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# Comparative Study Of Bioactive Compounds In Selected Medicinal Plants

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## ABSTRACT

The bioactive compounds in medicinal plants, including alkaloids, flavonoids, tannins, saponins, phenolics, glycosides and terpenoids, make them effective for treating and preventing a range of diseases, making their use go back to ancient times. These phytochemicals exhibit strong pharmacological activities such as antioxidant, antimicrobial, anti-inflammatory, anticancer and antidiabetic. The present study intends to make comparative study of bioactive compounds present in selected medicinal plants like Ocimum sanctum (Tulsi), Azadirachta indica (Neem), Aloe vera, Curcuma longa (Turmeric) and Withania somnifera (Ashwagandha). Major secondary metabolites have been identified and quantified by using the standard phytochemical screening techniques. The study showed that there is great variation in bioactive constituents' concentration and diversity in medicinal plants selected. Turmeric was rich in phenolic compounds and curcuminoids and Neem was rich in antimicrobial phytochemicals such as alkaloids and flavonoids. Tulsi exhibited high antioxidant activity with the presence of essential oils and phenolics in the plant. Aloe vera had a large number of polysaccharides and glycoproteins which are useful in wound healing while Ashwagandha had a large number of steroidal lactones which are useful in adaptogenic activity. The comparative results highlight the therapeutic potential of medicinal plants and justify their use in the pharmaceutical, nutraceutical and herbal medicine sector. The study adds to the knowledge of the phytochemical diversity of medicinal plants and suggests their utilization in the future for drug development and medicine.

**Keywords:** Medicinal plants, Bioactive compounds, Phytochemicals, Comparative study, Herbal medicine, Antioxidants

## 1. INTRODUCTION

Since ancient times, medicinal plants have been an integral part of traditional medicine systems. These have been used extensively to treat infections, inflammation, metabolic diseases, and chronic diseases (Alqahtani et al., 2022). The medicinal value of these plants is mainly due to the presence of bioactive compounds or phytochemicals, which are naturally synthesized during plant metabolism Rajesh and Patel (2026b). These compounds can protect plants from environmental stress, pathogens and herbivores (Andrea et al., 2020).

The important phytochemicals present in medicinal plants are alkaloids, flavonoids, tannins, phenolics, glycosides, saponins, steroids and terpenoids (Dawurung et al., 2021). These phytochemicals have several pharmacological properties including antioxidant, antimicrobial, anti-inflammatory, anticancer, antidiabetic and immunomodulatory effects (Patel, 2025). This

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therapeutic value spurred the medicinal plants to be of prime importance in pharmaceutical and herbal medicine research(Patel & Bharti, 2025).

The rising demand of natural remedies and herbal medicines has given rise to their phytochemical research (Patel, 2025). Comparative phytochemical analysis is important to understand the diversity and the medicinal value of bioactive compounds in various plant species (Patel & Bharti, 2025a). These studies also give scientific justification for the traditional medicinal applications of plants Rajesh and Patel (2026a).

In the present study, the comparative evaluation of bioactive compounds in selected medicinal plants Ocimum sanctum (Tulsi), Azadirachta indica (Neem), Aloe vera, Curcuma longa (Turmeric) and Withania somnifera (Ashwagandha) was carried out. The wide medicinal uses and therapeutic significance have motivated the choice of these plants (Idris & Mohd Nadzir, 2021).

### 1.1 Importance of Medicinal Plants

The medicinal plants are commonly utilized in traditional medicine systems like Ayurveda, Siddha and Unani medicine (Patel, 2026). They are valuable natural source of therapeutic agents due to the efficacy, low cost, and less side effects (Kumar, 2024). Many of the world's population still relies on herbal medicines today for primary healthcare (Kim et al., 2018).

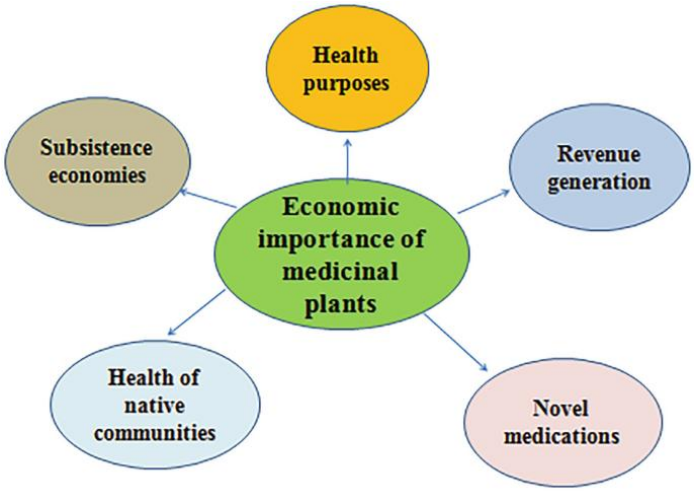


**Figure 1:** Economic Importance and Healthcare Applications of Medicinal Plants

Some commonly used plants for treating infections, boosting immunity, improving skin health and reducing inflammation are Tulsi, Neem, Aloe Vera, Turmeric and Ashwagandha Patel (2026). Many of their traditional medicinal properties have been proven by modern scientific research (Patel & Bharti, 2025).

### 1.2 Role of Bioactive Compounds

Bioactive compounds are chemical substances that are naturally occurring in the plants and have therapeutic properties (Patel et al., 2024). Flavonoids and phenolics have antioxidant activity, alkaloids have antimicrobial activity, terpenoids have anti-inflammatory activity and steroids have adaptogenic activity.

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**Figure 2:** Major Health Benefits and Therapeutic Applications of Medicinal Plants

These compounds are important for their anti-oxidative activity and their role in preventing chronic diseases like cancer, diabetes, cardiovascular and neurological diseases (Patel et al., 2025). Hence, the medicinal plants are seen as important source for the development of natural drugs and health care products.

### 1.3 Objectives of the Study

The main objectives of the study are:

- To isolate the main bioactive compound(s) present in certain medicinal plants.
- To compare the phytochemical composition of Tulsi, Neem, Aloe vera, Turmeric and Ashwagandha.
- To assess the medicinal value of the identified phytochemicals.
- To compare the therapeutic potential of some medicinal plants.

## 2.REVIEW OF LITERATURE

Rajkumar, Panambara, and Vinotha (2022) conducted a comparative study on the qualitative and quantitative phytochemical evaluation of selected medicinal plant leaves in Jaffna, Sri Lanka. The study identified the presence of important phytochemicals such as alkaloids, flavonoids, tannins, saponins, and phenolic compounds using standard screening methods (Rajkumar et al., 2022). The researchers found significant variation in phytochemical composition among different plant species and concluded that these medicinal plants possessed valuable therapeutic potential for herbal medicine and future pharmacological applications.

A comparative study between chemical composition, Antioxidant activity and Quantitative characterization of phenolics in some herbs and spices was conducted by Sepahpour et al. (2018) with the use of various chemical extraction methods. The extraction solvents effects on yield and concentration of phenolics and antioxidant activity were investigated. The study indicated that polarity of the solvents played a significant role in the extraction efficiency of phytochemicals. Methanolic extracts had greater phenolic content and higher antioxidant activity than aqueous extracts whereas ethanolic extracts did not show any significant

difference (Sepahpour et al., 2018). The authors have concluded that extraction methods were important in determining the phytochemical profile and biological activity of medicinal plants and herbs.

Spréa et al. (2022) conducted comparative study on the phenolic composition and in vitro bioactivity of medicinal and aromatic plants of Lamiaceae family. The phenolic contents were analysed and biological activities including antioxidant, antimicrobial and cytotoxic activities evaluated. The selected plants were found to have a variety of phenolic compounds with high antioxidant activity, according to the study (Spréa et al., 2022). The high content of flavonoids and phenolic acids showed remarkable antimicrobial and bioactive properties in certain species. The results revealed that most of the plants used in the traditional medicine are medicinal and aromatic plants, which can be utilized in pharmaceutical, cosmetic and food sectors.

A comparative study of the bioactive phenolic compound composition has been done in twenty-six medicinal plants by Sytar et al. (2018). In this study, diversity and concentration of phenolic compounds which have antioxidant and therapeutic effects were studied. The researchers looked at various categories of phenolics, such as flavonoids and phenolic acids, and found that there was a good deal of differences between the medicinal plant species (Sytar et al., 2018). The results showed that the plants with high phenolic content exhibited good antioxidant and medicinal properties. This study underscored the role of phenolic compounds for combating oxidative stress and the value of medicinal plants as natural sources of bioactive compounds used in pharmaceutical and nutraceutical industries.

Vaou et al. (2022) examined the interactions between medicinal plant-derived bioactive compounds with special focus on antimicrobial combination effects. The researchers examined the antimicrobial efficacy of phytochemicals in combination against different pathogenic microorganisms. The study states that synergistic interactions of plant compounds enhanced the antibacterial and antifungal activity of the compounds as compared to their antibacterial and antifungal activities alone (Vaou et al., 2022). They noted that the flavonoids, phenolics, alkaloids and essential oils showed remarkable inhibitory effects on microbial growth when combined. The results of the study indicated that the bioactive compounds of medicinal plants have a high potential for developing alternative antimicrobial drugs and could be a good source to combat antibiotic resistance.

## 3. MATERIALS AND METHODS

### 3.1 Study Design

The present study was designed as a comparative phytochemical study and its aim is to determine the bioactive compounds in the selected medicinal plants. This research aimed at the identification and comparison of the major phytochemicals which are responsible for the therapeutic activity of commonly used medicinal plants.

### 3.2 Selection of Medicinal Plants

The medicinal plants were selected based on their medicinal importance, traditional uses and availability; five plants were selected for the study. Plants chosen were Ocimum sanctum (Tulsi), Azadirachta indica (Neem), Aloe vera, Curcuma longa (Turmeric) and Withania

somnifera (Ashwagandha). The plants are being used widely in traditional medicines, including Ayurveda and herbal medicine, due to their known pharmacologic properties.

### 3.3 Collection and Authentication of Plant Samples

The fresh plants such as leaves, roots, rhizomes and gel were picked from the local herbal gardens and medicinal plants nurseries. All the collected samples were confirmed botanically to ensure proper identification of the plants. The samples collected were then carefully washed with distilled water to clean the dust, soil particles, and impurities from the samples.

The cleaned plant materials were shade dried at room temperature for several days so that the plant materials would maintain their phytochemical constituents and so that the active compounds would not be degraded.

### 3.4 Preparation of Plant Extracts

After drying, the plant materials were ground by a mechanical grinder to get fine homogeneous powder. The powdered samples of each medicinal plant were extracted using around 20g.

Ethanol and distilled water were used as extraction solvents for the extraction process conducted by maceration method. Powdered plant material was extracted in solvents for 48-72 hours with stirring every two hours to extract the bioactive compounds efficiently.

The mixtures were filtered after extraction to remove the solid residue and to separate the liquid extract from the solid residue. Filtrates were then concentrated by rotary evaporation, and stored at 4°C in sterile containers for phytochemical analysis.

### 3.5 Qualitative Phytochemical Screening

Major bioactive compounds were detected in prepared plant extracts by adopting standard qualitative phytochemical tests. The phytochemical screening of the extract was aimed at identifying alkaloids, flavonoids, phenolics, tannins, saponins, glycosides, terpenoids and steroids.

The identification of these phytochemicals was carried out by means of different types of chemical reagents and colour reaction methods. The characteristic color changes, precipitates or froth formation indicated the presence of certain bioactive compounds in the extracts.

### 3.6 Comparative Phytochemical Analysis

The phytochemicals detected were qualitatively compared with the selected medicinal plants and their reactions intensity. The phytochemicals were classified as low, moderate, high or very high based on the reactions observed in the phytochemical screening.

The comparative analysis assisted in assessing the medicinal value and therapeutic potential of the selected medicinal plants in terms of differences in their phytochemical content.

### 3.7 Data Interpretation

The phytochemical analysis and interpretation of contents obtained from the extracts of the various medicinal plants were carried out in a systematic manner by descriptive comparison method. The comparative findings were analysed for variations in bioactive compound composition and for the medicinal value of the selected plants in the pharmaceutical and herbal healthcare industry.

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## 4. RESULTS AND DISCUSSION

### 4.1 Comparative Phytochemical Screening of Selected Medicinal Plants

The phytochemical screening revealed considerable variation in the composition of bioactive compounds among the selected medicinal plants. The presence and relative abundance of alkaloids, flavonoids, phenolics, tannins, saponins, glycosides, terpenoids, and steroids were analyzed using standard qualitative methods. The comparative phytochemical profile is presented below.

**Table 1:** Comparative Phytochemical Composition of Selected Medicinal Plants

| Bioactive Compound | Tulsi | Neem | Aloe vera | Turmeric | Ashwagandha |
|---|---|---|---|---|---|
| Alkaloids | Moderate | High | Low | Moderate | High |
| Flavonoids | High | High | Moderate | High | Moderate |
| Phenolics | High | Moderate | Moderate | Very High | Moderate |
| Tannins | Moderate | High | Low | Moderate | Low |
| Saponins | Low | Moderate | High | Low | Moderate |
| Glycosides | Moderate | Moderate | High | Low | High |
| Terpenoids | High | Moderate | Moderate | High | High |
| Steroids | Low | Low | Moderate | Moderate | Very High |

The results indicate that Curcuma longa exhibited the highest concentration of phenolic compounds, mainly due to curcuminoids responsible for antioxidant and anti-inflammatory activities. Azadirachta indica demonstrated abundant alkaloids and tannins which contribute to its antimicrobial and antifungal properties.

Ocimum sanctum showed significant levels of flavonoids and terpenoids associated with antioxidant and immunomodulatory effects. Aloe vera contained high concentrations of glycosides and saponins responsible for wound healing and dermatological applications. Withania somnifera exhibited remarkable steroidal compounds and glycosides linked with adaptogenic and neuroprotective functions.

### 4.2 Relative Medicinal Importance of Identified Bioactive Compounds

Different bioactive compounds identified in medicinal plants possess distinct therapeutic activities. Their medicinal significance is summarized below.

**Table 2:** Therapeutic Activities of Major Bioactive Compounds

| Bioactive Compound | Major Therapeutic Activity |
|---|---|
| Alkaloids | Antimicrobial, analgesic, anticancer |
| Flavonoids | Antioxidant, anti-inflammatory, cardioprotective |
| Phenolics | Free radical scavenging, anti-aging |
| Tannins | Antibacterial, wound healing |
| Saponins | Immune stimulation, cholesterol reduction |
| Glycosides | Cardioprotective, antimicrobial |
| Terpenoids | Antiviral, anti-inflammatory |
| Steroids | Hormonal regulation, adaptogenic activity |

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The table demonstrates that medicinal plants containing diverse phytochemicals possess multiple therapeutic benefits. The synergistic action of these compounds enhances the medicinal value of herbal formulations.

### 4.3 Comparative Antioxidant Potential of Selected Medicinal Plants

Antioxidant activity is primarily associated with phenolics and flavonoids. Plants rich in these compounds show strong capacity to neutralize free radicals and reduce oxidative stress.

**Table 3:** Comparative Antioxidant Potential Based on Phenolics and Flavonoids

| Medicinal Plant | Phenolic Content | Flavonoid Content | Estimated Antioxidant Potential |
|---|---|---|---|
| Tulsi | High | High | Very Strong |
| Neem | Moderate | High | Strong |
| Aloe vera | Moderate | Moderate | Moderate |
| Turmeric | Very High | High | Excellent |
| Ashwagandha | Moderate | Moderate | Moderate |

The findings indicate that Curcuma longa possesses the strongest antioxidant potential due to its very high phenolic concentration. Tulsi also demonstrated strong antioxidant activity because of its rich flavonoid and phenolic profile.

### 4.4 Comparative Antimicrobial Properties of Medicinal Plants

The antimicrobial potential of medicinal plants is influenced by alkaloids, tannins, flavonoids, and terpenoids.

**Table 4:** Comparative Antimicrobial Activity Based on Phytochemical Presence

| Medicinal Plant | Alkaloids | Tannins | Terpenoids | Estimated Antimicrobial Activity |
|---|---|---|---|---|
| Tulsi | Moderate | Moderate | High | Strong |
| Neem | High | High | Moderate | Very Strong |
| Aloe vera | Low | Low | Moderate | Moderate |
| Turmeric | Moderate | Moderate | High | Strong |
| Ashwagandha | High | Low | High | Strong |

The table suggests that Neem possesses the highest antimicrobial potential because of the abundant presence of alkaloids and tannins. Tulsi and Turmeric also demonstrated considerable antimicrobial activity due to terpenoid-rich phytochemical profiles.

### 4.5 Pharmacological Applications of Selected Medicinal Plants

The identified phytochemicals support multiple pharmacological applications in traditional and modern medicine.

**Table 5:** Major Pharmacological Applications of Selected Medicinal Plants

| Medicinal Plant | Principal Bioactive Compounds | Major Pharmacological Applications |
|---|---|---|
| Tulsi | Flavonoids, terpenoids | Immunomodulatory, antioxidant |
| Neem | Alkaloids, tannins | Antimicrobial, antifungal |

| | | |
|---|---|---|
| Aloe vera | Saponins, glycosides | Wound healing, skin protection |
| Turmeric | Curcuminoids, phenolics | Anti-inflammatory, anticancer |
| Ashwagandha | Steroidal lactones, glycosides | Adaptogenic, neuroprotective |

The results highlight the wide medicinal importance of selected plants in pharmaceutical, nutraceutical, and herbal healthcare industries.

### 4.6 Comparative Discussion of Phytochemical Diversity

The comparative analysis revealed that each medicinal plant possesses unique phytochemical characteristics that determine its therapeutic potential. Turmeric emerged as a superior source of antioxidant compounds, whereas Neem showed stronger antimicrobial phytochemicals. Tulsi exhibited balanced phytochemical diversity with significant antioxidant and immune-enhancing properties. Aloe vera was found particularly beneficial for dermatological and wound-healing applications due to its glycoside and saponin content. Ashwagandha demonstrated remarkable adaptogenic potential because of its steroidal compounds.

The variation in phytochemical composition may be influenced by genetic factors, environmental conditions, geographical distribution, soil composition, and extraction methods. The findings of the present study support the traditional medicinal uses of these plants and emphasize their significance as natural sources of therapeutic agents.

Overall, medicinal plants serve as valuable reservoirs of bioactive compounds with immense pharmaceutical importance. Comparative phytochemical evaluation assists in identifying plants with superior medicinal value and promotes their utilization in future drug discovery and healthcare applications.

## 5.CONCLUSION AND RECOMMENDATIONS

The present study demonstrated that selected medicinal plants possess diverse bioactive compounds with significant therapeutic importance. Phytochemical screening revealed the presence of alkaloids, flavonoids, phenolics, tannins, saponins, glycosides, terpenoids, and steroids in varying concentrations among the selected plants. Curcuma longa showed strong antioxidant potential due to high phenolic content, while Azadirachta indica exhibited remarkable antimicrobial properties. Ocimum sanctum displayed balanced antioxidant and immunomodulatory activities, whereas Aloe vera and Withania somnifera were found beneficial for wound healing and adaptogenic applications respectively. The findings highlighted the pharmaceutical importance of medicinal plants and supported their traditional medicinal uses.

- Further advanced studies should be conducted to isolate and characterize specific bioactive compounds using modern analytical techniques.
- Quantitative and clinical investigations should be performed to validate the therapeutic efficacy and safety of medicinal plant extracts.
- Medicinal plants with high phytochemical potential should be utilized for the development of herbal drugs and nutraceutical products.
- Conservation and sustainable cultivation practices should be promoted to preserve valuable medicinal plant resources for future healthcare applications.

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