,8 cineole.	[35]
4	**Cameroon**	*ar*-Curcumene, **β-caryophyllene**, caryophyllene epoxide II.	[36]
5	**Algeria**	**β-Caryophyllene**, caryophyllene oxide, β –elemene.	[37]
6	**Madagaskar**	**β-Caryophyllene**, davanone, sabinene, linalool, α –humulene.	[17]
7	**Nigeria**	Sabinene, 1,8-cineole, **β -caryophyllene**, α –humulene.	[18]
8	**South China**	Germacrene-D, **β-caryophyllene**, α -humulene, germacrene-B.	[38]
9	**Egypt**	**β-Caryophyllene**, α-humulene, bicyclogermacrene, germacrene-D, Farnesol, spathulenol.	[39]
10	**Brazil**	**β-Caryophyllene**, germacrene-D, bicyclogermacrene, germacrene-D-4-ol.	[14,40,41]
11	**India**	Germacrene-D, β -elemene, γ -elemene, **β-caryophyllene**, α-copaene, α –cadinene.	[42,43]
12	**Cuba**	E-nerolidol, d-cadinene, α-humulene, **β-caryophyllene**.	[44]

If we make a comparative analysis of Saudi Arabian essential oil composition with the essential oil reported from other countries. Here, it is significant to mention that essential oils composition reported from Saudi Arabia is different as compare to other countries (Table.2). For instance *cis*-3-hexen-1-ol and 1-hexanol are major constituents of *L.camara* essential oils which are reported first time from Saudi Arabia and have not been detected by earlier studies reported [19]. Furthermore, β-caryophyllene; a natural bicyclic sesquiterpene is the main compound reported in most of the *L.camara* essential oils composition reported so far. Therefore, it is suggested that β-caryophyllene can be used as an important chemical marker for *L.camara* essential oils.

4. Ethnopharmacology

Lantana camara L. being a medicinal plant have used worldwide to cure of various diseases [9]. It's leaves can be boiled and used as tea and its decoction is used for the treatment of cough, tetanus, malaria and the lotion made from the leaves can be used to treat wounds [28,45]. In Ghana, the infusion prepared from the whole plant is used for treating bronchitis and roots powder form mixed with milk is used for stomach-ache [46]. It has been reported that lancamarone, an important steriod isolated from the leaves of *L.camara* possess cardiotonic potentials [47]. Traditionally, its leaves can be used as a tonic for abdominal pains as well as it can be used as insecticide [48]. In some countries of Asia the leaves of the plant have been used to cure cuts, ulcers and rheumatisms [11].

5. Pharmacological Properties

L.camara being a medicinal plant has several pharmacological properties mentioned below.

5.1 Antifungal and Antibacterial activities

L.camara as a medicinal plant possesses vital antifungal potential. Its antifungal potential was screened against *Alternaria* sp. a pathogenic fungus causing diseases especially in vegetables. The food poison plate technique was used to perform the antifungal activity with three different concentrations of extract i.e. 10mg/ml, 15mg/ml and 20mg/ml. It was noted that at 20mg/ml the plant showed significant antifungal activity against *Alternaria* sp. [49]. In another study ethanolic and hot water extract was used against white and brown rot fungi known as wood destroying fungi. A significant antifungal activity was seen in both extracts, however, low concentration (0.01%) ethanolic extract was more significant [50].

L.camara possesses antibacterial potential as a different part i.e. leaves and flowers have shown strong antibacterial activity. It was reported that leaf and flower tissue samples of different variety of *L.camara* in three different kind of solvent extract showed significant antibacterial activity against *E. coli*, *Bacillus subtilis* and *P. aeruginosa* however poor antibacterial activity was reported against *Staphylococcus aureus* [4]. In another study an ethanolic extract prepared from *L. camara* leaf and root tissues were testified and microdilution method was used for *in vitro* antibacterial activity. The results showed significant antibacterial activity against *Staphylococcus aureus*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, *Víbrio cholareae*,

Escherichia coli and two multi resistant strains *E. coli* and *S. aureus* [51].

Previous studies reported that different organs of *L. camara* were grind into powder and methanol was used to prepare the extracts and were subjected for antimicrobial activities against ten bacteria and five fungi by taking and advantage of disk diffusion broth microdilution methodologies. The activities showed significant results against *Bacillus cereus* (Gram positive bacteria)and *Salmonella typhi* (Gram negative bacteria) [52].

5.2 Antiulcerogenic and Antihyperglycemic activities

In order to discover the antiulcerogenic potential of *L.camara* a methanolic extract was prepared and its evaluation was done in aspirin induced gastric ulcerogenesis in pyloric ligated rats, ethanol induced gastric ulcer, and cysteamine induced duodenal ulcer models. Two different oral dosages of the extract were given with 250 mg/kg and 500 mg/kg. The results of *L. camara* extract showed significant ($P<0.01$) reduction in ulcer index, total acidity as well as significant ($P<0.01$) increase in the gastric pH of aspirin+pylorus-ligation induced ulcerogenesis and ethanol induced gastric ulcer models. Thus it was concluded that leaves of *L.camara* have the potential healing of gastric ulcer and can prevent intestinal ulcer in rats [11].

In another study a methanolic extract from leaf tissues was prepared and its effect was studied on aspirin, ethanol and cold restraint stress induced gastric lesions in rat models. The results revealed antiulcerogenic activity in a dose dependent manner and reduce the volume of gastric juice, total acidity, free acidity but showed a significant ($P<0.001$) enhancement in pH levels in aspirin induced gastric ulcer. When a pre-treatment was given with two dosages (200 and 400 mg/kg) an ulcer protective effect was seen with a protection percentage of (63.31%, 71.02%) in aspirin induced, (85.79%, 93.09%) in ethanol induced and (46.86%, 63.90%) protection in cold restraint stress induced ulcer models. It was shown that the extract possess *in vivo* antioxidant potentials as an increase was noticed in superoxide dismutase (SOD), catalase, reduces glutathione (GR) activities in treated group [53].

Antihyperglycemic activity was also performed using methanolic extract prepared from *L. camara* leaf tissues and subjected to alloxan induced diabetic rats. The extract was orally administered (400 mg/kg) and the results stated a reduction in glucose level to (121.94 mg/dl) in the blood in alloxan induced diabetic rats [54]. Additionally, hypoglycemic activity of methanolic extracts of the fruit was tested in streptozotocin induced diabetic rats. As result s a dose dependent reduction was seen in the glucose level of serum as well as development in body weight, HbA1c profile and liver cells regeneration in streptozotocin induced diabetic rats [55].

5.3 Nematicidal and Insecticidal activities

To investigate the nematicidal potential of *L. camara* various concentrations of leaf extract were considered under in-vitro conditions against second stage juveniles (J2) of Meloidogyne incognita. When the standard condition 'S' (extract made of leaf tissues) was given and checked after 12 and 48 h the result noted was highly nematostatic, and nematodes were found paralyzed, however at same concentration 96% of juveniles were seen to be dead. Nonetheless, in S2 dilution at 48 hours the mortality rate of juveniles was found 75% [56].

It was shown that lantanilic acids, camaric acid as well as oleanolic acid possess nematicidal activities. Further investigation and isolation was done by bio-assay guided fractionation method using extract prepared with methanol from the aerial parts of *L. camara* L. The result showed 98%, 95% and 70% mortality rate against *Meloidogyne incognita* (root-knot nematode) at 0.5% concentration. However, furadan an important insecticide displayed 100% mortality 0.5% concentration [16].

L.camara exhibits strong activities against different insects. To identify the potential of insecticidal activity an extract was prepared from leaf tissues and it was noticed that the extract possess fumigant and have shown significant toxicity against *S. oryzae*, *C. chinesis* and *T. castaneum*. The results of the fumigant assay indicated that the LC_{50} for *T. castaneum* was (178.7 µl/L), *C. chinensis* (130.3 µl/L) as well as *S. oryzae* was (128 µl/L). However, the values of LD_{50} in contact toxicity for *S. oryzae* was (0.158), *C. chinensis* (0.140) and *T. castaneum* (0.208 mg/cm^2). The results of grain treatment indicated that 7 days exposure and 500 mg/L concentrations are required for obtaining 90 – 100 % extinction of population in these insects. Furthermore, by using probit analysis it was suggested that *C. chinensis* were more susceptible than *S. oryzae* and *T. castaneum* [57].

In additional study an investigation was done on *L. camara* in order to find their insecticidal, antifeedant and antiovipositional activities against *Callosobruchus chinensis*. The results showed that petroleum ether and methanolic extracts of the plant possess 10–43% mortality rate at 1–5% concentrations as well as the results also indicate the complete feeding deterrent action at 5% concentrations. A reduction in fecundity rate was also observed in both extracts at higher dosages. The antiovipositional values for petroleum ether extract was 30 mg/100 g and 40 mg/100 g of seed for methanolic extract [58].

5.4 Antipyretic and Antihelmentic activities

The antipyretic activity of *L.camara* was determined by using ethanolic and ethyl acetate extracts. The results showed a decrease in the body temperature from 1.5th hour. However the antipyretic activity for both the extracts were significant (P<0.01) between 2nd and 3rd hour as compared with the negative control [59].

Helminths also known as parasitic worms are pathogens of great importance worldwide. Nowadays billions of people, especially in least develop countries, are infected with soil-transmitted helminths. Helminths infection is also a severe problem in livestock production globally, and has caused significant loss to economy as well as threatened food security. In order to find a solution for such serious problems *L. camara* L. was selected for its anthelmintic activity against Pheretima posthuma. An ethanolic extract was made using stem of *L.camara* L. and subjected for investigation of anthelmintic potential. The analysis showed significant result at 500 mg/ml dosage when compared to standard drug albendazole at 20mg/ml concentration [60].

4.5 Larvicidal and Wound healing activities

Mosquitoes are a group of insects which affect human beings more than any other organism. Although the loss of blood by mosquitos bite from human beings is trivial, but several contagious diseases i.e. fever, malaria, dengue; caused by these mosquitoes are of great importance in terms of public health. As a step forward to find cure for such diseases researchers have done alot of studies by using various parts of *L.camara* extracts.

Mosquito larvicidal activity of extracts prepared using leaf and flower tissues of *L. camara* L. in methanol and ethanol have been thoroughly studied. As a step forward the larvae of Aedes aegypti and Culex quinquefasciatus (mosquito species) was used for (24h) in a dose dependent manner. The results showed maximum mortality rate in *Aedes aegypti* with 1.0 mg/ml concentration of extracts of *L.camara* when exposed for 24 hours. However, in case of Culex quinquefasciatus the mortality rate was maximized with increase in concentration to 3.0mg/ml [61].`

In additional study an extract from *L.camara* leaf tissues was prepared to determine its efficiency against mosquito larvae. The effects showed that *L.camara* is a best larvicide as the larvae required 80mg/100ml concentration of the aqueous extract for 6 hours for getting 100% mortality rate [62]. Additionally, in another study extracts from various parts of the plant was made and screened for activity in the brine shrimp lethality test (BST). The active fractions yielded known oleanonic acid (1), lantadene A (2) and oleanolic acid (3), which were very toxic to brine shrimp larvae. Compounds 1-3 were not lethal to Spodoptera littoralis Biosduval (Lepidoptera: Noctuidae), Clavigralla tomentosicollis Stal. (Hemiptera: Coreidae) and Aphis craccivora Koch (Homoptera: Aphididae) when tested at 5000µg/ml. Compound 2, however, suppressed the fecundity of C. tomentosicollis at this concentration [63].

6. Conclusion

There is a high increase in demand of herbal drugs nowadays. Plants are famous for possessing many chemical moieties with a lot of pharmacological properties. Many powerful and efficient drugs have been isolated from medicinal plants for treating dreadful diseases. So it is quite clear that the studies of medicinal plants are very important for the benefits of human beings in terms of manufacturing herbal drugs. *Lantana camara* is one of these vital medicinal plants which have been used as folk medicine globally. Several phytochemical reports showed that the plant is rich in important chemical compounds as well as essential oils. Steroids, coumarin, monoterpenoids, flavonoids, diterpenes including many other chemical compounds have been reported from *L camara*. Maximum numbers of the pharmacological investigations carried out on L camara are just preliminary tests on some animal models. These studies are not sufficient in order to develop pharmaceutical products, however, intensive preclinical and clinical research studies are needed for the evaluation of the efficacy and toxicity of these products. Additionally, more research is required for the investigation of unexplored potential of this important medicinal plant.

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