

Phytochemical Profiling and Biological Assessment of *Lantana camara* Extracts: In Vitro Evaluation of Cytotoxicity and Anti-inflammatory Activities

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ABSTRACT

The present study investigates the phytochemical composition and in vitro biological activities of solvent-specific extracts of *Lantana camara*. Petroleum ether, methanol and aqueous extracts were prepared using Soxhlet and microwaveassisted extraction methods, respectively, and characterized by FT-IR, and GC-MS analysis. The anticancer potential was evaluated against human hepatocellular carcinoma (HepG2) cells using the MTT assay, while anti-inflammatory activity was assessed through the hemolysis inhibition (membrane stabilization) assay. The petroleum ether extract exhibited potent cytotoxic activity with an IC₅₀ value below 100 µg/mL, indicating strong anticancer potential. In contrast, the aqueous extract showed comparatively lower cytotoxicity but demonstrated significant antiinflammatory activity, with marked inhibition of protein denaturation and effective membrane stabilization. These findings highlight a clear solvent-dependent structure-activity relationship and support the therapeutic potential of *Lantana camara* as a source of complementary anticancer and anti-inflammatory agents.

Keywords: *Lantana camara*; phytochemical analysis; cytotoxicity; antiinflammatory activity; HepG2 cells; GC-MS

I. INTRODUCTION

Lantana camara belonging to the family Verbenaceae, stands as one of the most widely distributed ornamental shrubs globally, yet surprisingly occupies a position among the most invasive and toxic plant species (Sharma et al., 2005). This perennial flowering

plant, native to the tropical regions of Central and South America, has established itself across diverse geographical locations worldwide, demonstrating remarkable adaptability to various climatic conditions (Ghisalberti, 2000). Despite its notorious reputation as a noxious weed causing significant ecological and economic damage, recent scientific investigations

have unveiled the substantial therapeutic potential harbored within its phytochemical constituents (Kumar et al., 2013). The exploration of *L. camara*'s medicinal properties has gained considerable momentum in contemporary phytochemical research, primarily due to its rich reservoir of bioactive secondary metabolites.

These compounds encompass a diverse array of chemical classes including triterpenes, flavonoids, alkaloids, phenolic acids, and essential oils, each contributing to the plant's multifaceted biological activities (Sousa & Viccini, 2011).

Phytochemical profiling of *Lantana camara* has revealed the presence of numerous bioactive compounds responsible for its wide spectrum of biological activities. The leaf extracts particularly demonstrate significant concentrations of polyphenolic compounds, which serve as the primary contributors to the plant's antioxidant properties (Kalita et al., 2012). Similarly, the presence of flavonoids, particularly quercetin, kaempferol, and their derivatives, has been extensively documented, with these compounds exhibiting remarkable free radical scavenging capabilities (Venkatachalam et al., 2011). The yield proportion for various solvent extracts typically ranges from 8% to 20%, with methanol and ethyl acetate extracts consistently demonstrating superior phytochemical content compared to aqueous extracts (Misra et al., 2014).

Contemporary research efforts have focused extensively on evaluating the cytotoxic potential of *Lantana camara* extracts against various cancer cell lines. In vitro investigations have demonstrated promising results, with methanolic leaf extracts exhibiting substantial growth inhibitory effects against human cancer cells including breast cancer (MCF-7), colon cancer (HT-29), and hepatocellular carcinoma (Mahdi et al., 2011). The cytotoxic mechanisms appear to involve various mechanisms, such as triggering apoptosis, halting the cell cycle, and causing mitochondrial dysfunction, suggesting the plant's potential as a source of novel anticancer agents

(Saxena et al., 2012). The anti-inflammatory properties of *Lantana camara* extracts have emerged as another significant area of research interest. Various studies have demonstrated the plant's capacity to modulate inflammatory responses through inhibition of pro-inflammatory intermediaries, including cyclooxygenase (COX), lipoxygenase (LOX), and various cytokines (Singh et al., 2010). Acquired evidences favor the methanolic extracts as particularly effective in suppressing inflammatory cascades, with activity comparable to standard anti-inflammatory drugs in several experimental models (Wollenweber et al., 2005). The anti-inflammatory mechanisms appear to be mediated through multiple pathways, including nuclear factor-kappa B (NF-κB) inhibition and prostaglandin synthesis modulation.

In short, the present study aims to comprehensively evaluate the phytochemical composition of *Lantana camara* leaf extracts prepared using different solvents, followed by rigorous assessment of their cytotoxic and antiinflammatory activities through established in vitro methodologies.

II. MATERIALS AND METHODS

Plant Material Collection, Authentication, and Preparation

Fresh leaves of *Lantana camara* were collected from Aurangabad, India, accordance with standard guidelines for medicinal plant collection (World Health Organization, 2011). The plant material was taxonomically authenticated to ensure correct botanical identity. Collected leaves were thoroughly washed under running tap water to remove dust and extraneous matter, followed by rinsing with distilled water (Edeoga et al., 2005). The plant material, once cleaned, was left to dry in the shade at room temperature ($25 \pm 2^\circ\text{C}$) for a period of 10 to 14 days until it reached a stable weight, a technique that helps retain heat-sensitive bioactive compounds. After drying, the leaves were ground into a fine powder using a mechanical grinder, passed through a 40-mesh

sieve to ensure uniform particle size, and then stored in airtight amber containers at 4 °C to prevent the degradation of phytochemicals (Kale & Yadav, 2010). An independent parallel extraction method was adopted to obtain phytochemicals with different chemical properties using solvents of varying polarity. Separated portions of 30 g of finely powdered plant material were extracted individually with petroleum ether, methanol, and water to allow direct comparison of solvent efficiency. Petroleum ether extraction was carried out using a Soxhlet apparatus with 300 mL solvent (1:10 w/v) at 40–60 °C to isolate nonpolar compounds such as hydrocarbons, waxes, and lipids, following standard Soxhlet extraction procedures (Vogel, 2002). Methanolic extraction was performed independently to recover semi-polar metabolites, including phenolics, flavonoids, and terpenoids, while aqueous extraction was conducted separately to isolate polar constituents such as glycosides and water-soluble phenolic compounds, in accordance with conventional phytochemical extraction protocols (Harborne, 1998).

All extracts were concentrated under reduced pressure using a rotary evaporator, a method commonly applied to prevent thermal degradation of heat-sensitive phytoconstituents (Azwanida, 2015). The concentrated extracts were stored in amber-colored glass containers at 4 °C to protect them from light and oxidative degradation until further analysis. The extracts underwent phytochemical analysis through Gas Chromatography–Mass Spectrometry (GC–MS) to identify volatile and semi-volatile compounds by examining their mass fragmentation patterns (Adams, 2007), and Fourier Transform Infrared Spectroscopy (FTIR) was used to ascertain the functional groups present in the extracts (Coates, 2000).

The anti-inflammatory activity of the methanolic (M), aqueous (W), and petroleum ether (P) extracts of *Lantana camara* was evaluated using the hemolysis inhibition (membrane stabilization) assay, a well-established in vitro method for assessing anti-

inflammatory potential through erythrocyte membrane protection (Oyedapo et al., 2004). The cytotoxic activity was assessed against HepG2 human hepatocellular carcinoma cells using the MTT colorimetric assay, which estimates cell viability based on mitochondrial metabolic activity. The assay enables determination of IC₅₀ values, defined as the concentration required to inhibit 50% of cell viability, and is widely used for anticancer screening (Mosmann, 1983; van Meerloo et al., 2011).

III.RESULTS

Extraction yields of plant extracts.

The extraction yields obtained in this study demonstrated significant variations across different solvents and plant species, reflecting the differential solubility of bioactive compounds in various extraction media. *Lantana camara* exhibited the highest yield with methanol (36.63%), followed by water (21.4%) and petroleum ether (13.77%), indicating that polar solvents are more effective in extracting bioactive metabolites from this species.

Plant Species	Water (%)	Petroleum Ether (%)	Methanol (%)
<i>Lantana camara</i>	21.4	13.77	36.63

Table 1: Extraction yields of *Lantana camara*

FTIR spectroscopic analysis

FTIR analysis of the aqueous, petroleum ether, and methanolic extracts of *Lantana camara* showed clear differences in functional groups based on solvent polarity. The aqueous extract mainly contained hydroxyl groups, indicating alcohols and phenolic compounds, while the petroleum ether extract was rich in saturated aliphatic hydrocarbons, confirming the presence of nonpolar lipid components. The methanolic extract exhibited prominent O–H and C–O vibrations along with alkyl groups, suggesting an

abundance of alcohol-rich and moderately polar solvent-dependent phytochemical extraction and the constituents. Overall, the FTIR results confirm chemical diversity of *Lantana camara*. (Fig. 1)

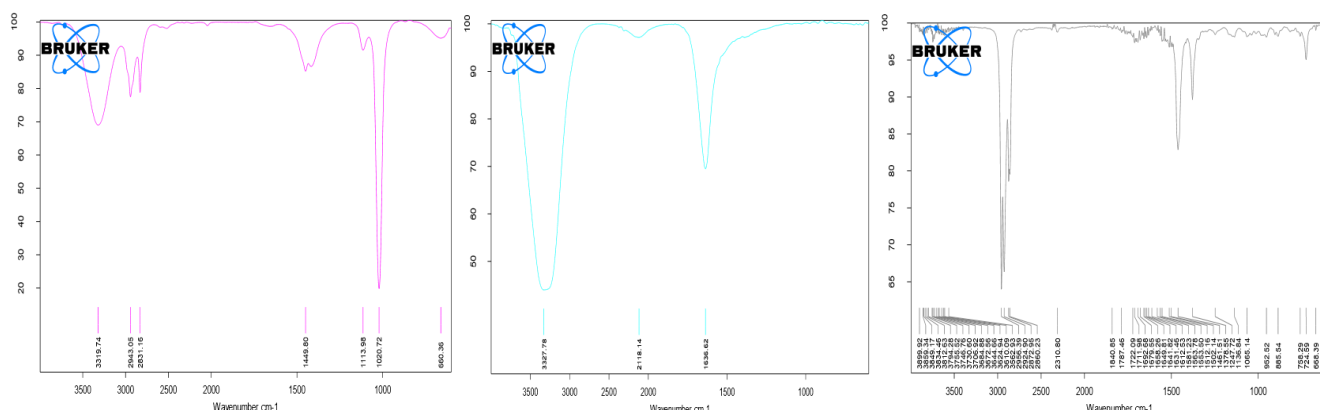


Fig. 1: FTIR Spectroscopic analysis of *Lantana camara* methanol extract, aqueous Extract and petroleum ether extract respectively.

GC–MS Analysis

GC–MS analysis of the methanolic, petroleum ether, and aqueous extracts of *Lantana camara* revealed a wide range of phytochemicals distributed across retention times of approximately 8.0–21.8 minutes. The methanolic extract showed a broad composition, with early-eluting volatile terpenoids followed by fatty acids and long-chain lipid components. The petroleum ether extract was dominated by nonpolar constituents, including monoterpenes, fatty acids, and

sterol derivatives such as stigmasterol, reflecting its affinity for lipophilic compounds. In contrast, the aqueous extract mainly contained oxygenated compounds and fatty acids, with long-chain lipids appearing at higher retention times. Overall, the GC–MS profiles highlight solvent-dependent phytochemical extraction and confirm the chemical diversity of *Lantana camara*, supporting its traditional medicinal relevance. (Fig.2).

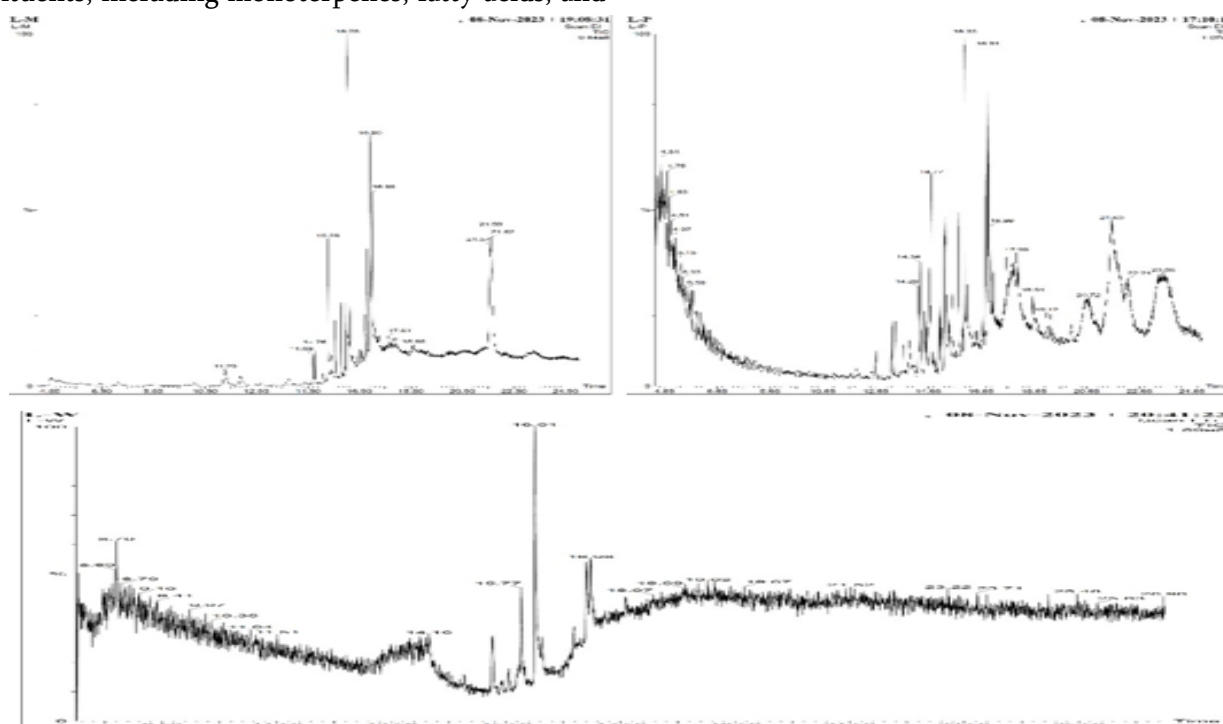


Fig 2: GC–MS analysis of *Lantana camara* methanol, petrol ether and Aqueous extracts.

Anti-Inflammatory Activity (Hemolysis Inhibition Assay)

Lantana camara extracts exhibited notable anti-inflammatory activity in the hemolysis inhibition assay, with clear differences based on solvent polarity. The methanolic extract showed the highest activity, achieving complete (100%) inhibition at 1000 µg/mL and demonstrating a strong dose-dependent response,

with 52.4% inhibition observed at 100 µg/mL. The aqueous extract also displayed substantial hemolysis inhibition, particularly at higher concentrations. In contrast, the petroleum ether extract exhibited comparatively low activity, indicating that the major anti-inflammatory constituents of *Lantana camara* are predominantly polar in nature. (Fig)

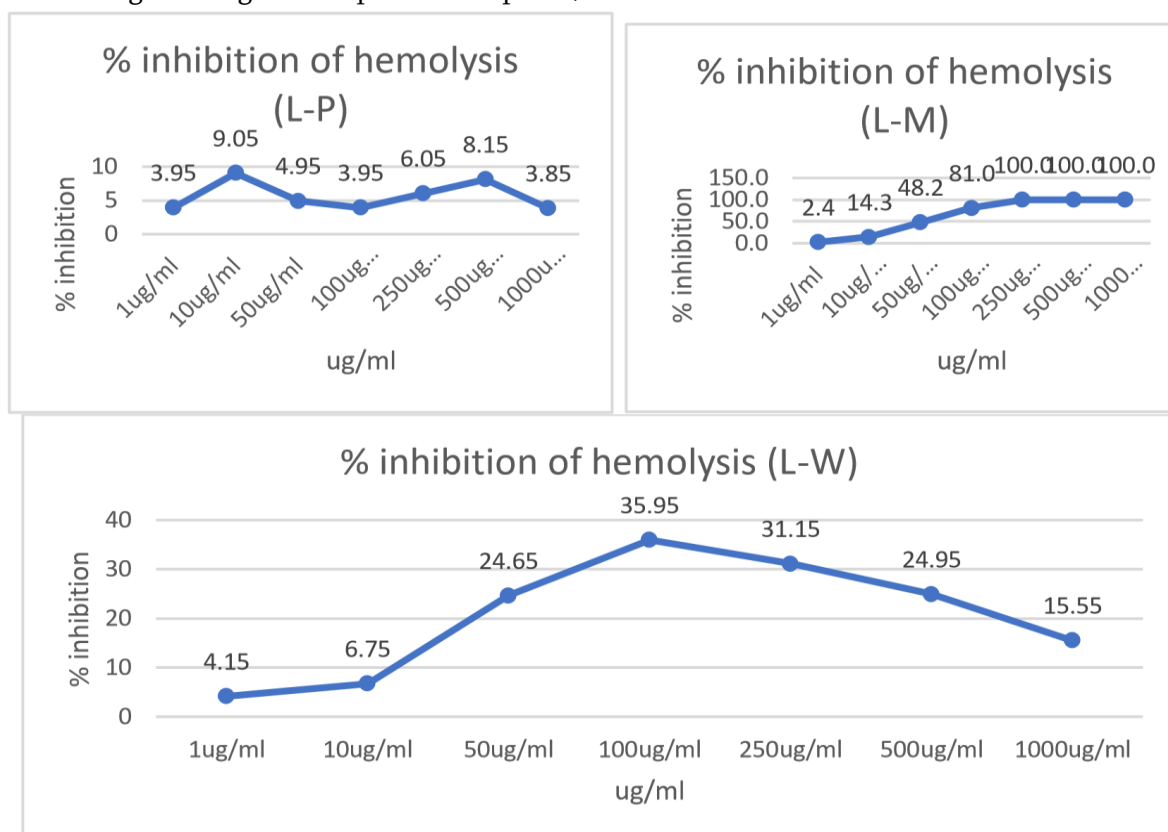


Fig 3: *Lantana camara*, petroleum ether (L-P) methanol (L-M), Aqueous (L-W) extract — hemolysis inhibition

Cytotoxicity Assessment

The cytotoxic effects of *Lantana camara* extracts varied notably depending on the extraction solvent. The aqueous extract exhibited relatively low cytotoxicity, with an IC₅₀ value of 345.2 µg/mL. (Table 2 and fig 4). The methanolic extract showed the weakest cytotoxic activity among all tested extracts, with an IC₅₀ of 630.6 µg/mL, indicating limited growth inhibition of HepG2 cells. In contrast, the petroleum ether extract demonstrated markedly

higher cytotoxic potency, highlighting the enrichment of nonpolar bioactive constituents with stronger antiproliferative effects

Sample code	IC ₅₀ value (µg/ml)
L-W	345.2
L-m	630.6
L-p	162.3

Table 2: IC₅₀ value of *Lantana camara* extracts

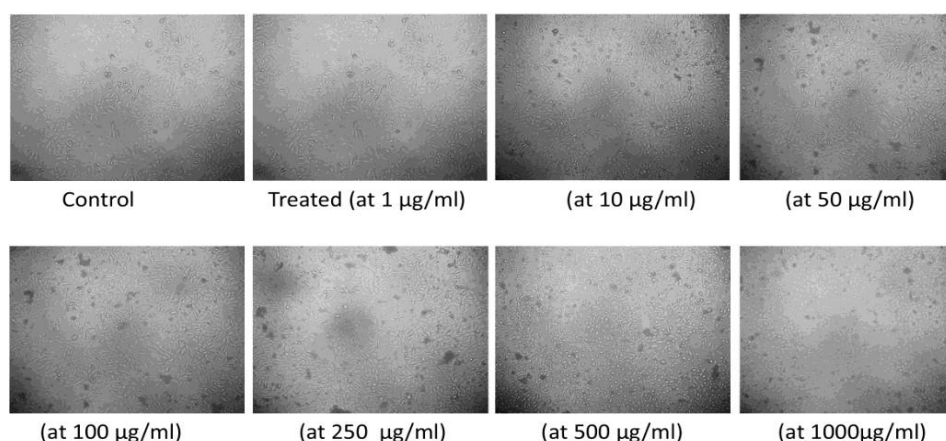


Fig 4: HepG2 L-M extract effect of different concentrations

IV.DISCUSSION

The present study provides a comprehensive evaluation of the extraction efficiency, phytochemical composition, and biological activities of *Lantana camara* using solvents of varying polarity. The results clearly demonstrate that solvent polarity plays a crucial role in determining extraction yield, phytochemical diversity, and subsequent biological activity.

Extraction Yield and Solvent Polarity

The highest extraction yield was obtained with methanol, followed by water and petroleum ether, indicating that *Lantana camara* is rich in polar and semi-polar phytoconstituents. Previous research has similarly noted that methanol is highly effective in extracting phenolics, flavonoids, and terpenoids from medicinal plants, owing to its capacity to dissolve a broad spectrum of bioactive compounds (Azwanida, 2015). The lower yield obtained with petroleum ether reflects its selectivity for nonpolar constituents such as lipids and hydrocarbons, which are generally present in smaller quantities.

FTIR-Based Functional Group Analysis

FTIR analysis confirmed solvent-dependent differences in functional groups across the extracts. The dominance of hydroxyl groups in aqueous and methanolic extracts suggests the presence of alcohols and phenolic compounds, which are widely associated

with antioxidant and anti-inflammatory properties (Coates, 2000; Pandey & Rizvi, 2009). In contrast, the petroleum ether extract exhibited characteristic aliphatic C–H vibrations, indicating enrichment of saturated hydrocarbons and lipid components. These findings are consistent with earlier FTIR studies on *Lantana camara* and other medicinal plants, where polar solvents preferentially extracted phenolic compounds, while nonpolar solvents concentrated lipophilic metabolites (Kumar et al., 2014).

GC–MS Profiling and Phytochemical Diversity

GC–MS analysis revealed a broad spectrum of phytochemicals across all extracts, with retention time patterns reflecting solvent selectivity. The methanolic extract contained volatile terpenoids, fatty acids, and long-chain lipids, indicating its ability to extract structurally diverse metabolites. Terpenoids and fatty acids identified in methanolic extracts of *Lantana camara* have previously been reported to hold antimicrobial, anti-inflammatory, and anticancer activities (Ghisalberti, 2000; Verma & Singh, 2013).

The petroleum ether extract was dominated by nonpolar compounds, including sterol derivatives such as stigmasterol. Plant sterols are known for their membrane-modulating, anti-inflammatory, and cytotoxic properties, which may explain the higher antiproliferative activity observed for this extract (Fernandes & Cabral, 2007). The aqueous extract primarily contained oxygenated compounds and fatty

acids, supporting earlier reports that water preferentially extracts hydrophilic metabolites with moderate biological activity (Tiwari et al., 2011).

Anti-Inflammatory Activity

The hemolysis inhibition assay demonstrated strong anti-inflammatory potential of *Lantana camara*, particularly in the methanolic and aqueous extracts. The superior activity of the methanolic extract can be accredited to its high content of phenolics and flavonoids, which stabilize erythrocyte membranes by inhibiting lysosomal enzyme release and oxidative damage (Shinde et al., 1999; Oyedapo et al., 2004). The comparatively low activity of the petroleum ether extract further supports the role of polar phytochemicals in anti-inflammatory mechanisms.

Cytotoxic Activity Against HepG2 Cells

Cytotoxicity assessment revealed marked solvent-dependent differences, with petroleum ether extracts exhibiting the strongest antiproliferative effects, followed by aqueous and methanolic extracts. The enhanced cytotoxicity of the petroleum ether extract may be linked to the presence of nonpolar bioactive compounds such as sterols, fatty acids, and terpenoid derivatives, which are known to induce apoptosis and disrupt cancer cell membranes (Ghisalberti, 2000; Fulda, 2010). In contrast, the lower cytotoxicity of methanolic and aqueous extracts suggests a more selective and potentially safer biological profile, which may be advantageous for anti-inflammatory or nutraceutical applications.

V. CONCLUSION

This study highlights *Lantana camara* as a valuable source of diverse bioactive compounds, with extraction efficiency and biological activity strongly influenced by solvent polarity. Phytochemical analyses confirmed the presence of phenolics, terpenoids, fatty acids, and sterol-related compounds across different extracts. The methanolic and aqueous extracts showed notable anti-inflammatory activity, while the petroleum ether extract exhibited stronger

cytotoxic effects against HepG2 cells, indicating the role of lipophilic constituents in antiproliferative activity. Overall, these findings support the traditional medicinal use of *Lantana camara* and suggest its potential for further development as a natural anti-inflammatory and anticancer agent.

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