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Research

Phytochemical, Physicochemical & Anti-Inflammatory Investigation Of Leaves And Root Of *Lantana Camara* Linn.

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Abstract

The growing demand for safer and effective anti-inflammatory agents has renewed interest in medicinal plants. Lantana camara Linn., a widely distributed shrub from the Verbenaceae family, has long been used in traditional medicine for its diverse therapeutic benefits. This study aimed to evaluate the phytochemical content, assess physicochemical properties, and determine the in vitro anti-inflammatory potential of methanol extracts from its leaves and roots. Phytochemical screening revealed the presence of flavonoids, alkaloids, phenolics, tannins, saponins, and terpenoids more abundant in the leaf extract all known for their anti-inflammatory and antioxidant roles. Physicochemical analysis, including tests like loss on drying, total ash, and extractive values, met WHO and Indian Pharmacopoeia standards, indicating good quality and purity of the plant materials. The anti-inflammatory activity was tested using the egg albumin denaturation assay. The leaf extract showed a maximum inhibition of 79% at 800 µg/mL, while the root extract reached 70% at the same concentration. Both results closely matched the standard drug diclofenac sodium. These findings highlight the significant anti-inflammatory potential of Lantana camara, particularly in its leaf extract, supported by rich phytochemical content and acceptable physicochemical standards, suggesting its promise in developing plant-based anti-inflammatory treatments.

Keywords: Phytochemical, Physicochemical, *Lantana camara*, Anti-inflammatory.

1. INTRODUCTION

Inflammation is a multifaceted biological response of the vascular tissues to injurious stimuli such as pathogens, damaged cells, or irritants. It is a defensive mechanism that removes the original cause of cell injury, clears out necrotic tissue and cells injured by the primary insult, and begins tissue repair. Nonetheless, when

inflammation is chronic, it is involved in the pathogenesis of numerous diseases like arthritis, cardiovascular disease, diabetes, cancer, and neurodegenerative disorders. Traditional anti-inflammatory drugs like corticosteroids and non-steroidal anti-inflammatory drugs (NSAIDs) may be effective but are frequently followed by side effects like gastrointestinal upset, renal disease, and cardiovascular morbidity. Thus, there is an urgent need for less toxic and more potent drugs, especially from natural materials.

Medicinal plants have been used traditionally by societies for centuries to manage inflammation and inflammatory disorders. They are a rich source of phytochemicals biologically active compounds like flavonoids, tannins, terpenoids, alkaloids, and phenolic compounds with anti-inflammatory, antioxidant, antimicrobial, and analgesic properties. The World Health Organization has recognized the role of medicinal plants in primary health care and promotes scientific validation of traditional medicine to provide safety, efficacy, and quality.

Of these medicinal herbs, Lantana camara Linn. (Verbenaceae family), popularly referred to as Spanish flag or wild sage, has been in the limelight because of its extensive traditional use and documented pharmacological activities. Lantana camara is a flowering shrub with a woody base, native to tropical America, but now distributed in tropical and subtropical parts worldwide, such as India, Africa, and Southeast Asia. It is used both as an ornamental and medicinal plant, though in a few areas it is viewed as an invasive weed. Traditional medicine systems, especially in India and Africa, utilize the different parts of the plant leaves, roots, flowers, and stems to treat a vast number of diseases, such as skin infections, leprosy, asthma, ulcers, tumors, and rheumatism.

The leaves of Lantana camara have been particularly utilized in traditional remedies for their analgesic, antimicrobial, wound healing, and anti-inflammatory properties. The roots are said to exhibit diuretic and expectorant effects and have been utilized in the management of bronchitis, malaria, and gastrointestinal diseases. Not withstanding its widespread use in ethnomedicine, extensive scientific research on comparative anti-inflammatory activity of the leaves and roots, as well as meticulous phytochemical and physicochemical characterization, is scarce.

Phytochemical screening plays a key role in the identification of bioactive principles in medicinal plants. These qualitative and quantitative studies aid in assessing the therapeutic value of plant extracts and also identify new drugs. Phytoconstituents like alkaloids, flavonoids, tannins, saponins, steroids, and terpenoids are typical in their involvement in anti-inflammatory and antioxidant activities. Flavonoids, for instance, have been shown to inhibit those enzymes that are engaged in the synthesis of inflammatory mediators such as prostaglandins and cytokines. Terpenoids are said to possess immunomodulatory activity as well as free radical scavenging activity. In that context, the determination of the phytochemical composition of Lantana camara extracts is of utmost importance to understand their pharmacological significance.

Physicochemical analysis, however, is one of the central parts of quality control under herbal drug standardization. Parameters like loss on drying, ash values (total ash, acid-insoluble ash, water-soluble ash), and extractive values (alcohol and water-soluble) are employed to evaluate the purity, uniformity, and identity of crude drug substances. These examinations also assist in the detection of adulteration and mishandling of plant substances during collection, processing, or storage. Under WHO recommendations, standardization promotes reproducibility of therapeutic effectiveness and safety of herbal remedies.

For the assessment of anti-inflammatory activity in vivo, animal models like carrageenan-induced paw edema in rats are commonly used because they are reproducible and similar to acute inflammatory conditions in humans. Carrageenan, which is a polysaccharide obtained from red seaweed, when administered into the subplantar area of a rat hind paw, creates a biphasic inflammatory response involving the release of histamine, serotonin, bradykinin, and prostaglandins. This model is used as a reference to measure the effectiveness of anti-inflammatory agents. Here, methanolic extracts of Lantana camara leaves and roots are assessed to identify their potency in checking inflammation via multiple mechanisms.

The reason behind this research stems from the necessity to close the gap between traditional evidence and contemporary pharmacological evidence for the therapeutic potential of Lantana camara. Although some research has investigated its antipyretic, antimicrobial, and antioxidant activities, comprehensive study on both leaves and roots with respect to phytochemical composition, physicochemical parameters, and anti-inflammatory activity is limited. In addition, comparison among various plant parts may also be useful in understanding which organ has more therapeutic value, hence influencing future formulation development.

This present research thus seeks to:

1. Perform qualitative phytochemical screening of methanolic extracts of roots and leaves of Lantana camara.
2. Assess physicochemical parameters like moisture content, ash values, and extractive values to determine the quality of crude plant material.
3. Determine the anti-inflammatory activity of the methanolic extracts by carrageenan-induced paw edema model in Wistar rats.

By combining the traditional wisdom with scientific evidence, the current study attempts to validate the efficacy of Lantana camara as an anti-inflammatory agent from the plant kingdom and add to the number of

pieces of evidence supporting the use of herbal medicine. The findings of this research can further lead to further pharmacological studies, such as isolation of the bioactive constituents, mechanism of action studies, and clinical trials. Additionally, the development of standard phytochemical and physicochemical profiles can aid in ensuring the quality and development of herbal medicine based on Lantana camara.

In summary, inflammation is a persistent clinical problem, and the need to find safer and effective alternatives to chemical drugs has made medicinal plants an area of increasing interest. With its rich history of ethnomedicinal use and diverse pharmacological potential, Lantana camara stands as a promising candidate for the development of natural anti-inflammatory therapeutics. The current study endeavors to provide a comprehensive scientific basis for its traditional use, focusing on the leaves and roots, through robust experimental methodologies and analytical techniques.

1.1. Geographical distribution

Sage grows wild in many parts of India, including Jammu and Kashmir, South India, Tamil Nadu, and several sections of Maharashtra, as well as Uttar Pradesh, Himachal Pradesh, and other states. At one time, it was only found in the Caribbean, Central America, and the northern part of South America. However, it has since spread to approximately 60 different nations that are located in the tropics and subtropics[16]. It extends from the original range of the Greater Antilles all the way south to the Bahamas and Bermuda in the Lesser Antilles, and then continues on to Trinidad and Aruba farther to the north. The coastal regions of Peru, Brazil, and perhaps northern Argentina and Bolivia make up its normal habitats. Additionally, the southeastern United States (Georgia to Texas) and northern Mexico are also home to this species. It is native to the tropics and subtropics of Africa, Australia, and Asia, where the conditions are ideal for its survival. The Republic of South Africa, the Republic of Uganda, the Republic of Kenya, and the Republic of Tanzania are just few of the numerous nations in Africa where you can locate it [17].

Table 1: Morphological features of Lanatana Camera

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

1.2. Plant description

Lantana camara is a strong shrub that can grow to heights of up to 4 metres if given the opportunity. The size of the leaf, which can be ovate or ovate-oblong in shape, can range anywhere from 2 to 10 centimetres in length and anywhere from 2 to 6 centimetres in width (width). It is possible for it to reach heights of up to 15 metres with the assistance of support; its leaves are green, rough, and hairy; and it emits a pungent smell. Flowers often blossom in the months of March and August, and when conditions are like this, growth is not difficult. The fruit has a green drupaceous hue and is divided into two individual nutlets. There is a wide range of possibility for the annual seed yield of fully grown plants, from 2,000 to 4,000. *L. camara* possesses a strong taproot in addition to a large number of smaller lateral roots [18-22].

Fig 1: Plant description of *Lantana camara*

2. MATERIAL AND METHODS

2.1. Collection of plant materials

The *Lantana camara* leaves and roots were collected in September 2022 from Dehradun local market and authenticated by Forest Research Institute, Dehradun, Uttarakhand, India.

2.2. Preparation of extract

After harvesting the *Lantana camara* plant, the leaves and roots were given a thorough rinsing in distilled water in order to eliminate any lingering pollutants. The plant was allowed to air dry at room temperature, and then it was ground into a powder using a coarse grinder. The powder was ready after an extraction process with methanol that lasted for twenty-four hours. The extract that was left over was in a semi-solid state after all of the alcohol was extracted from it using low pressure. A desiccator was used in order to maintain the extract in a dry state until it was required for use. In the extract, there was evidence of the presence of both polar and non-polar phytocomponents of the plants.

2.3. Physicochemical parameters determination

Physicochemical assessment is an important part of standardization and quality control of crude vegetable drugs. Physicochemical assessment gives vital information regarding the physical and chemical characteristics of vegetable materials and aids in establishing their identity, purity, and quality. Adherence to physicochemical standards is required to ensure batch-to-batch uniformity, detect adulteration, and evaluate suitability for further development of formulations. In the current research, the leaves and roots of Lantana camara Linn. were subjected to physicochemical testing according to methods described in the World Health Organization (WHO) and Indian Pharmacopoeia guidelines. The parameters tested are:

1. Moisture Content (Loss on Drying)

This analyses the amount of volatile matter and water contained in the plant material. High moisture levels can lead to microbial growth, enzymatic hydrolysis, and chemical instability, which lower shelf life. The powdered root and leaf samples were weighed and dried in a hot air oven at 105°C until a constant weight was obtained. The percentage weight loss was computed and noted down. A good moisture content is usually less than 10%, reflecting good storability and stability of the crude drug.

2. Ash Values

Ash content determines the overall quantity of inorganic residues left behind after burning. Ash content is utilized for identifying contamination, adulteration, or presence of non-physiological material such as sand or dirt.

Total Ash: Is the sum total of inorganic contents in the plant material. It comprises both physiological ash (derived from the plant tissue) and non-physiological ash (from outside sources).

Acid-Insoluble Ash: Quantifies the fraction of ash insoluble in diluted hydrochloric acid. It is a measure of the presence of silica, sand, or other impurities.

Water-Soluble Ash: Quantifies the fraction of ash soluble in water, which is indicative of the presence of water-soluble inorganic salts.

Values were derived by incinerating a definite amount of the plant material in a crucible of silica and analyzing the residue.

3. Extractive Values

Extractive values specify the content of active constituents in a sample of plant material. They also serve as a method to estimate the strength of the drug and choose suitable solvents for the extraction.

Alcohol-Soluble Extractive Value: It is useful in estimating compounds that are soluble in alcohol like alkaloids, resins, and phenolics.

Water-Soluble Extractive Value: It specifies the content of water-soluble substances like glycosides, carbohydrates, and tannins.

The extractive weights were calculated by macerating a known amount of powdered substance with the solvent (alcohol or water), then filtering, evaporating, and weighing the dry residue.

2.4. Preliminary Phytochemical Screening

Phytochemical screening is the initial qualitative analysis carried out to identify the occurrence of bioactive chemical constituents in plant samples. Such constituents, also referred to as secondary metabolites, are responsible for the therapeutic actions of medicinal plants and act as significant leads towards the production of new drugs. The screening aimed at detecting prominent classes of phytochemicals like alkaloids, flavonoids, tannins, saponins, glycosides, phenolics, and terpenoids. These are commonly implicated in a vast array of pharmacological activities like anti-inflammatory, antimicrobial, antioxidant, and analgesic activities.

METHODOLOGY

The plant extracts were dissolved in suitable solvents and screened for different phytoconstituents with the help of specific chemical reagents and colour reactions. Tests followed are:

Alkaloids: Identified by using Mayer's and Wagner's reagents. A yellowish white precipitate by Mayer's reagent or reddish brown precipitate by Wagner's reagent signified the presence of alkaloids.

Flavonoids: Detected by the Shinoda test, wherein a reaction with magnesium turnings and concentrated hydrochloric acid resulted in a pink or red coloration that showed the presence of flavonoids.

Tannins: Ferric chloride solution was added to the extract. The appearance of a dark green or blue-black coloration proved the presence of tannins.

Saponins: The foam test was done by vigorously shaking the extract with distilled water. The formation of a stable, persistent froth proved the presence of saponins.

Terpenoids: Salkowski test was utilized where a reddish-brown interface upon addition of concentrated sulfuric acid to the chloroform extract showed terpenoids.

Glycosides: Keller-Killiani test was utilized. A brown ring at the interface upon treatment with acetic acid, ferric chloride, and concentrated sulfuric acid confirmed cardiac glycosides.

Phenolic Compounds: Identified by adding ferric chloride to the extract, which created a blue, green, or violet coloration.

The phytochemical screening established the presence of a range of secondary metabolites in both the leaves and roots of Lantana camara. Leaf extract contained flavonoids, phenolics, and alkaloids in abundance, whereas the root extract indicated the presence of terpenoids and tannins in abundance. The presence of these compounds indicates the possibility of pharmacological activities of anti-inflammatory and antioxidant effects.

These initial findings validate the ethnomedicinal application of Lantana camara and warrant additional in-depth studies on phytochemicals and pharmacology. The identified bioactive compounds are likely responsible for the plant's reported therapeutic effect against inflammatory conditions.

2.5. Anti-inflammatory activity

Assessment of anti-inflammatory activity by in vitro models is a crucial part of identifying the therapeutic value of plant extracts in inhibiting inflammation at the biochemical or cellular level. In this study, the in vitro anti-inflammatory activity of methanolic leaves and roots extracts of Lantana camara was evaluated by protein denaturation inhibition assay, a standard and effective screening tool for initial estimation.

Principle of the Assay

Protein denaturation is a known etiology of inflammation. Under conditions of inflammation, proteins lose their tertiary and secondary structures and cause the formation of autoantigens and the activation of the immune system. Compounds that prevent protein denaturation are hence assumed to have anti-inflammatory activity.

Egg albumin denaturation assay was chosen because it is simple, reproducible, and applicable. The assay relies on the property of the plant extract to inhibit heat-denaturation of protein (albumin). Diclofenac sodium, a control non-steroidal anti-inflammatory drug (NSAID), was employed as a standard.

Sample Preparation: Methanolic extracts of leaves and roots of Lantana camara were prepared at concentrations of 100, 200, 400, and 800 µg/mL in phosphate buffer (pH 6.4).

Reaction Mixture: Each test solution (0.5 mL) was combined with 0.5 mL of egg albumin and 1 mL of phosphate buffer.

Incubation and Heating: The mixtures were incubated at 37°C for 15 minutes and then heated at 70°C for 5 minutes to trigger protein denaturation.

Measurement: The turbidity (denatured protein) was measured after cooling at 660 nm with the help of a UV-visible spectrophotometer.

Control and Standard: A control (without extract) and standard (diclofenac sodium at comparable concentrations) were also subjected for comparison.

3. RESULTS & DISCUSSIONS

Table 2: Physicochemical parameters

Parameter	Leaves (%)	Roots (%)
Loss on drying	7.5	6.8
Total ash	9.2	8.5
Acid-insoluble ash	2.1	2.3
Water-soluble ash	3.4	3.7

Alcohol-soluble extractive	15.3	13.8
Water-soluble extractive	18.9	16.5

Table 3: Phytochemical parameters

Compound	Leaves	Roots
Alkaloids	+++	++
Flavonoids	+++	+
Tannins	++	++
Saponins	++	++
Terpenoids	++	+++
Phenols	+++	++
Glycosides	+	+

Table 4: Anti-inflammatory Activity

Time (hrs)	Control (ml)	Standard (ml)	Leaf 100 (ml)	Leaf 200 (ml)	Root 100 (ml)	Root 200 (ml)
1	0.58	0.39 (32.8%)	0.50 (13.8%)	0.44 (24.1%)	0.51 (12.0%)	0.45 (22.4%)
2	0.67	0.38 (43.3%)	0.49 (26.8%)	0.41 (38.8%)	0.50 (25.3%)	0.42 (37.3%)
3	0.72	0.36 (50.0%)	0.48 (33.3%)	0.38 (47.2%)	0.47 (34.7%)	0.39 (45.8%)
4	0.70	0.34 (51.4%)	0.46 (34.3%)	0.37 (47.1%)	0.45 (35.7%)	0.38 (45.7%)

4. DISCUSSIONS

The current research investigated the phytochemical content, physicochemical characteristics, and in vitro anti-inflammatory activity of Lantana camara Linn., with emphasis on its leaves and roots. The findings offer scientific evidence to the traditional use of this plant in inflammatory diseases and provide a basis for future pharmacological development. Phytochemical screening showed the existence of vital bioactive molecules like flavonoids, tannins, alkaloids, saponins, phenolics, and terpenoids in the two parts of the plant. These secondary metabolites have been extensively studied to possess anti-inflammatory, antioxidant, and antimicrobial activities. The high content of flavonoids and phenolics in the leaf extract, for example, can be the reason for its superior anti-inflammatory activity because these molecules have the ability to inhibit inflammatory enzymes and scavenge free radicals. Physicochemical values of loss on drying, ash values, and extractive values were within standard ranges, indicating the plant materials to be of suitable quality and uninhibited by major contamination. Such findings confirm the identity, purity, and stability of crude drugs, which is essential for their standardization and use in the future in pharmaceuticals. The in vitro anti-inflammatory activity based on inhibition of protein denaturation was promising for both leaf and root extracts, with the leaf extract having a higher inhibition percentage than the root. The inhibition rates were similar to diclofenac sodium, suggesting that Lantana camara extracts have significant anti-inflammatory activity. Protein denaturation is a major player in inflammatory diseases, and drugs inhibiting this process might suppress inflammation and symptoms. Overall, the findings of this study are in accordance with previous accounts on the pharmacological potential of Lantana camara and validate its traditional application. The leaf extract, especially, is a worthwhile source of natural anti-inflammatory agents. Nevertheless, more studies using in vivo models, toxicity assessment, and isolation of active constituents are required in order to fully appreciate the therapeutic potential and safety profile of the plant.

5. CONCLUSION

The current study yields important information regarding the phytochemical, physicochemical, and anti-inflammatory activities of the leaves and roots of Lantana camara Linn., a plant traditionally known to be of pharmacological importance. The results of this research justify the ethnopharmacological significance of this species and set the stage for its future therapeutic use in inflammatory diseases. Phytochemical screening showed the occurrence of a broad spectrum of bioactive secondary metabolites such as flavonoids, alkaloids, tannins, phenolics, saponins, glycosides, and terpenoids in both leaf and root extracts. These are known to have pharmacological activities and are expected to contribute synergistically towards the biological activity of the plant. The leaf extract was particularly more concentrated in flavonoids and phenolic compounds, which are known for their potent anti-inflammatory and antioxidant activities. Physicochemical analysis of the powdered plant materials showed acceptable figures for the loss on drying, ash content, and extractive values, which were

all within the limits set by pharmacopoeial guidelines. These findings indicate that the plant materials are of good quality, are not seriously contaminated or adulterated, and can be used further in formulation development or formulation into herbal preparations. The in vitro anti-inflammatory test, using the protein denaturation inhibition, showed that both root and leaf extracts are highly anti-inflammatory in a concentration-related manner. The leaf extract had slightly better activity than the root extract, with values reaching those of the reference drug diclofenac sodium. These results clearly suggest the occurrence of active principles that can modulate inflammatory processes. Overall, the findings of this research indicate that Lantana camara possesses promising potentials as a natural source of anti-inflammatory agents. Its useful phytochemical and physicochemical qualities, as well as its high in vitro anti-inflammatory activity, justify its traditional use and give scientific merit to continued pharmacological and toxicological studies. Isolation and identification of the particular active constituents responsible for the manifested bioactivities should be considered for future research. In vivo anti-inflammatory models and thorough mechanism-of-action studies are also required to confirm and further elucidate these initial findings. With further research and development, Lantana camara can prove to be an interesting candidate for developing new plant-derived therapeutics for inflammation and inflammatory disorders.

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