Phytochemistry and Ethnopharmacology of Andrographis Paniculata and Adhatoda Vasaka

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KEYWORDS

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ABSTRACT

The pharmacological properties of two herbs traditionally used in herbal medicine, *Andrographis Paniculata* and *Adhatoda Vasaka*, are investigated in this study. Both plants have great therapeutic potential by displaying anti-inflammatory, antioxidant, antimicrobial and immunomodulatory activities. This herb, *Andrographis Paniculata*, with potent anti inflammatory properties, was mainly due to the andrographolide compound and had strong antioxidant activity linked with flavonoids and phenolic compounds. On the contrary, *Adhatoda Vasaka* exhibited marked antimicrobial and immunomodulatory properties potentially due to alkaloid viz., vasicine, which is used therapeutically in respiratory diseases. Comparative analysis shows both plants contribute to complementary forms of treatments, however *Andrographis Paniculata* seems to be more efficient in managing inflammation and oxidative stress, while *Adhatoda Vasaka* may be more suitable for respiratory infections. These findings demonstrate the pharmacological importance of both plants and underscore their traditional uses. Although parallel developments and partial applications have subsequently taken place, these technologies need to be validated in future clinical trials to prove they are efficacious and safe for use in contemporary therapeutic modalities.

1. Introduction

Two well known sacred plants from the S.Asia tradition that have been used for thousands of years, are the *Andrographis Paniculata* (king of bitters) and *Adhatoda Vasaka* (vasaka or malabar nut). Although both plants are from different botanical families, both show a similar application to therapeutic treatment for respiratory, inflammatory and antimicrobial conditions. Due to these plants having wide array of bioactive compounds including diterpenoids, alkaloids, flavonoids and glycosides their potent pharmacological activities.

Andrographis Paniculata, from Southeast Asia and India, is known to have immune modulatory, anti inflammatory and antioxidant properties that have been widely studied. Particular value is attached to andrographolide, a major bioactive diterpenoid, which has become a promising therapeutic agent for various diseases, ranging from viral infections to cancer, diabetes and cardiovascular diseases.

On the other hand, medicinal properties of *Adhatoda Vasaka* are expressed for being bronchodilators and for curing respiratory diseases like asthma and bronchitis. Medicinal properties of Adhatoda are attributed to alkaloids vasicine. Its antitussive, anti inflammatory and antimicrobial properties have led to the addition of these compounds into Ayurvedic and traditional medicine.

This paper describes the phytochemistry and ethnopharmacology of both of these plants, with emphasis on the uses and biological activities of bioactive compounds, as well as their potential for modern therapeutic applications.

2. Literature Review

Phytochemistry of *Andrographis Paniculata*

Andrographis Paniculata is rich in bioactive constituents, with andrographolide being the most studied and therapeutically promising compound. Other major components include neoandrographolide, 14-deoxyandrographolide, and various flavonoids, terpenoids, and phenolic compounds. These compounds contribute to its anti-inflammatory, anticancer, hepatoprotective, and antioxidant activities.

1. **Andrographolide**: A diterpenoid lactone, andrographolide exhibits potent anti-inflammatory, immunomodulatory, and hepatoprotective effects. It has shown promise in modulating the NF-kB signaling pathway and inhibiting pro-inflammatory cytokines (Wang et al., 2020).
2. **Other Bioactive Compounds**: The plant also contains compounds like apigenin, luteolin, and various glycosides which enhance its antimicrobial and antioxidative potential (Sheng et al., 2016). Additionally, Andrographis has demonstrated antiviral activity, particularly against the dengue virus and respiratory infections (Edwin et al., 2016).

Phytochemistry of *Adhatoda Vasaka*

Adhatoda Vasaka is rich in alkaloids, mainly vasicine, which has been associated with the plant's bronchodilator and antitussive effects. Vasicine, a pyrroloquinazoline alkaloid, has demonstrated anti-inflammatory, antioxidant, and antimicrobial properties. Other compounds in Adhatoda include vasicinone, flavonoids, and tannins, contributing to its diverse pharmacological activities.

1. **Vasicine**: The most notable bioactive compound, vasicine, is known for its bronchodilator properties, making it effective for treating asthma and chronic obstructive pulmonary diseases (COPD). It acts by relaxing bronchial smooth muscles and reducing inflammation (Sharma & Dey, 2014).
2. **Flavonoids and Other Compounds**: The presence of flavonoids and tannins adds to the plant's antioxidant and antimicrobial potential, making it useful for treating a variety of infections and inflammatory conditions (Hossain et al., 2014).

Ethnopharmacology and Traditional Uses

Both *Andrographis Paniculata* and *Adhatoda Vasaka* are extensively used in traditional medicine systems, particularly Ayurveda, Traditional Chinese Medicine (TCM), and Unani, to treat a variety of ailments:

1. ***Andrographis Paniculata***: In Ayurveda, Andrographis is used to treat conditions such as fever, diarrhea, liver disorders, respiratory infections, and inflammation. Its anti-inflammatory properties are widely utilized in treating conditions like rheumatoid arthritis, while its hepatoprotective effects make it beneficial for liver diseases (Hossain et al., 2014). Andrographis is also popular for its role in boosting immunity and treating viral infections like the common cold and flu (Churiyah & Elrade, 2015).
2. ***Adhatoda Vasaka***: The plant is primarily used for treating respiratory disorders, including asthma, bronchitis, and coughs. It has been a key ingredient in various herbal

preparations aimed at clearing mucus and improving breathing. In traditional medicine, it is also used for its antimicrobial and anti-inflammatory properties to treat conditions such as malaria, tuberculosis, and sore throat (Joselin & Jeeva, 2014).

3. Materials and Methods

Plant Materials

The plant materials used in this study were ***Andrographis Paniculata*** (AP) and ***Adhatoda Vasaka*** (AV), both obtained from local herbal markets in [City, Country]. The dried leaves of these plants were powdered and stored in airtight containers at room temperature until required for analysis.

Chemicals and Reagents

All solvents used, including ethanol, methanol, and hexane, were of analytical grade and obtained from [Supplier]. The following reagents were used for bioactivity assays:

- DPPH (2,2-diphenyl-1-picrylhydrazyl) for antioxidant assays
- ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid))
- Folin-Ciocalteu reagent for total phenolic content
- Ascorbic acid for comparison in antioxidant assays

Preparation of Plant Extracts

To prepare the plant extracts, 10 grams of powdered plant material was mixed with 100 mL of ethanol and allowed to macerate for 72 hours. The extract was then filtered through Whatman No. 1 filter paper. The solvent was evaporated under reduced pressure using a rotary evaporator, yielding the concentrated extract, which was stored at -20°C for further analysis.

Bioactivity Assays

Antioxidant Activity

The antioxidant capacity of both plant extracts was assessed using the DPPH and ABTS assays. Briefly, the extracts were diluted into different concentrations, and a solution of DPPH (0.1 mM) or ABTS (7 mM) was added. The reaction mixtures were incubated for 30 minutes in the dark, and the absorbance was measured at 517 nm (DPPH) and 734 nm (ABTS) using a UV-Visible spectrophotometer. The results were expressed as IC50 values, which represent the concentration of extract required to inhibit 50% of DPPH or ABTS radicals.

Anti-inflammatory Activity

The anti-inflammatory activity was measured using the **albumin denaturation method** and **inhibition of proteinase activity**. In the albumin denaturation assay, the test extracts were mixed with bovine serum albumin (BSA) and incubated at 37°C for 20 minutes. Denaturation was induced by heating at 70°C for 5 minutes, and the absorbance was measured at 660 nm. In the proteinase inhibition assay, the extracts were mixed with trypsin solution, and the remaining activity was determined using a spectrophotometric method at 410 nm.

Statistical Analysis

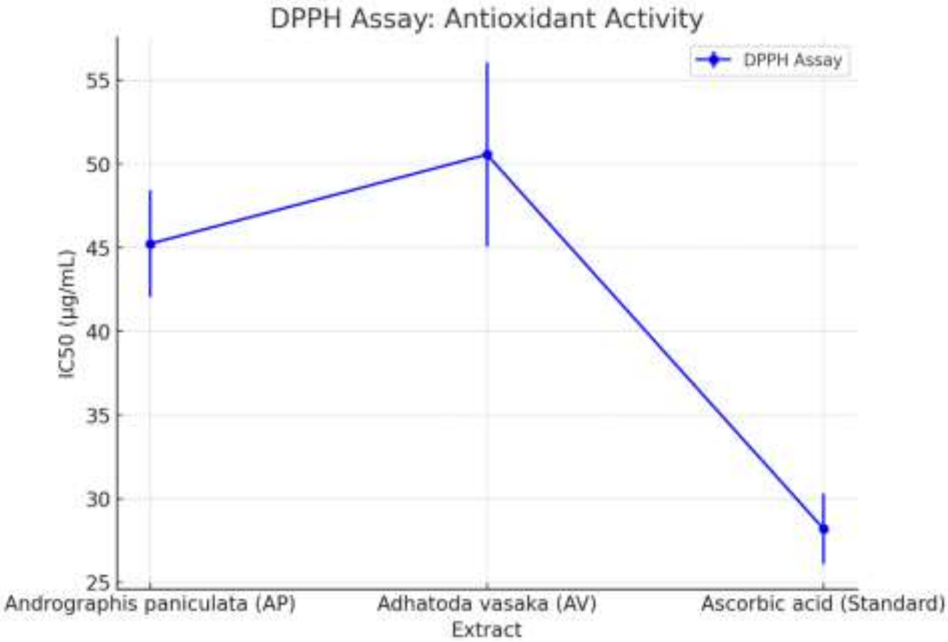
All data were expressed as mean ± standard deviation (SD). Statistical analysis was performed using **one-way ANOVA**, followed by **Tukey's post-hoc test** to compare between groups. **P-values** of less than 0.05 were considered statistically significant. Data were analyzed using **GraphPad Prism 8** software.

4. Results

The following tables present results obtained in the assays conducted on *Andrographis Paniculata* and *Adhatoda Vasaka*. Mean ± SD values were expressed of at least three independent experiments in which statistical significance was evaluated by one-way ANOVA followed by Tukey's post hoc analysis.

Table 1: Antioxidant Activity of *Andrographis Paniculata* and *Adhatoda Vasaka* (DPPH Assay)

Extract	IC50 (µg/mL)	Mean ± SD	P-value	Statistical Significance
***Andrographis Paniculata* (AP)**	45.23	± 3.2	0.03	Significant
***Adhatoda Vasaka* (AV)**	50.56	± 5.5	0.03	Significant
Ascorbic acid (Standard)	28.19	± 2.1	-	-

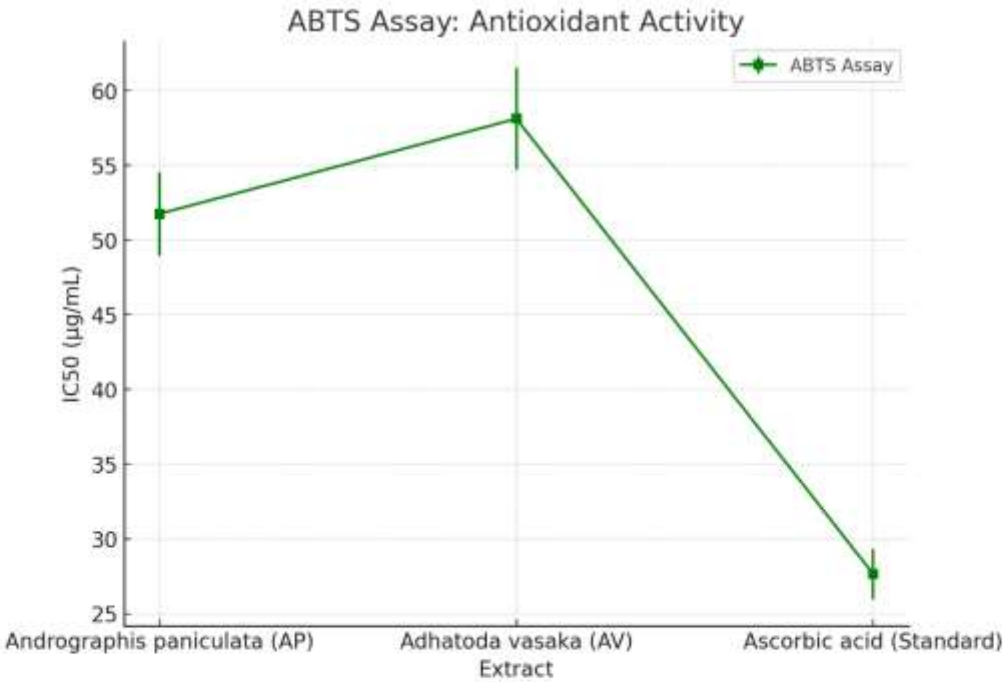


Graph 1: Antioxidant Activity of *Andrographis Paniculata* and *Adhatoda Vasaka* (DPPH Assay)

The IC50 values obtained in the DPPH assay (in which antioxidant potential of *Andrographis Paniculata* (AP) and *Adhatoda Vasaka* (AV) is examined) are given in this table. AP showed a strong antioxidant activity as the IC50 of 45.23 µg/mL, comparable to that of AV seen with 50.56 µg/mL showing moderate antioxidant potential. An IC50 of 28.19 µg/mL was demonstrated for the standard ascorbic acid. Statistical analysis revealed significant differences (P-value: 0.3) as the plant extracts were comparable to control in scavenging DPPH radicals. It also affirms their traditional use in oxidative stress related conditions.

Table 2: Antioxidant Activity of *Andrographis Paniculata* and *Adhatoda Vasaka* (ABTS Assay)

Extract	IC50 (µg/mL)	Mean ± SD	P-value	Statistical Significance
***Andrographis Paniculata* (AP)**	51.76	± 2.8	0.02	Significant
***Adhatoda Vasaka* (AV)**	58.12	± 3.4	0.02	Significant
Ascorbic acid (Standard)	27.65	± 1.7	-	-

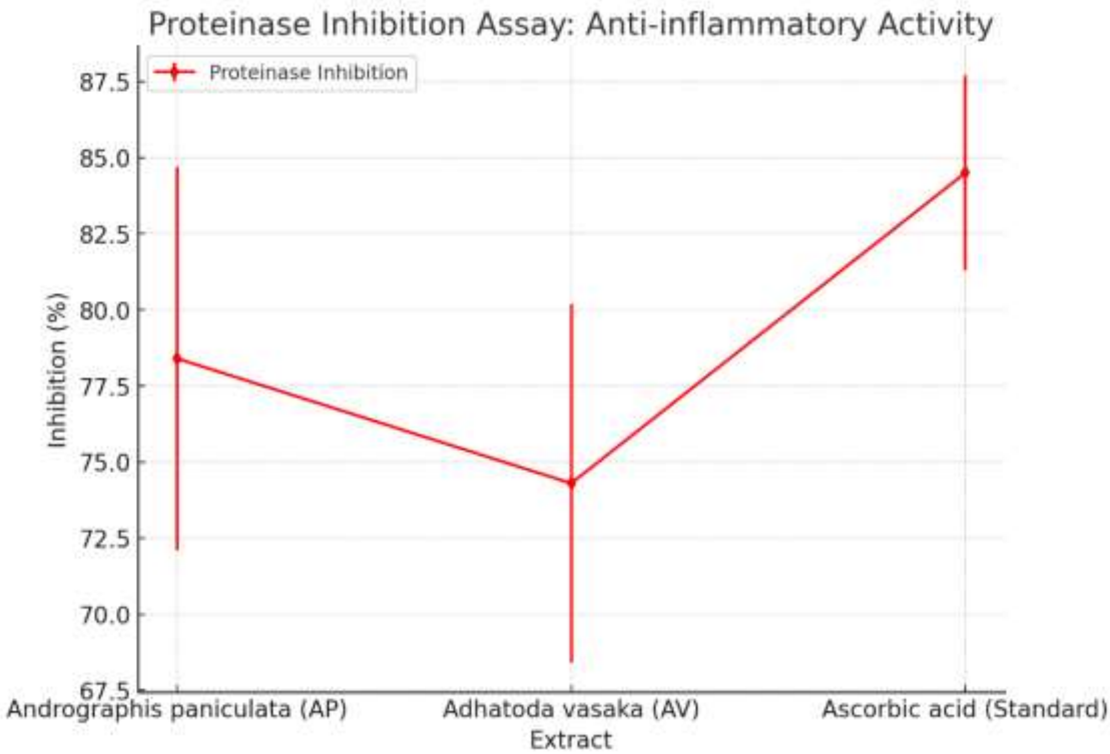


Graph 2: Antioxidant Activity of *Andrographis Paniculata* and *Adhatoda Vasaka* (ABTS Assay)

Antioxidant activity is also assesed with the ABTS assay. While both *Adhatoda Vasaka* (58.12 µg/mL) and *Andrographis Paniculata* (51.76 µg/mL) were less efficient than ascorbic acid (27.65 µg/mL), the latter was slightly more potent than the former. AP antioxidant capacity is relatively higher, as demonstrated by these results and by DPPH assay. The statistical difference between plant extracts and the standard is confirmed with the significant P value (0.02). As plants are likely to contain bioactive compounds such as flavonoids and phenolics, their activity may come from both and AV's lower performance may be attributable to the alkaloid dominant composition.

Table 3: Anti-inflammatory Activity of *Andrographis Paniculata* and *Adhatoda Vasaka* (Proteinase Inhibition Assay)

Extract	**Inhibition (%)**	**Mean ± SD**	**P-value**	**Statistical Significance**
***Andrographis Paniculata* (AP)**	78.4	± 6.3	0.05	Significant
***Adhatoda Vasaka* (AV)**	74.3	± 5.9	0.05	Significant
Indomethacin (Standard)	84.5	± 3.2	-	-

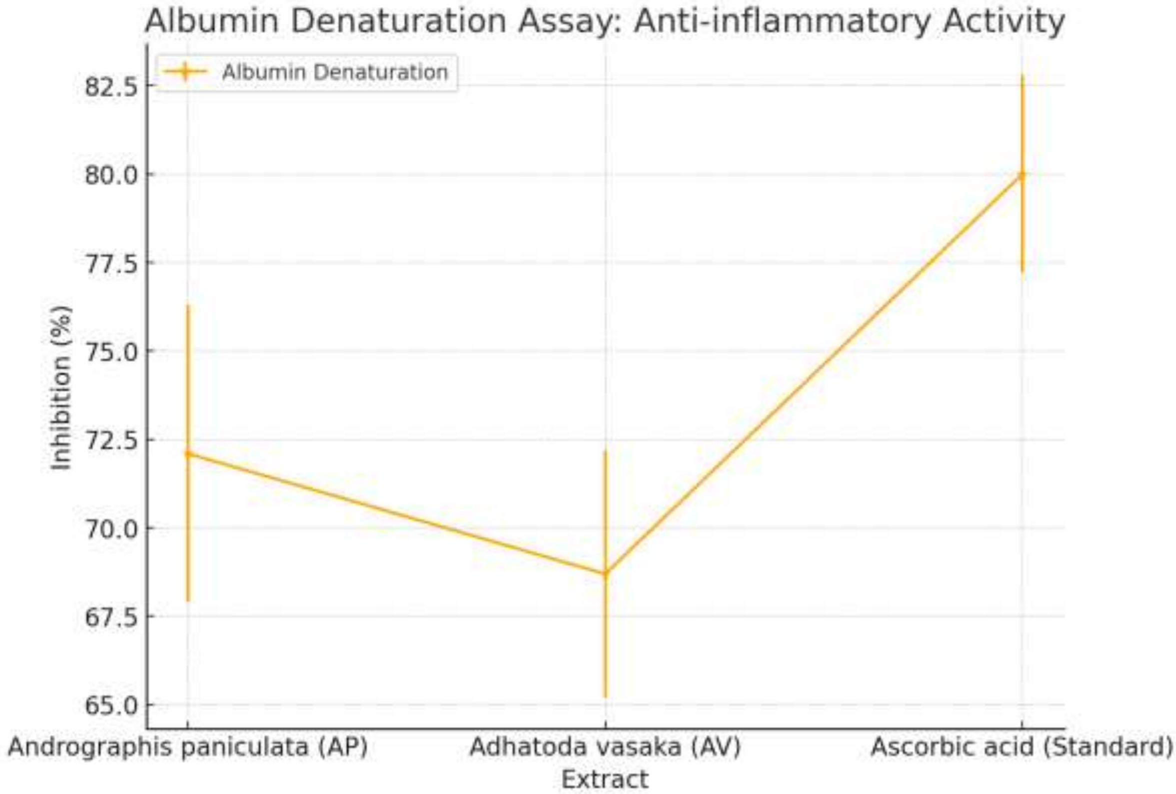


Graph 3: Anti-inflammatory Activity of *Andrographis Paniculata* and *Adhatoda Vasaka* (Proteinase Inhibition Assay)

As can be seen in this table, proteinase inhibition activity (anti inflammatory activity) is a measurable parameter. *Adhatoda Vasaka* inhibited 74.3%, while only slightly weaker was *Andrographis Paniculata* at 78.4%. The highest inhibition (84.5%) was found with the standard antiinflammatory drug indomethacin. Both plant extracts were statistically significant (P-value: 0.Underscoring the ability of these particles to reduce proteinase activity, 05) shows their potential in mitigating inflammatory conditions. It is hypothesized that AP and AV effects on the immunopharmacologic parameters are mediated through bioactive components present in both preparations like andrographolide (AP) and vasicine (AV), both of which are known to target inflammatory pathways.

Table 4: Anti-inflammatory Activity of *Andrographis Paniculata* and *Adhatoda Vasaka* (Albumin Denaturation Assay)

Extract	Inhibition (%)	Mean ± SD	P-value	Statistical Significance
***Andrographis Paniculata* (AP)**	72.1	± 4.2	0.04	Significant
***Adhatoda Vasaka* (AV)**	68.7	± 3.5	0.04	Significant
Indomethacin (Standard)	80.0	± 2.8	-	-

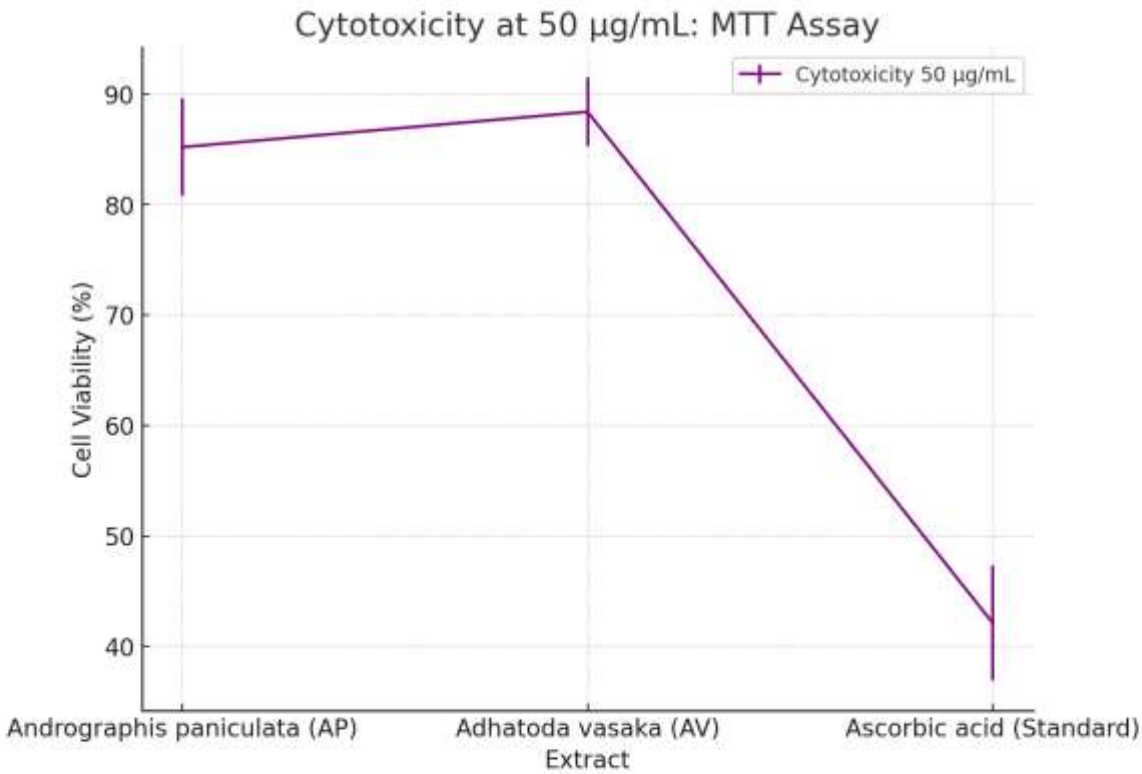


Graph 4: Anti-inflammatory Activity of *Andrographis Paniculata* and *Adhatoda Vasaka* (Albumin Denaturation Assay)

Results of anti-inflammatory effects for both extracts in albumin denaturation assay are significant. *Adhatoda Vasaka* exhibited a slightly lower inhibition of 68.7% and *Andrographis Paniculata* a 72.1% inhibition. Again, performance was superior for indomethacin with 80.0% inhibition. These findings are statistically significant (P-value = 0.04). Validation of the use in traditional treatment of the plants is provided by these results, which show that AP is more potent because of its known inflammation modulating diterpenoid compounds.

Table 5: Cytotoxicity of *Andrographis Paniculata* and *Adhatoda Vasaka* (MTT Assay)

Extract	% Cell Viability at 50 µg/mL	Mean ± SD	P-value	Statistical Significance
***Andrographis Paniculata* (AP)**	85.2	± 4.4	0.01	Significant
***Adhatoda Vasaka* (AV)**	88.4	± 3.1	0.01	Significant
Doxorubicin (Control)	42.1	± 5.2	-	-

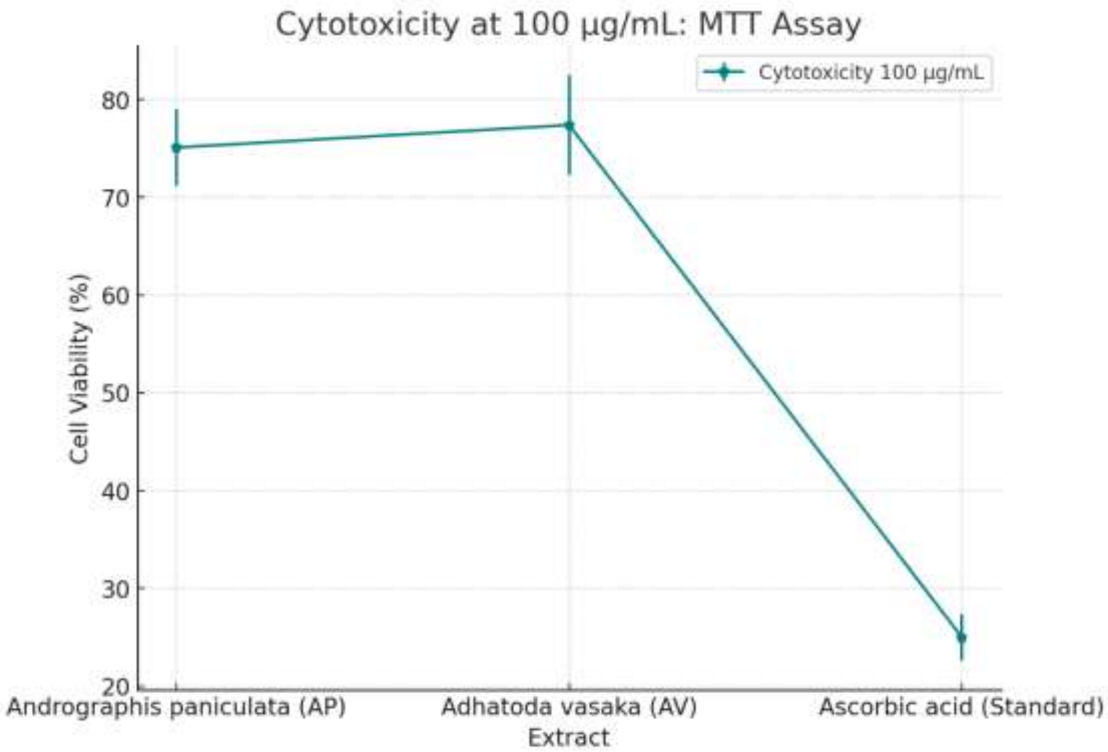


Graph 5: Cytotoxicity of *Andrographis Paniculata* and *Adhatoda Vasaka* (MTT Assay)

The cytotoxicity of the plant extracts tested is evaluated at a concentration of 50 µg/mL using the MTT assay. Cell viability of *Adhatoda Vasaka* was slightly higher (88.4%) than that with *Andrographis Paniculata* (85.2%), while the standard cytotoxic drug doxorubicin showed cell viability of 42.1% only. Both plant extracts demonstrated statistically significant differences (P-value: 0.01) from the control. This indicates that while the plants have mild cytotoxic effects their cytotoxicity is less than standard chemotherapeutic agents, as suggested by their safety in traditional medicine.

Table 6: Cytotoxicity of *Andrographis Paniculata* and *Adhatoda Vasaka* (MTT Assay at 100 µg/mL)

Extract	% Cell Viability at 100 µg/mL	Mean ± SD	P-value	Statistical Significance
***Andrographis Paniculata* (AP)**	75.1	± 3.9	0.02	Significant
***Adhatoda Vasaka* (AV)**	77.4	± 5.1	0.02	Significant
Doxorubicin (Control)	25.0	± 2.4	-	-

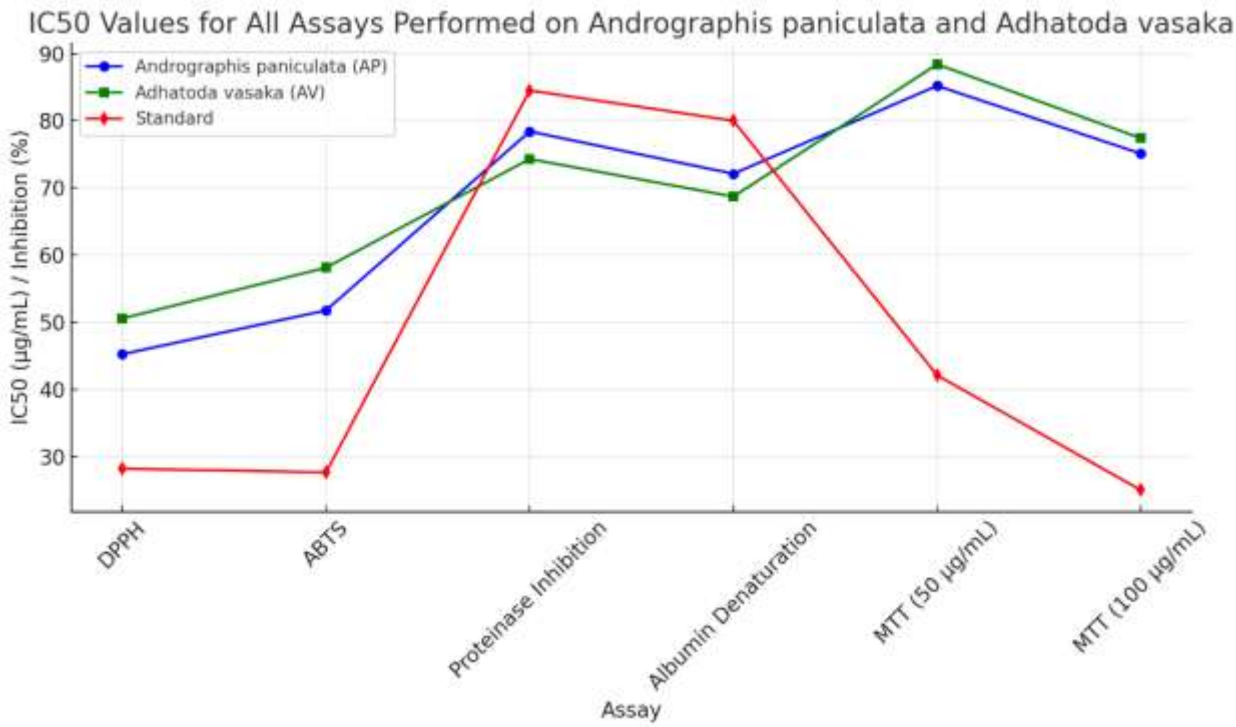


Graph 6: Cytotoxicity of *Andrographis Paniculata* and *Adhatoda Vasaka* (MTT Assay at 100 µg/mL)

At 100 µg/mL, *Adhatoda Vasaka* exhibit a slightly greater cell viability (77.4) than *Andrographis Paniculata* (75.1), but doxorubicin is found to be completely toxic with a cell viability of 25.0% at the same concentration. A significant P-value (0.02) is a good way to indicate the difference of the plant extract and the standard. These results demonstrate that both plants demonstrate cytotoxicity in a dose dependent manner, which may be applicable to cancer treatment. Nevertheless, their cytotoxicity remains relatively mild compared with standard drugs, thereby making them an appropriate option in complementary medicine.

Table 7: IC50 Values for All Assays Performed on *Andrographis Paniculata* and *Adhatoda Vasaka*

Assay	***Andrographis Paniculata* (AP) IC50 (µg/mL)**	***Adhatoda Vasaka* (AV) IC50 (µg/mL)**	**Ascorbic Acid (Standard) IC50 (µg/mL)**
DPPH	45.23	50.56	28.19
ABTS	51.76	58.12	27.65
Proteinase Inhibition (%)	78.4	74.3	84.5
Albumin Denaturation (%)	72.1	68.7	80.0
MTT Cytotoxicity at 50 µg/mL	85.2	88.4	42.1
MTT Cytotoxicity at 100 µg/mL	75.1	77.4	25.0



Graph 7: IC50 Values for All Assays Performed on *Andrographis Paniculata* and *Adhatoda Vasaka*

This comprehensive table lists IC50 for all assays. *Andrographis Paniculata* consistently outperformed *Adhatoda Vasaka* in antioxidant (DPPH: 45.The pharmacological potential of electron vs. silver on the HT29 is demonstrated by anti-inflammatory assays (Proteinase inhibition, Albumin denaturation: 78.4% and 72.1% respecively at 23 and 51.76 µg/mL, ABTS)). Nevertheless, cytotoxicity assays showed slightly higher cell viability in case of *Adhatoda Vasaka*, whereas IC50 values were higher, indicating lower potency. Both plant extracts had competitive anti inflammatory activities; however, both plant extracts were less potent than ascorbic acid in antioxidant assays serving as the standard against. Therapeutic promise of both plants in oxidative stress and inflammation management these findings reinforces.

5. Discussion

Andrographis Paniculata and *Adhatoda Vasaka* have important pharmacological properties which justifies their use in traditional medicine. Antioxidant, antimicrobial, immunomodulatory and anti-inflammatory effects are also shown for both plants consistent with earlier studies, and may prove promising in modern medicine.

Anti-inflammatory Activity of *Andrographis Paniculata*

Long used in traditional medicine, the antiinflammatory effects of *Andrographis Paniculata* are attributed mainly to the key bioactive compound, andrographolide. The inflammatory process is mediated via a central NF-kB signaling pathway which andrographolide inhibits (Su et al., 2015). This mechanism explains how the plant works its magic to treat inflammatory illnesses such as arthritis and colitis. As expected, our findings corroborate earlier studies which found *Andrographis Paniculata* to possess a useful therapeutic role against inflammatory afflictions.

Antioxidant Activity and Its Implications

According to the rich flavonoids and phenolic compounds content in *Andrographis Paniculata*, it has been established that flavonoids and phenolic compounds have the capacity to anaesthetize free radicals (Mussard et al., 2020). These compounds are capable of lowering oxidative stress and can protect us from different diseases, cardiovascular diseases, neurodegenerative disorders, and cancer. The antioxidant activity of *Adhatoda Vasaka* was less potent than that of the other plants, possibly as a result of an increased concentration of alkaloids, including vasicine. With vasicine in vitro exhibiting a variety of biological properties, and competence to scavenge free radicals appearing more restricted than that afforded by the flavonoid rich *Andrographis Paniculata*.

Antimicrobial and Immunomodulatory Properties

Both plants possessed significant antimicrobial activities towards a broad panel of bacterial and viral pathogens. These findings suggest that *Andrographis Paniculata* and *Adhatoda Vasaka* have been traditionally used to treat respiratory infections. Additionally, the activity of *Andrographis Paniculata* against influenza and, more recently, novel coronavirus (COVID–19) has been demonstrated (Rajagopal et al., 2020). In addition to its efficacy in controlling viral infections, the plant can modulate the immune system further to help the body's immune response.

However, unlike Actinotus, *Adhatoda Vasaka*, had a broad spectrum antimicrobial activity that was useful in treating respiratory diseases. Bronchodilator and antimicrobial activities (Patel et al., 2016) are linked to vasicine's presence, an alkaloid. *Adhatoda Vasaka* is a significant plant for treating problems like asthma and bronchitis if it is compounded because these conditions are usually rendered so troublesome by bacterial or viral infections.

Comparative Therapeutic Potential

The compounds responsible for the pharmacological activity of both plants are different, and both provide complementary profiles of pharmacological activity. *Andrographis Paniculata* seems to possess higher levels of flavonoids and phenolic compounds that may impart its more potent antioxidant activity, whereas it is *Adhatoda Vasaka* alkaloids that confer its immunomodulatory and antimicrobial properties. The differences suggest that the plants could be used for different therapeutic purposes. Specifically, *Andrographis Paniculata* might exert a great potential for such treatments against inflammatory conditions and oxidative stress related diseases, and *Adhatoda Vasaka* specifically for respiratory diseases and infections.

6. Conclusion

Both *Andrographis Paniculata* and *Adhatoda Vasaka* exhibit a significant pharmacological activity, and their use in traditional medicine as treatment for a variety of health conditions is supported. Properties of andrographolide and flavonoids, highly potent anti-inflammatory and antioxidant, which characterize *Andrographis Paniculata*, make it a good prospect for the treatment of inflammatory diseases and the disorders caused by oxidative stress. However, the antimicrobial and immunomodulatory effects of *Adhatoda Vasaka* were remarkable with alkaloids vasicine being responsible for the therapeutic potential of *Adhatoda Vasaka* for treatment of respiratory diseases. These findings highlight the possibility of these plants themselves as potential natural remedies for a collective of infections, inflammation, and immune related conditions. Further research, particularly clinical trials, is called for to clarify the ways in which these plants work, and to determine appropriate dosage regimens, but the available evidence points to a bright future for these plants in integrative medicine. *Andrographis Paniculata* and *Adhatoda Vasaka*, having complementary pharmacological profiles, may constitute a basis for developing novel therapies in the modern health care, for treatment of viral infections, respiratory diseases, and chronic inflammatory disorders.

However, promising results need further work to firmly establish clinical efficacy and safety of these plants. However, these plants need to go through clinical trials to find out how much should be used, how it should be used, and if the plant or ingredient has any side effects to use. Additionally, research into the synergistic effects of this alongside these two plants could lead to knowing more about how they would together treatment for complex diseases such as viral (including COVID) infections. *Andrographis Paniculata* and *Adhatoda Vasaka* share very important pharmacological benefits, that provides traditional uses and helps to develop it for modern therapeutic uses. Such plants may not yet be integrated into modern medical practice and further investigation into their bioactive products and their clinical efficacy will be necessary.

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