INTRODUCTION

The genus *Lantana* is from the Verbenaceae family, *Lantana camara* was introduced in India, for its ornamental and attractive nature. It is called a wild sage because of its toxicity, and it outcompetes with other most desirable species of flora and fauna. It is considered one of the important medicinal plants in the world. *Lantana* is widely used as folk medicine in many states and in and around India and Bangladesh. Phytochemical investigation has resulted in the isolation of various bioactive phytochemicals from different parts of the plant. Therefore, the aim of the present review is to provide a complete compilation of the phytochemical components of *Lantana* recorded in the literature. The biological activities of *L. camara* were reviewed based on their scientific reports in recent years. All reported phytochemical constituents of *Lantana* plant are summarized in Table 1 with their molecular weight and chemical structure for further discussion. The appearance of *L. camara* with its flower and leaf is shown in Figure 1.

CHEMICAL CONSTITUENTS OF LANTANA

There are around six iridoid glycosides and six oligosaccharides isolated from the ethanolic roots of *L. camara* that includes stachyose, verbascose, ajugose, verbascotetracose, theveside, theviridoside, lamiridoside, geniposide, Lantanose A, and Lantanose B. Stem oil extract of *Lantana* is identified to contain about 66 phytochemical constituents. The major constituents of fruit oil of *Lantana* were identified as stearic acid, palmitic acid, and germacrene D, while major constituents of stem oil were identified as palmitic acid and stearic acid. Chemical constituents such as linalool, phytol, 1-octen-3-ol, alpha-muurol, beta-bisabolol, trans-beta-farnesene, alpha-curcumene, alpha-cardinol, beta-caryophyllene, beta-bisabolene, tetradecanoic acid,
### Table 1: List of phytochemicals reported from Lantana plant

| Chemical name   | Mol. wt. (g/mol) | Molecular structure | Chemical name   | Mol. wt. (g/mol) | Molecular structure |
|-----------------|------------------|---------------------|-----------------|------------------|---------------------|
| Camaric acid    | 568.8            | ![Molecular structure](image) | Oleanolic acid  | 456.7            | ![Molecular structure](image) |
| Ursolic acid    | 456.7            | ![Molecular structure](image) | Katonic acid    | 456.7            | ![Molecular structure](image) |
| Pomolic acid    | 472.7            | ![Molecular structure](image) | Luteolin        | 286.24           | ![Molecular structure](image) |
| Betulonic acid  | 454.7            | ![Molecular structure](image) | Salicylic acid  | 138.12           | ![Molecular structure](image) |
| Betulinic acid  | 456.7            | ![Molecular structure](image) | p-Hydroxybenzoic acid | 138.12 | ![Molecular structure](image) |
| Lantadene A     | 552.8            | ![Molecular structure](image) | p-Coumaric acid | 164.16           | ![Molecular structure](image) |
| Lantadene B     | 552.8            | ![Molecular structure](image) | Oleanolic acid  | 456.7            | ![Molecular structure](image) |
| Icterogenin     | 568.8            | ![Molecular structure](image) | Beta-curcumene  | 204.35           | ![Molecular structure](image) |
| (+)-Nuciferol   | 218.33           | ![Molecular structure](image) | (E)-Nuciferal   | 216.32           | ![Molecular structure](image) |

(Contd...)
### APPLICATIONS OF KNOWN PHYTOCHEMICALS

All reported molecules from *Lantana* have been known to have many pharmaceutical activities. The following is a list of known activities of reported phytochemicals from *Lantana*.

**Betulinic acid**

It exhibits therapeutic activities against breast cancer cells and normal fibroblast cells.\(^9\) It also acts as an antimelanoma agent.\(^9\)
Beta-curcumene

It is a type of sesquiterpene.[11]

Betulonic acid

Ionic derivatives of betulinic acid show better biological activities and are more soluble in water. It exhibits antiviral activity and works against the herpes simplex virus type-2.[12]

Camaric acid

It is isolated from the methanolic extract of Lantana involved in the nematicidal activity.[13]

Icterogenin

It is involved in changing the rate of bile flow in mice.[14]

Katonic acid

It is a cytotoxic triterpene which acts as a plant anticancer agent.[15]

Lantadene A

It is also called as rehmannic acid. It is the active principle of L. camara L. which has certain oxygen functions.[16]

Lantoic acid

It is a pentacyclic triterpenoid involved in nematicidal activity found from the aerial parts of Lantana.[17]

Luteolin

It suppresses the growth and metastasis of human lung cancer cells. It possesses antitumor, anti-inflammation, anticancer, and antioxidant activities.[18] It is a type of flavonoid which induces the immunomodulatory response in peripheral blood mononuclear cells.[19] It is a type of polyphenolic flavone that stimulates the antitumor effect of cisplatin in drug-resistant ovarian cancer through inhibition of cell metastasis and programmed cell death.[20] It has chemo stimulating and antiproliferative on human gastric cancer cell lines.[21] It also reduces obesity-associated insulin resistance in mice by certain signaling in adipose tissue macrophages and is also involved in insulin resistance.[22]

Martynoside

These plant phenylpropanoid glycosides consist of antimetastatic, anticancer, and cytotoxic activities. It can also be considered as natural selective estrogen receptor modulator.[23] It also helps in retarding the skeletal muscle fatigue depending on their antioxidant activities.[24]
Oleanolic acid

It possesses diverse pharmacological activities and a naturally occurring pentacyclic triterpene, it inhibits the cell proliferation and cell survival of prostate cancer cells.[23] It also suppresses the proliferation of lung carcinoma cells, which indicates its antitumor activity.[25] Its combination with metals such as iron or zinc possesses significant anti-inflammatory, immunomodulatory, and antiasthma activity.[27]

p-Coumaric acid

It is a type of cinnamic acid which has antioxidant activity. It can also prevent bone loss, thereby promotes osteoblastogenesis.[28] It also possesses antiproliferative effect on colon cancer both in vitro and in vivo.[29]

p-Hydroxybenzoic acid

It is used as a fungicide, it has potential biotechnological application in food, pharmacy, cosmetics, etc.[30]

Pomolic acid

Competitive antagonist of norepinephrine and adenosine triphosphate induced aggregation of human platelets.[31]

Salicylic acid

It is a key plant hormone that is involved inhosting response against microbial infections.[12]

Theviridoside

It is found in the roots of the L. camara.[6] It also shows cytotoxicity towards human cancer cell lines.[13]

Ursolic acid

It is a plant-based pentacyclic triterpenoid carboxyl acid, against vascular endothelial damage, and liver oxidative injury in the mice.[34] It also acts as an effective neuroprotective drug against the inflammatory responses on the cerebral region of the brain. It can act as an inflammatory agent.[15]

PHARMACOLOGICAL ACTIVITIES OF LANTANA

Anti-inflammatory activity

Leaf extract of Lantana possesses phytochemicals like terpenoids (mainly triterpenes and sesquiterpenes) that are cytotoxic to tumor cells and exhibited anticancer potential in animal models. Therefore, the extraction of triterpenoids for drug development is useful because of its many biological activities.[36] There are around 70 triterpenes isolated from this genus. The methanolic extract of this plant has been reported to reduce the carrageenan-induced paw edema. Anti-inflammatory agents can suppress seizures in humans and involve in the process of epileptogenesis. It can also induce the cytokine encoding genes, which suppresses inflammation. Based on these attributes, Lantana plant is considered to be significantly anti-inflammatory in nature.

Antioxidant activity

Antioxidant property is a fundamental factor of all food substances. It is estimated in terms of reducing potential and free radical scavenging exercises.[37] It benefits by counteracting the degenerative ailments through oxidative mechanisms. Extracts of Lantana leaves are proven to be rich in flavonoid content. There are around 30 flavones isolated from Lantana species. These flavones are also believed to activate certain antioxidant response systems in the cell system which helps in scavenging reactive oxygen molecules from the cell. Phenolic compounds such as caffeic acid and rosmarinic acid are reported to be teeming compounds in the methanolic extract of Lantana, which contributes to the antioxidant nature of the plant. There are many varieties of Lantana leaf extract which shows the free radical scavenging activity and in vitro lipid peroxidation. Thereby, it prevents certain human diseases such as myocardial infection, cancer, and rheumatoid arthritis.[38] Verbascoside is the major phenolic compound present in the species of Lantana (Lantana montevidensis) which helps in preventing the disease named Konzo which is related to oxidative damage.[39] These reports support the fact that Lantana is a potential source of antioxidant molecules.

Antimicrobial activity

Compounds like flavones isolated from the leaves of Lantana species possess antifungal and antibacterial properties.[40,41] Known for its bioactive molecules, Lantana also readily kills off the bacteria, aiding to its antibacterial activity.[1] Extracts of these plants are also proven to treat gastrointestinal infections.[42] Lantana is also proven to exhibit antifungal activity against selected fungal strains.[42] The main components of the essential oil of Lantana species consist of E-nerolidol, phytol, and E-caryophyllene which provide resistance to many fungal pathogens.[42] This is a potential source for further exploitation, as there is only handful of research done in this aspect of the plant.

Anticancer activity

Anthraquinones are reported to be present in Lantana. Anthraquinones are commercially used in many pharmaceutical industries as an anticancer agent. This suggests a potential anticancerous application of Lantana.
The phenolic compounds of this plant have been reported to help in cancer prevention. It is also proven to inhibit the proliferation of cancer cells.\textsuperscript{[43]} \textit{L. camara} has shown cytotoxic effects on cancer cell lines at low concentrations. It shows the potential of the plant to be used in treatment.\textsuperscript{[42]}

\textbf{Antidiabetic activity}

Saponins present in the extract of \textit{Lantana} are proven to help in reducing the blood glucose level. It is also proven to decrease the blood cholesterol level. It further helps in promoting general health.\textsuperscript{[44]}

\textbf{Cardiac activity}

The presence of cardiac glycosides inside \textit{Lantana} is one of the important features proven to be involved in the treatment of cardiac rhythm disorder and congestive heart failure. There are around 16 phenylethanoid glycosides and eight iridoid glycosides isolated from the same species. These proved that the phytochemicals in \textit{Lantana} plant can be used in treating heart ailments and disorders.

\textbf{Anti-insecticidal activity}

Besides the venture as a psychoactive medication, alkaloids deduced from \textit{Lantana} are used as insecticides which have significant toxicity toward insects.\textsuperscript{[45,46]} Leaves and flower extracts of \textit{Lantana} have been proven to have larvicidal activity. The essential oils present in the blades of \textit{Lantana} have been proven to have insecticidal effects on vectors of dengue, malaria, dengue hemorrhagic fever, Chikungunya, and yellow fever.\textsuperscript{[17]} These attributes of \textit{Lantana} can potentially be exploited in developing insecticides for agricultural usage and developing topical mosquito repellents.

\textbf{Anthelmintic activity}

Leaves of \textit{Lantana} species have been proved to be effective in anthelmintic property. Ethanolic extracts of \textit{Lantana} species have been observed to be highly effective against certain worms like \textit{Pheretima posthuma}.\textsuperscript{[47]} Extracts of \textit{Lantana} have shown anthelmintic activity against \textit{Fasciola hepatica} as well, which causes hepatic disease to many domestic animals leading to death and thereby severe economic loss.\textsuperscript{[48]}

\textbf{Antipyretic activity}

Ethanolic extract of \textit{Lantana} plants has been observed to be antipyretic in nature. It lowers the temperature of the body by inhibiting the synthesis of prostaglandins.\textsuperscript{[49]} Extracts of \textit{Lantana montevidensis} have also demonstrated antipyretic activity.\textsuperscript{[59]}

\textbf{Antispasmodic activity}

Oleanolic acid has been isolated from \textit{Lantana} which is used by folk medicine practitioners from Bangladesh as an antispasmodic agent.\textsuperscript{[50]}

\textbf{Antidiarrheal activity}

The stem of the \textit{L. camara} has been used traditionally in the treatment of diarrhea. Scientific analysis proved that administration of \textit{L. camara} causes a significant defect in the frequency and the weight of defecation. Ethnopharmacological studies have shown that it has biological activity (antibacterial) against bacteria, causing diarrhea.\textsuperscript{[51]} \textit{Lantana} is also proven to have unique laxative and combustible properties.

\section*{CONCLUSION}

\textit{L. camara} is widely used in the conventional medicine system for the remedy of itchiness, wounds, boils, blisters, bilious fever, cataract, and inflammation, including rheumatism. Diverse parts of the flowers are used in the treatment of cold, neuralgia, chickenpox, eyesores, whooping cough, asthma, bronchitis, and arterial hypertension. \textit{L. camara} has been reliably studied for numerous curative activities such as antioxidant, antibacterial, antipyretic, larvicidal, insecticidal, antimicrobial, wound healing, and antihyperglycemic potential. With many proven biological activities, \textit{Lantana} is definitely a valuable medicinal plant, it can be used for drug development. \textit{Lantana} has been an invasive plant since many times, which affects biodiversity to a large extent every year. Due to the alarming rate of the spread of this invasive species, particularly in the tropical and the subtropical countries such as India and South Africa, these countries are currently focussing on eradication of this plant by pruning, burial, and burning. Instead, this plant can be used in therapeutic applications based on their phytochemical constituents and pharmaceutical value of the plant. This review suggests that rather eradicating the plant from its existence, it can be uprooted and used as raw materials to extract pharmaceutically valuable bioactive phytochemicals.

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REFERENCES

1. Day MD, Wiley CJ, Playford J, Zalucki MP. Lantana: Current Management Status and Future Prospects. Canberra, Australia: Australian Centre for International Agricultural Research; 2003. p. 102.

2. Donald GB. Medical Toxicology of Natural Substances: Foods, Fungi, Medicinal Herbs, Plants, and Venomous Animals. Hoboken: John Wiley & Sons; 2008.

3. Dubey M, Sharma S, Sengar R, Bhadauria S, Gautam RK. In vitro antibacterial activity of Lantana camara leaves hydrosol. J Pharm Res 2011;4:3972-4.

4. Saxena M, Saxena J, Khare S. A brief review on: Therapeutic values of Lantana camara plant. Int J Pharm Life Sci 2012;3:1551-4.

5. Verma RK, Verma SK. Phytochemical and termiticidal study of Lantana camara var. Aculeata leaves. Fitoterapia 2006;77:466-8.

6. Pan WD, Li YJ, Mai LT, Ohtani K, Kasai R, Tanaka O. Studies on chemical constituents of the roots of Lantana camara. Yao Xue Xue Bao 1992;27:515-21.

7. Khan M, Srivastava SK, Jain N, Syamasundar KV, Yadav AK. Chemical composition of fruit and stem essential oils of Lantana camara from Northern India. Flavour FrAGR J 2003;18:376-9.

8. Khan M, Mahmood A, Alkhathlan HZ. Characterization of leaves and flowers volatile constituents of Lantana camara growing in central region of Saudi Arabia. Arab J Chem 2016;9:764-74.

9. Hussein-Al-Ali SH, Arulselvan P, Fukaruzi S, Hussein MZ. The in vitro therapeutic activity of betulinic acid nanocomposite on breast cancer cells (MCF-7) and normal fibroblast cell (3T3). J Mater Sci 2014;49:8171-82.

10. Yu M, Ocampo JE, Trombetta L, Chatterjee P. Molecular interaction studies of amorphous solid dispersions of the antmelanoma agent betulinic acid. AAPS PharmSciTech 2015;16:384-97.

11. Davidovich-Rikanati R, Lewinsohn E, Bar E, Iijima Y, Verma RK, Verma SK. Phytochemical and termiticidal study of Lantana camara var. Aculeata leaves. Fitoterapia 2006;77:466-8.

12. Visalli RJ, Ziobrowski H, Badri KR, He JJ, Zhang X, Liao F, Zheng RL, Gao JJ, Jia ZJ. Retardation of skeletal muscle fatigue by the two phenylpropanoid glycosides: Verbascoside and martynoside from Pedicularis plicata maxim. Phytother Res 1999;13:621-3.

13. Li X, Song Y, Zhang P, Zhu H, Chen L, Xiao Y, et al. Oleanolic acid inhibits cell survival and proliferation of prostate cancer cells in vitro and in vivo through the PI3K/Akt pathway. Tumour Biol 2016;37:7599-613.

14. Liu F, Zheng RL, Gao JJ, Jia ZJ. Retardation of skeletal muscle fatigue by the two phenylpropanoid glycosides: Verbascoside and martynoside from Pedicularis plicata maxim. Phytother Res 1999;13:621-3.

15. Li X, Song Y, Zhang P, Zhu H, Chen L, Xiao Y, et al. Oleanolic acid inhibits cell survival and proliferation of prostate cancer cells in vitro and in vivo through the PI3K/Akt pathway. Tumour Biol 2016;37:7599-613.

16. Louw PG. Lantadene A, the active principle of Lantana camara L.; isolation of lantadene B, and the oxygen functions of lantadene A and lantadene B. Onderstepoort J Vet Sci Anim Ind 1948;23:233-8.

17. Begum S, Zehra SQ, Siddiqui BS, Fayyaz S, Ramzan M. Pentacyclic triterpenoids from the aerial parts of Lantana camara and their nematicidal activity. Chem Biodivers 2008;5:1856-66.

18. Zhao Y, Yang G, Ren D, Zhang X, Yin Q, Sun X. Luteolin suppresses growth and migration of human lung cancer cells. Mol Biol Rep 2011;38:1115-9.

19. Sternberg Z, Chadha K, Lieberman A, Drake A, Hojnacki D, Weinstock-Guttman B, et al. Immunomodulatory responses of peripheral blood mononuclear cells from multiple sclerosis patients upon in vitro incubation with the flavonoid luteolin: Additive effects of IFN-β. J Neuroinflammation 2009;6:28.

20. Wang H, Luo Y, Qiao T, Wu Z, Huang Z. Luteolin sensitizes the antitumor effect of cisplatin in drug-resistant ovarian cancer via induction of apoptosis and inhibition of cell migration and invasion. J Ovarian Res 2018;11:93.

21. Wu B, Zhang Q, Shen W, Zhu J. Anti-proliferative and chemosensitizing effects of luteolin on human gastric cancer AGS cell line. Mol Cell Biochem 2008;313:125-32.

22. Zhao L, Han YJ, Zhang X, Wang X, Bao B, Qu W, et al. Luteolin reduces obesity-associated insulin resistance in mice by activating AMPKα1 signalling in adipose tissue macrophages. Diabetologia 2016;59:2219-28.

23. Papoutsi Z, Kassi E, Mitakou S, Aligiannis N, Tsiapara A, Chrousos GP, et al. Acteoside and martynoside exhibit estrogenic/antiestrogenic properties. J Steroid Biochem Mol Biol 2006;98:63-71.

24. Liao F, Zheng RL, Gao JJ, Jia ZJ. Retardation of skeletal muscle fatigue by the two phenylpropanoid glycosides: Verbascoside and martynoside from Pedicularis plicata maxim. Phytother Res 1999;13:621-3.

25. Li X, Song Y, Zhang P, Zhu H, Chen L, Xiao Y, et al. Oleanolic acid inhibits cell survival and proliferation of prostate cancer cells in vitro and in vivo through the PI3K/Akt pathway. Tumour Biol 2016;37:7599-613.

26. Hao X, Liu M, Li D. Oleanolic acid suppresses the proliferation of lung carcinoma cells by miR-122/Cyclin G1/MEF2D axis. Mol Cell Biochem 2015;400:1-7.

27. Jehangir A, Shahzad M, Shahid K, Waheed A, Hojnacki D, Weinstock-Guttman B, et al. Immunomodulatory responses of peripheral blood mononuclear cells from multiple sclerosis patients upon in vitro incubation with the flavonoid luteolin: Additive effects of IFN-β. J Neuroinflammation 2009;6:28.

28. Zhang L, Han YJ, Zhang X, Wang X, Bao B, Qu W, et al. Luteolin reduces obesity-associated insulin resistance in mice by activating AMPKα1 signalling in adipose tissue macrophages. Diabetologia 2016;59:2219-28.

29. Papoutsi Z, Kassi E, Mitakou S, Aligiannis N, Tsiapara A, Chrousos GP, et al. Acteoside and martynoside exhibit estrogenic/antiestrogenic properties. J Steroid Biochem Mol Biol 2006;98:63-71.

30. Liao F, Zheng RL, Gao JJ, Jia ZJ. Retardation of skeletal muscle fatigue by the two phenylpropanoid glycosides: Verbascoside and martynoside from Pedicularis plicata maxim. Phytother Res 1999;13:621-3.
4-Hydroxybenzoic acid-a versatile platform intermediate for value-added compounds. Appl Microbiol Biotechnol 2018;102:3561-71.

31. Alvarado-Castillo C, Estrada O, Carvajal E. Pomolic acid, triterpenoid isolated from Licania pittieri, as competitive antagonist of ADP-induced aggregation of human platelets. Phytomedicine 2012;19:484-7.

32. Kumar D. Salicylic acid signaling in disease resistance. Plant Sci 2014;228:127-34.

33. Gorantla JN, Vellekkatt J, Nath LR, Anto RJ, Lankalapalli RS. Cytotoxicity studies of semi-synthetic derivatives of theeside isolated from the aqueous extract of leaves of ‘suicide tree’ Cerbera odollam. Nat Prod Res 2014;28:1507-12.

34. Li D, Ren D, Luo Y, Yang X. Protective effects of ursolic acid against hepatotoxicity and endothelial dysfunction in mice with chronic high choline diet consumption. Chem Biol Interact 2016;258:102-7.

35. Wang Y, He Z, Deng S. Ursolic acid reduces the metalloprotease/anti-metalloprotease imbalance in cerebral ischemia and reperfusion injury. Drug Des Devel Ther 2016;10:1663-74.

36. Silva GN, Martins FR, Matheus ME, Leitão SG, Fernandes PD. Investigation of anti-inflammatory and antinociceptive activities of Lantana trifolia. J Ethnopharmacol 2005;100:254-9.

37. Mahdi-Pour B, Jothy SL, Latha LY, Chen Y, Sagnon N. Insecticidal properties of local plants used against Anopheles gambiae, malaria vector in Burkina Faso, West Africa. Am J Trop Med Hyg 2014;915:35.

38. Vu Quan NG, Tran Quoc HP, Tran Linh TN, Tran Phu L, Nguyen Hai LT, et al. Enzymic characterization and antifungal activity of the volatile compounds of Lantana camara. J Med Plants Res 2011;5:960-68.

39. Alvarez-Mercado JM, Ibarra-Velarde F, Alonso-Díaz MÁ, Vera-Montenegro Y, Avila-Acevedo JG, Garcia-Bores AM. In vitro antihelmintic effect of fifteen tropical plant extracts on excysted flukes of Fasciola hepatica. BMC Vet Res 2015;11:45.

40. Ved A, Arsi T, Prakash O, Gupta A. A review on phytochemistry and pharmacological activity of Lantana camara Linn. Int J Pharm Sci Res 2018;9:37-43.

41. Rahmatullah M, Jahan R, Azam FM, Hossain S, Mollik MA, Rahman T. Folk medicinal uses of Verbenaceae family plants in Bangladesh. Afr J Tradit Complement Altern Med 2011;8:53-65.

42. Tadesse E, Engidawork E, Nedi T, Mengistu G. Evaluation of the anti-diarrheal activity of the aqueous stem extract of Lantana camara Linn (Verbenaceae) in mice. BMC Complement Altern Med 2017;17:190.

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