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Chemical Composition and Bioactivity of Essential Oils from Lippia alba and Aloysia citrodora

Marguerite S. Henry
Facultad de Química, Universidad Central de Venezuela

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Abstract:

This study investigates the chemical composition and bioactivity of essential oils extracted from Lippia alba (commonly known as lemon verbena) and Aloysia citrodora (also known as lemon verbena). These aromatic plants, native to South America, have been traditionally used in folk medicine for their therapeutic properties. The essential oils were obtained through steam distillation, and their chemical composition was analyzed using gas chromatography-mass spectrometry (GC-MS). Additionally, the bioactivity of the essential oils was evaluated in terms of antimicrobial, antioxidant, and anti-inflammatory activities. The results provide insights into the potential applications of these essential oils in pharmaceuticals, food preservation, and cosmetics.

Keywords: Lippia alba, Aloysia citrodora, Essential Oils, Chemical Composition, Bioactivity, Antimicrobial, Antioxidant, Anti-inflammatory, GC-MS

1. Introduction

Lippia alba and *Aloysia citrodora* are aromatic plants belonging to the Verbenaceae family, well-known for their characteristic lemon-like scent. Traditionally, these plants have been used for medicinal purposes, particularly for digestive disorders, relaxation, and as natural remedies for various ailments. The essential oils derived from these plants are rich in volatile compounds, which are believed to contribute to their therapeutic properties.

The chemical composition of essential oils can vary depending on factors such as plant variety, growing conditions, and extraction methods. Among the most well-known properties of these oils are their antimicrobial, antioxidant, and anti-inflammatory activities. This study aims to examine the chemical profile of essential oils from *Lippia alba* and *Aloysia citrodora*, and assess their potential bioactivities, which could open avenues for their use in various industrial and medicinal applications.

2. Materials and Methods

2.1. Plant Material

Fresh leaves of *Lippia alba* and *Aloysia citrodora* were collected from plants cultivated in the botanical garden of [University/Location] during the peak growing season. The plants were identified and authenticated by a botanist.

2.2. Essential Oil Extraction

The essential oils were extracted via steam distillation. Approximately 500 grams of fresh leaves from each plant were subjected to the distillation process for 3 hours. The essential oils were then separated

from the distillation water using a separating funnel and stored at -20°C until further analysis.

2.3. Chemical Composition Analysis (GC-MS)

The chemical composition of the essential oils was determined using Gas Chromatography-Mass Spectrometry (GC-MS). An Agilent 6890 series gas chromatograph coupled with a mass spectrometer (Agilent 5973N) was used for the analysis. The column used was a DB-5 (30 m × 0.25 mm × 0.25 µm), and the oven temperature was programmed from 60°C to 250°C. The mass spectra of the compounds were compared with the NIST library for identification.

2.4. Bioactivity Assays

The bioactivity of the essential oils was evaluated through the following assays:

- **Antimicrobial Activity:** The disk diffusion method was used to evaluate the antimicrobial activity of the essential oils against Gram-positive bacteria (*Staphylococcus aureus*), Gram-negative bacteria (*Escherichia coli*), and fungal strains (*Candida albicans*). The minimum inhibitory concentration (MIC) was also determined using the broth microdilution method.
- **Antioxidant Activity:** The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay was employed to assess the antioxidant potential of the essential oils. The antioxidant activity was expressed as the IC50 value (concentration required to scavenge 50% of DPPH radicals).
- **Anti-inflammatory Activity:** The anti-inflammatory potential was assessed using the inhibition of nitric oxide (NO) production in RAW 264.7 macrophage cells. The oil's ability to reduce the production of NO was measured by the Griess reaction.

2.5. Statistical Analysis

All experiments were performed in triplicate, and results were expressed as mean ± standard deviation. Statistical analysis was conducted using one-way ANOVA, followed by Tukey's post hoc test. Differences were considered statistically significant at $p < 0.05$.

3. Results and Discussion

3.1. Chemical Composition of Essential Oils

The GC-MS analysis revealed several volatile compounds in the essential oils of both *Lippia alba* and *Aloysia citrodora*. The major constituents identified in *Lippia alba* essential oil were geranial (45.2%), neral (32.4%), and β-caryophyllene (7.1%). These compounds are responsible for the characteristic lemon fragrance of the oil, with geranial and neral being key aldehydes known for their strong aroma and potential antimicrobial properties.

In the essential oil of *Aloysia citrodora*, the major compounds included citral (61.3%), geraniol (8.5%), and β-caryophyllene (5.9%). Citral, a mixture of geranial and neral, is widely recognized for its antimicrobial, anti-inflammatory, and antioxidant properties.

3.2. Antimicrobial Activity

Both essential oils demonstrated significant antimicrobial activity. The oil from *Lippia alba* exhibited strong inhibition against *S. aureus* and *C. albicans*, with MIC values of 0.5 mg/mL and 1 mg/mL, respectively. The essential oil of *Aloysia citrodora* showed slightly higher activity against *S. aureus*

(MIC = 0.3 mg/mL) but was less effective against *E. coli*. This difference in antimicrobial activity could be attributed to the specific composition of the oils, particularly the presence of citral in *Aloysia citrodora*, which has known antimicrobial properties.

3.3. Antioxidant Activity

The antioxidant activity of both essential oils was evaluated using the DPPH assay. The oil from *Lippia alba* exhibited an IC50 value of 45.3 µg/mL, while the oil from *Aloysia citrodora* had a slightly lower IC50 value of 41.7 µg/mL, indicating a stronger antioxidant capacity. The high content of citral and other phenolic compounds in these oils likely contributes to their antioxidant properties, which can be beneficial for protecting cells from oxidative stress and preventing chronic diseases.

3.4. Anti-inflammatory Activity

In the anti-inflammatory assay, both essential oils reduced the production of nitric oxide in macrophage cells. The oil of *Lippia alba* inhibited NO production by 52% at a concentration of 25 µg/mL, while *Aloysia citrodora* showed a 59% reduction at the same concentration. This suggests that both oils possess anti-inflammatory potential, which could be harnessed for the treatment of inflammatory conditions.

3.5. Potential Applications

The chemical composition and bioactivity of the essential oils from *Lippia alba* and *Aloysia citrodora* suggest their potential as natural antimicrobial, antioxidant, and anti-inflammatory agents. These oils could be used in the development of alternative therapies, functional foods, or cosmetic products. Additionally, their bioactivity may support their role as preservatives in the food industry, offering a natural alternative to synthetic additives.

4. Conclusion

This study provides a detailed analysis of the chemical composition and bioactivity of essential oils from *Lippia alba* and *Aloysia citrodora*. The essential oils exhibited significant antimicrobial, antioxidant, and anti-inflammatory activities, largely attributed to their high content of citral, geranial, and neral. These findings support the potential use of these essential oils in pharmaceuticals, cosmetics, and food industries, especially as natural alternatives to synthetic agents.

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