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Research paper

Phytochemical Profiling and TLC analysis of Indigenous Plants

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ABSTRACT

Plants are an abundant source of bioactive compounds, particularly secondary metabolites, which play vital ecological roles and hold significant therapeutic potential. Traditional medicine, often relying on plant-based compounds, is used by nearly 80% of the global population, highlighting its relevance. This study focuses on the phytochemical screening and Thin Layer Chromatography (TLC) analysis of five medicinal plants: *Curcuma longa, Mentha piperita, Aegiceras corniculatum, Zingiber officinale, and Piper nigrum.* Qualitative analysis revealed the presence of key secondary metabolites such as alkaloids, flavonoids, phenols, glycosides, saponins, and terpenoids, which contribute to the therapeutic properties of these plants. TLC profiles further confirmed the consistent presence of terpenoids across all species and variations in flavonoids and phenolics depending on polarity. These findings underline the medicinal potential of these indigenous plants and provide a basis for their application in drug development and other therapeutic industries. This study reinforces the importance of phytochemical research in exploring natural resources for innovative healthcare solutions.

1. Introduction

Plants are reservoirs of bioactive compounds, including secondary metabolites such as alkaloids, flavonoids, phenolics, and terpenoids, which contribute to their ecological functions and pharmacological properties. These metabolites exhibit diverse biological activities, including antimicrobial, antioxidant, and anti-inflammatory effects, making them valuable for medicinal applications. Herbal medicines, being of natural origin, are widely considered safe and are a promising resource for developing novel therapeutic agents, particularly to address challenges such as antibiotic resistance and the toxicity of conventional drugs (Sawant and Godghate, 2013).

Approximately 80% of individuals in developed countries rely on traditional medicine, which often incorporates plant-derived compounds (Aggarwal *et al*., 2007). India, with its rich medicinal plant heritage, serves as a significant source of therapeutic resources (Sharma *et al*., 2017). In this study, we examined locally available plants with a history of medicinal use, including *Curcuma longa, Mentha piperita, Aegiceras corniculatum, Zingiber officinale*, and *Piper nigrum*.

Curcuma longa, a staple in Ayurvedic, Unani, and Siddha medicine, is prescribed for conditions like diabetes, inflammation, and cancer and is valued for its role in blood purification (Sawant and Godghate, 2013).

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The essential oils from Mentha species have been extensively studied for their medicinal properties (Gulluce *et al.,* 2007 and Rasooli, 2008). *Aegiceras corniculatum* has traditional uses in treating asthma, rheumatism, and diabetes, and pharmacological studies have revealed its anti-inflammatory, antimicrobial, and antioxidant activities, along with its potential as a cardio- and hepatoprotective agent (Ellison *et al*., 2010, Roome *et al.,* 2011 and Gupta *et al*., 2012). *Zingiber officinale* has been used medicinally for over 2,500 years in China and India to treat ailments such as headaches, nausea, and colds and is renowned for its anti-inflammatory, anticancer, and antioxidant effects (Mohamed *et al.,* 2015 and Tohma *et al*., 2017). *Piper nigrum*, widely used as a spice and medicinal ingredient, exhibits antimicrobial and antioxidant properties, while betel leaves are valued for their stimulant and antiseptic properties and are used in remedies for pain relief and as diuretics (Shetty and Vijayalaxmi, 2012).

To utilize these plants for therapeutic purposes, understanding their phytochemical composition is crucial. Phytochemical screening, the systematic identification and characterization of bioactive compounds, is the first step in this process. This study combines qualitative tests with Thin Layer Chromatography (TLC), a simple and cost-effective technique for separating and visualizing plant metabolites.

By examining the phytochemical profiles of these indigenous plants, this research contributes to the growing body of knowledge on plant-based resources and their potential applications in drug development, agriculture, and other industries.

2. Material and Methods

2.1 Study Area

Plant materials were collected from Ratnagiri, Maharashtra, India (16.9954° N latitude and 73.3120° E longitude). The rhizomes, leaves, and seeds of selected species were processed and analyzed in the Department of Zoology at Gogate Jogalekar College.

2.2 Preparation of plant extracts

The plant parts were examined for any foreign matter or mold and cleaned with distilled water. They were then cut into small pieces and air-dried in the shade at the laboratory. Once dried, the plant material was ground into a fine powder using a grinder. The resulting powdered material was packaged in 250-gram portions and stored in clean, airtight polythene bags. The plant material powder (50 gm each) was extracted with 300 ml of ethanol using Soxhlet apparatus for 24 Hours. The extracts were stored at 4^0 C and were used for the further analysis of secondary metabolites.

2.3 Phytochemical Screening

Standard protocols were used to detect the presence of alkaloids (Hager's test), glycosides, phenols, flavonoids, proteins, saponins, and terpenoids (Adetuyi and Popoola, 2001, Tiwari *et al*., 2011). Each test provided qualitative insights into the chemical constituents of the plant extracts.

2.4 Thin layer chromatography

The extracts were analyzed using ready to use TLC plates coated with 0.2 mm thick silica gel. A solvent system consisting of a 5:4:1 mixture of chloroform, methanol, and water was used, allowing the solution to migrate on the silica-coated plates via capillary action. After the plate was fully developed, it was air-dried. The bands were observed under UV chamber at 254 nm.
These spots were expressed by its retention factor (R*f*).

$$R_f = \frac{\text{Distance travelled by solute}}{\text{Distance travelled by solvent}}$$

The R*f* value for each compound of each plant species was calculated and compared with the standard data to identify the probable plant secondary metabolite.

3. Results

Table 1 Phytochemical Presence in Selected Species

Metabolite	*Curcuma longa*	*Mentha piperita*	*Aegiceras corniculatum*	*Zingiber officinale*	*Piper nigrum*
Alkaloids	-	++	++++	-	+++
Saponins	+	++	++++	++	+++
Phenols	++	++	++	+	++
Proteins	+	++	++	-	-
Flavonoids	+++	+++	++	+	++
Glycosides	-	-	++++	++	++
Terpenoids	+	+	++++	++	+

Table 2 The R*f* value for each spot and probable secondary metabolite

Plant	Rf Value	Type	Likely Metabolites
Curcuma longa	0.18	Polar compound	Phenolic compounds (e.g., phenolic acids), flavonoids (such as flavones or flavanols)
	0.96	Non-polar compound	Terpenoids (e.g., monoterpenes, sesquiterpenes), lipophilic compounds (oils, waxes), non-polar alkaloids
Mentha piperita	0.20	Moderately polar compound	Phenolic compounds, flavonoid glycosides, tannins
	0.32	Moderately polar compound	Flavonoids (e.g., aglycones), phenolics (e.g., hydroxycinnamic acids), alkaloids
	0.44	Moderate polarity	Flavonoid aglycones (e.g., quercetin), phenolics (e.g., coumarins), moderately polar terpenoids
	0.55	Moderately non-polar compound	Terpenoids (e.g., sesquiterpenes), flavonoid aglycones, alkaloids
	0.87	Non-polar compound	Terpenoids (e.g., monoterpenes), lipophilic compounds (e.g., waxes, oils), non-polar alkaloids
	0.96	Highly non-polar compound	Highly non-polar terpenoids, lipophilic compounds, non-polar alkaloids
Aegiceras corniculatum	0.20	Polar compound	Phenolic compounds, flavonoids (glycosides), tannins
	0.32	Moderately polar compound	Flavonoid glycosides, phenolics (e.g., hydroxycinnamic acids), alkaloids
	0.96	Highly non-polar compound	Non-polar terpenoids, lipophilic compounds, non-polar alkaloids
Zingiber officinale	0.73	Moderately non-polar compound	Terpenoids (e.g., sesquiterpenes), non-polar alkaloids, flavonoids (aglycones)
	0.96	Highly non-polar compound	Non-polar terpenoids, lipophilic compounds, non-polar alkaloids
Piper nigrum	0.25	Polar compound	Flavonoids (glycosides), phenolic compounds (e.g., hydroxybenzoic acids), tannins
	0.68	Moderately non-polar compound	Terpenoids (e.g., sesquiterpenes), flavonoids (aglycones), alkaloids
	0.75	Moderately non-polar compound	Terpenoids, non-polar alkaloids, flavonoid aglycones

Qualitative tests revealed varying levels of metabolites across species. *Aegiceras corniculatum* showed the highest concentration of alkaloids, glycosides, and terpenoids, while Mentha piperita and Piper nigrum exhibited moderate metabolite diversity. Curcuma longa and Zingiber officinale displayed lower levels of metabolites.

4. Discussion

The pharmacological potential of plants studied in this research aligns with previous studies highlighting their therapeutic applications and bioactive properties. The qualitative and TLC analyses revealed a diverse range of secondary metabolites, with each species demonstrating distinct chemical profiles, including alkaloids,

flavonoids, glycosides, terpenoids, and phenolic compounds. These findings support their significance in traditional medicine and their potential for future pharmaceutical exploration.

4.1 Secondary Metabolite Profiles

The qualitative tests indicated that *Aegiceras corniculatum* exhibited a rich profile of secondary metabolites, with the highest levels of alkaloids (++++) as well as glycosides and terpenoids. These findings are consistent with prior studies that demonstrated the presence of glycosides, carbohydrates, sterols, flavonoids, and phenolic compounds in *Aegiceras corniculatum*, along with its antibacterial activity in chloroform and aqueous extracts (Karthi and Purushothaman, 2017, Bulbula *et al*., 2017). This mangrove species holds promise for therapeutic applications, particularly concerning its antioxidant properties.

Mentha piperita, known for its therapeutic versatility, demonstrated moderate levels of secondary metabolites. Previous studies identified alkaloids, flavonoids, tannins, phenols, saponins, steroids, terpenoids, proteins, and carbohydrates in its extracts, with ethanol, acetone, and aqueous extracts containing the highest levels of most phytochemicals (Sontakke and Shinde, 2019).

Curcuma longa and *Zingiber officinale* exhibited relatively low levels of secondary metabolites in this study, although prior research highlights their pharmacological significance. For Curcuma longa, extraction using acetone, methanol, ethanol, and chloroform revealed substantial yields of active compounds (Sawant and Godghate, 2013). Similarly, Zingiber officinale extracts are rich in alkaloids, saponins, tannins, flavonoids, terpenoids, and phlobotannins, aligning with its traditional use as an anti-inflammatory and digestive aid (Bhargava *et al*., 2012).

4.2 TLC Analysis

The TLC profiling underscored the chemical diversity among the selected species, with notable observations:
Curcuma longa displayed both polar (Rf 0.18) and non-polar (Rf 0.96) compounds. Polar fractions were dominated by phenolic compounds and flavonoids, contributing to its antioxidant properties (Sawant and Godghate, 2013).

Mentha piperita exhibited a broad polarity spectrum (Rf 0.20–0.96), suggesting a wide range of metabolites, including flavonoids, glycosides, tannins, and terpenoids. This profile aligns with its known antimicrobial and antioxidant activities (Sontakke and Shinde, 2019).

Aegiceras corniculatum showed a metabolite range from polar (Rf 0.20) to highly non-polar (Rf 0.96). The strong presence of terpenoids emphasizes its ecological adaptability and medicinal promise, supported by earlier reports of antibacterial activity (Karthi and Purushothaman, 2017, Bulbula *et al*., 2017)

Zingiber officinale predominantly displayed moderately non-polar (Rf 0.73) and non-polar (Rf 0.96) compounds, with terpenoids like sesquiterpenes aligning with its pharmacological effects (Bhargava *et al*., 2012).

Piper nigrum demonstrated metabolites across the polarity spectrum (Rf 0.25–0.96), with phenolics and flavonoids in the polar fractions and terpenoids dominating the non-polar range. This profile supports its diverse medicinal applications, including antioxidant properties and bioavailability enhancement (Shetty and Vijayalaxmi, 2012).

4.3 Cross-Species Observations

Terpenoids were consistently identified in all species, with phenolic compounds and flavonoids prominently found in the polar fractions. These secondary metabolites are key contributors to the antioxidant properties of the plants, validating their traditional use in medicine.

The results of this study provide a strong foundation for further chemical characterization and exploration of these plants. The prominent profile of *Aegiceras corniculatum*, in particular, suggests its untapped potential in medicinal and pharmaceutical applications. Future studies focusing on its ecological and pharmacological adaptations could provide deeper insights into its therapeutic benefits.

Overall, the TLC and qualitative phytochemical analyses collectively highlight the unique pharmacological signatures of the selected plant species, emphasizing their importance in traditional medicine and the need for further scientific validation.

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