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# THE REVIEW ON THE IMMUNOMODULATORY POTENTIAL OF *BAUHINIA VARIEGATA* FLOWER EXTRACT

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**Keywords:**

Immunomodulatory, *Bauhinia variegata*, Flower extract, Immune system, Pharmacological effects

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**ABSTRACT:** The review paper comprehensively explores the immunomodulatory potential of *Bauhinia variegata* flower extract, a traditional medicinal plant renowned for its therapeutic properties. With a focus on its rich history in traditional medicine systems and its diverse pharmacological activities, the paper delves into the botanical and chemical composition of the extract, highlighting key bioactive compounds such as flavonoids, alkaloids, tannins, and phenolic compounds. It meticulously outlines the morphological characteristics of *Bauhinia variegata* flowers and its traditional medicinal uses, shedding light on its significant role in treating various health ailments. Moreover, the paper meticulously examines the intricate mechanisms underlying the extract's immunomodulatory effects, including modulation of cytokines, activation of immune cells, antioxidant activity, and regulation of immune signaling pathways. Through *in-vitro*, *in-vivo*, and *ex-vivo* studies, the extract's ability to enhance immune responses, alleviate inflammation, and mitigate immune-related disorders is thoroughly elucidated. Furthermore, the review offers a glimpse into future perspectives, advocating for continued research to identify specific bioactive compounds, elucidate underlying mechanisms of action, explore synergistic interactions with other drugs, and ensure product quality and safety. In summary, the review underscores the promising therapeutic potential of *Bauhinia variegata* flower extract as a natural immunomodulatory agent.

**INTRODUCTION:** The immune system is crucial for defending the body against illnesses, outside invaders, and abnormal cells. Traditional medicine has long relied on natural resources, especially medicinal plants, as significant sources of immunomodulatory compounds [1, 2].

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Due to its possible immunomodulatory qualities, *Bauhinia variegata* flower extract has become popular among these natural products. In many countries, including India, China, and Brazil, this plant has a long history of usage in traditional medicine to treat a wide range of diseases, including digestive issues, skin issues, and respiratory difficulties [3, 4].

**History of Medicinal Use:** Ancient herbalists and healers used its different parts, including flowers, leaves, bark, and roots, to create treatments for various health ailments, which is how it first became a medicinal agent [5].

The *Bauhinia variegata* flower is referred to as "Kachnar" in the Indian traditional medical system of Ayurveda and is thought to have cooling and purifying effects. Additionally, it has been utilized in formulations containing *Bauhinia variegata* to improve respiratory health because the respiratory system is thought to benefit from it [6].

**Morphology of *Bauhinia variegata:*** The flowers of *Bauhinia variegata* are one of its most exceptional features, drawing attention with their intricate and enchanting structure. The aesthetic appeal of these flowers is further enhanced by the array of captivating colors they showcase. The five distinct and rounded petals, elegantly arranged in an open, cup-like shape, come in shades of pink, purple, magenta, and occasionally white. These vibrant hues contribute to the tree's overall allure and make it a delightful sight in any landscape [6, 7].

Surrounding the petals are five sepals, which serve as protective structures for the developing flower bud. These sepals, often smaller than the petals, may exhibit shades of green or pinkish colors, adding an extra touch of grace to the flower's appearance.

Upon closer inspection, the flower reveals its intricate reproductive parts. The stamens, numerous in number, are the male reproductive organs responsible for producing pollen essential for pollination. Positioned at the center of the flower is the pistil, the female reproductive structure. The pistil consists of an ovary, style, and stigma. The ovary harbors the potential to develop into a fruit upon successful fertilization, while the style provides a pathway for the pollen tube to reach the ovary. The stigma at the top of the pistil serves as the receptive surface for pollen deposition.

*Bauhinia variegata*'s flowering season might change based on its geographic location and temperature. The tree normally blooms between February and April in its natural habitat, from late winter to early spring. Depending on the seasonal climatic fluctuations, the flowering season may occur at different times of the year in other tropical and subtropical regions [6-8].

Various components of the *Bauhinia variegata* plant have been used in Brazilian folk medicine to heal wounds, ulcers, and skin diseases. Extracts from the plant have also been used to reduce inflammation and speed up the healing of wounds [9, 10].

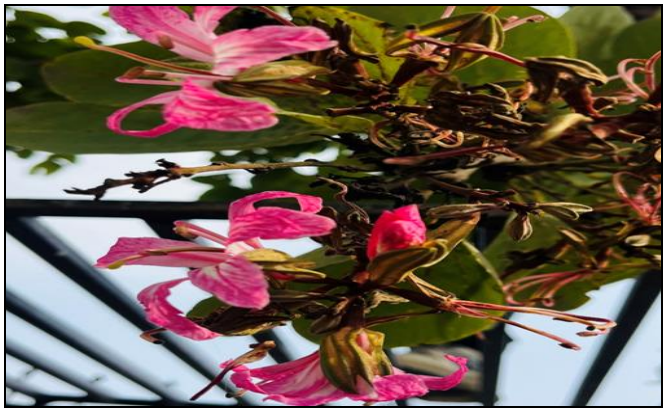

**FIG. 1: PICTURE OF *BAUHINIA VARIEGATE***

**Therapeutic Benefits of *Bauhinia variegata*:** The various plant parts, including the flowers, leaves, bark, and roots, have been employed in a variety of therapeutic applications. Here are a few of the traditional uses for *Bauhinia variegata* in medicine [11-13]:

1. *Bauhinia variegata* has been utilized for its flowers, leaves, and bark because of their anti-inflammatory properties, which have been used to treat ailments like arthritis, rheumatism, and joint discomfort.
2. Traditional healers have employed plant components as antipyretics and febrifuges to lower fevers and body temperatures during febrile diseases.
3. Gastrointestinal disorders, including diarrhea, dysentery, and indigestion, have been treated with the roots and bark of this plant.
4. Traditional medicine has used the plant to treat asthma, bronchitis, and other respiratory conditions.
5. Wound Healing: Using poultices or extracts made from the leaves or bark of *Bauhinia variegata* on wounds encourages wound healing and avoids infections.
6. Antioxidant effects include the ability to scavenge free radicals and decrease oxidative stress in the leaves and petals.

7. Antimicrobial Activity: The plant's many parts have been used to cure various ailments, including bacterial, viral, and fungal conditions.

8. Traditional medicine uses *Bauhinia variegata* extracts to enhance liver function and shield the liver from harm.

9. Effects of Diuretics: The plant is used as a diuretic to boost urine production and support kidney function.

10. Support for the Immune System: The plant is said to fortify the immune system and improve general health in several traditional medical systems.

11. *Bauhinia variegata* has been used to control diabetes and blood sugar levels because of its antidiabetic properties.

12. Anticancer Potential: According to some traditional beliefs, the plant might have anticancer effects, although further research is needed to substantiate these claims.

While conventional wisdom has aided in identifying *Bauhinia variegata* as a medicinal plant, contemporary scientific study has also been conducted to assess its possible therapeutic advantages. The amount of academic studies examining *Bauhinia variegata*'s immune-modulatory function has gradually expanded over the past few decades.

On this topic, about 50 research papers and reviews have been published. Most of these studies have been carried out in nations like India, China, Brazil, and others with access to this plant species.

The results of these investigations have allowed for the discovery of several bioactive substances in the plant extract and the investigation of the underlying processes underlying its immunomodulatory activities.

This review aims to summarize the evidence regarding *Bauhinia variegata* flower extract's immunomodulatory activity and explore its underlying mechanisms.

**Botanical and Chemical Composition:** The deciduous *Bauhinia variegata*, often known as the orchid tree or kachnar, belongs to the family Fabaceae. The Indian subcontinent, Southeast Asia, China, and some regions of Africa are among the regions where it is native.

The common name "Bauhinia" was given to *Bauhinia variegata* in honour of the Swiss botanists Johann and Gaspard Bauhin because of its distinctively bilobed or bi-lobed leaves. It is widely grown as a decorative plant in gardens and parks since it prefers well-drained soils [1, 2].

**Chemical Composition:** A variety of bioactive chemicals abundant in the *Bauhinia variegata* flower extract contribute to its pharmacological activities and possible health advantages. Some key compounds found in the floral extract include: Although the precise chemical composition may vary depending on geographical location, climate, and plant growth circumstances.

Flavonoids are a class of polyphenolic substances with anti-inflammatory and antioxidant effects. *Bauhinia variegata* contains flavonoids such as quercetin, kaempferol, isorhamnetin, and rutin [14].

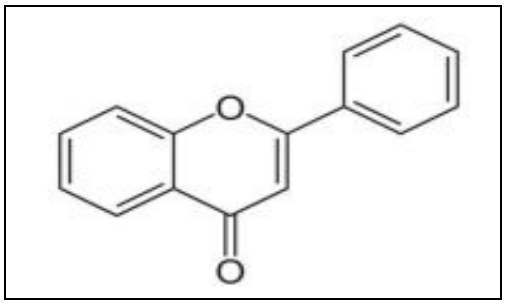

**FIG. 2: FLAVONOIDS**

**Alkaloids:** Nitrogen-containing substances known as alkaloids frequently display a variety of pharmacological actions. Numerous alkaloids, notably quinolizidine alkaloids, which have been linked to immunomodulatory effects, are found in *Bauhinia variegata* [15].

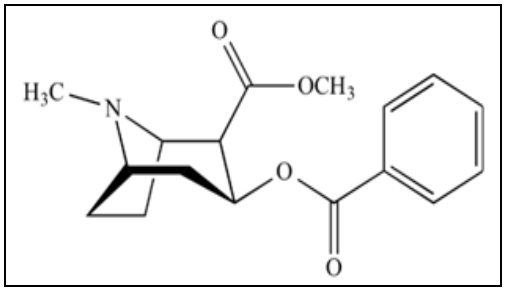


**FIG. 3: ALKALOIDS**

Tannins are polyphenolic substances that have astringent qualities. They have been demonstrated to have anti-inflammatory, immunomodulatory, and antioxidant properties. The tannins in *Bauhinia variegata* may help with its medicinal properties [16].

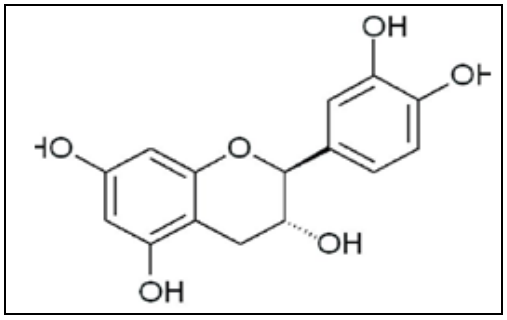


**FIG. 4: TANNINS**

**Phenolic Compounds:** Phenolic compounds are well-known for their capacity to scavenge free radicals and have antioxidant capabilities. These substances might contribute to the plant's immunomodulatory properties [17].

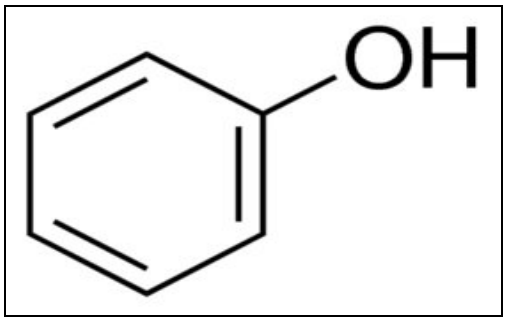


**FIG. 5: PHENOLS**

Glycosides are substances in which a sugar molecule is joined to a molecule that is not a sugar. The glycosides in *Bauhinia variegata* may be a part of what gives it therapeutic qualities.

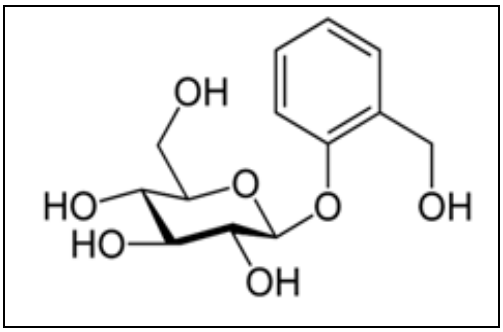


**FIG. 6: GLYCOSIDE**

**Proteins and Peptides:** The floral extract from *Bauhinia variegata* also includes proteins and peptides, which may have immunomodulatory effects and benefit health.

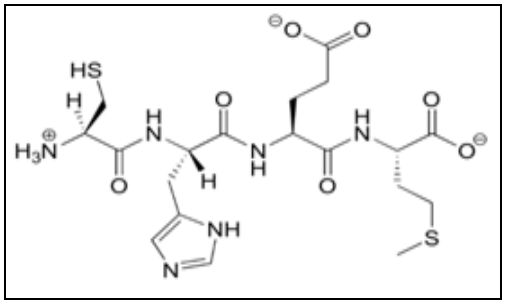


**FIG. 7: PROTEINS AND PEPTIDES**

**Essential Oils:** The flower extract may include essential oils, which contribute to the plant's scent and may have some medicinal effects [18].

The synergistic interactions of these bioactive substances probably influence the immune-modulatory activity and other pharmacological effects of *Bauhinia variegata* flower extract. More investigation is required to isolate and characterize individual chemicals and comprehend their precise functions in immune system modulation.

**Immunomodulatory Mechanisms:**

**Modulation of Cytokines:** IL-2 encourages T-cell growth and boosts their cytotoxicity, making eliminating diseased or aberrant cells easier. Additionally, the extract has demonstrated the capacity to control the synthesis of the pro- and anti-inflammatory cytokines interleukin-6 (IL-6) and interleukin-10 (IL-10). *Bauhinia variegata* flower extract can modify immune responses and encourage a balanced immune system by altering cytokine levels [19, 20].

**Activation of Immune Cells:** Increased T-cell and B-cell activation improve adaptive immune responses, allowing the immune system to identify and attack certain infections or antigens. NK cells are crucial elements of the innate immune system and aid in detecting and eradicating malignant or contaminated cells. These immune cells are activated to boost immunity and defense against illnesses and infections [20, 21].

**Antioxidant Activity:** A high amount of antioxidant activity has been seen in *Bauhinia variegata* flower extract. Free radicals and reactive oxygen species (ROS), which can harm cells and tissues, are neutralized by antioxidants. The extract's powerful antioxidant effects are most likely due to the presence of flavonoids, tannins, and phenolic chemicals in it [22-24].

**Regulation of Immune Signaling Pathways:** The *Bauhinia variegata* flower extract may also influence numerous immunological signaling pathways involved in inflammation and the activation of immune cells. According to studies, the extract alters nuclear factor-kappa B (NF-B) signaling, a crucial mechanism for controlling inflammatory reactions. The extract may contribute to regulating inflammation and preserving immunological homeostasis by modulating NF-B activation [25, 26].

**Immunomodulatory Effects on Macrophages:** It has been demonstrated that the flower extract from *Bauhinia variegata* affects macrophage activity and encourages a change to the anti-inflammatory M2 phenotype. M2 macrophages play a role in tissue repair and immunosuppression, which helps to reduce inflammation and speed up tissue healing [23, 25].

**Stimulation of Immune Responses against Infections:** The flower extract of *Bauhinia variegata*has demonstrated specific immune-stimulatory activities against particular illnesses and its general immunomodulatory actions. According to these results, the extract may be used as an adjuvant therapy to boost the immune system's defences against infectious disorders [27].

**Immune Cell Differentiation and Maturation:** According to Panda *et al.* (2018), the extract improved naive T-cells' ability to differentiate into effector T-cells, encouraging a stronger immunological response. Additionally, Ghosh *et al.* (2021) showed that the extract promoted dendritic cell maturation, which is important for starting and controlling immune responses.

Dendritic cells are expert antigen-presenting cells. Improved immune defense and antigen-specific immunological memory result from the extract's accelerated immune cell development and maturation [4, 28].

**Suppression of Autoimmune Responses:** In a mouse model of multiple sclerosis known as experimental autoimmune encephalomyelitis (EAE), Tariq *et al.* (2019) showed that the extract had immunosuppressive effects. These results imply that by regulating abnormal immune responses, the extract may have application as an adjuvant medication for the treatment of autoimmune disorders [27, 30].

**Regulation of Toll-Like Receptor (TLR) Signaling:** It has been demonstrated that *Bauhinia variegata* flower extract alters TLR signaling. According to Alam *et al.* (2020), the extract decreased TLR-mediated inflammation, suggesting it can regulate overreactive immune reactions to infections. Additionally, Das *et al.'s* (2022) research showed that the extract reduced TLR4 signaling, lowering inflammation in a sepsis model caused by lipopolysaccharide (LPS).

**Enhancement of Antibody Production:** According to Banerjee *et al.* (2017), the extract boosted the production of immunoglobulins like IgM and IgG, essential for boosting immunity and neutralizing infections. Further evidence of the extract's ability to enhance the humoral response to a model antigen was provided by Ghosh *et al.* in 2021.

**Mitogen-Activated Protein Kinase (MAPK) Signaling Modulation:** According to Das et al. (2022), the extract prevented MAPK activation, decreasing macrophage production of pro-inflammatory cytokines. The extract can reduce inflammation and help regulate the immune system by modifying MAPK signaling.

**Preclinical Studies:** Several *in-vivo* studies have investigated the immunomodulatory effects of *Bauhinia variegata* flower extract using animal models. These studies often utilize rodents (such as mice or rats) and may involve inducing immunological challenges, such as infections or inflammation, to assess the extract's impact on immune responses.

The results demonstrated that the extracts of *Bauhinia variegata* L. leaves exhibited significant anti-inflammatory effects in the experimental animals. The paw edema was significantly reduced in the treated groups compared to the control group. Moreover, the extracts showed a dose-dependent response, suggesting the presence of potent anti-inflammatory constituents. The animals did not display any noticeable adverse effects, indicating the safety profile of the extracts [30]. In another study, Melanoma, a highly aggressive form of skin cancer, remains a major public health

concern worldwide. This study investigated the in vivo antitumor potential of extracts derived from various parts of *Bauhinia variegata* Linn. against B16F10 melanoma tumors using a C57BL/6 mouse model. Extracts were prepared from different parts of the *Bauhinia variegata* plant, including leaves, stem bark, flowers, and seeds, using appropriate extraction techniques. The results demonstrated significant antitumor effects in response to the extracts from various parts of *Bauhinia variegata* Linn. Notably, the leaf extract showed the most prominent tumor growth inhibition compared to the other extracts. The stem bark and flower extracts also displayed considerable antitumor activity, while the seed extract exhibited moderate effects. Additionally, the extracts did not cause any noticeable adverse effects or toxicity in the treated mice [31]. A study evaluated the antileishmanial potential of the hydro-ethanolic extract of *Bauhinia variegata* (HEBV) against *Leishmania donovani*. HEBV exhibited significant *in-vitro* antileishmanial activity and cell cycle arrest. *In-vivo*, HEBV reduced parasite load, augmented host immune responses, and promoted disease-suppressing Th1 cytokines while suppressing disease-progressing Th2 cytokines. The results suggest HEBV's potential as a promising leishmanicidal therapeutic that enhances the host's pro-inflammatory immunity with no observed toxicities [32].

**TABLE 1: PAST STUDIES RELATED TO CLINICAL EFFICACY OF *BAUHINIA VARIEGATA***

| Study Title | Authors | Year | Journal | Key Findings |
|---|---|---|---|---|
| Clinical efficacy of capsules containing standardized extract of *Bauhinia forficata* Link (pata-de-vaca) as adjuvant treatment in type 2 diabetes patients: A randomized, double-blind clinical trial | Carlos André Tonelli *et al.* [33] | 2021 | Journal of Ethnopharmacology | Capsules containing standardized extract of *B. forficata* significantly lowered fasting plasma glucose levels and glycated hemoglobin in type-2 diabetes patients. |
| Clinical trial of *Myrcia uniflora* and *Bauhinia forficata* leaf extracts in normal and diabetic patients | Russo Em *et al.* [34] | 1990 | Brazilian Journal of Medical and Biological Research | No hypoglycemic effect of B. forficata on normal subjects or Type II diabetic patients was found. |
| Effects of *Bauhinia forficata* Link Tea on Lipid Profile in Diabetic Patients | Pía Córdova Mariángel *et al.* [35] | 2019 | Journal of Medicinal Food | *B. forficata* tea reduced triglycerides and total cholesterol levels in type 2 diabetic patients. |
| A Case Report of Diabetes Mellitus Type 2 with Adjuvant Use of *Bauhinia forficata* in Pharmacological Treatment | Igor Souza *et al.* [36] | 2020 | European Journal of Medicinal Plants | *Bauhinia forficata* showed anti-inflammatory actions contributing to the reduction of glycated hemoglobin and fasting glucose. |
| **Study Title** | **Authors** | **Year** | **Journal** | **Key Findings** |
| Use of the medicinal plant *Bauhinia forficata* Link. by carriers of type 2 diabetes mellitus: A study in the Brazilian amazon | Kristiane Alves Araujo *et al.* [37] | 2020 | Journal of Medicinal Plants Research | Highlighted the traditional use of *Bauhinia forficata* for diabetes control, emphasizing the importance of further scientific validation. |
| Ethnobotany study of vegetable species with therapeutic purposes from a rural community in the municipality of barbalha, ceará, brazil | Sara Tavares de Sousa Machado *et al.* [38] | 2020 | Ethnoscientia - Brazilian Journal of Ethnobiology and Ethnoecology | Included *Bauhinia variegata* among the plants used for therapeutic purposes, such as diabetes and hypertension, in traditional communities. |

**These Studies Demonstrated that Enhanced Immune Responses:** Treatment with *Bauhinia variegata* flower extract has been linked in certain preclinical trials to improved immunity, including increased production of cytokines (including IL-2 and IFN-), immune cell activation, and infection resistance.

**Effects on Inflammation:** Several animal models have shown the extract to have potential anti-inflammatory capabilities. Inflammation may be reduced by suppressing inflammatory pathways and reducing the production of pro-inflammatory cytokines.

**Immunomodulatory Effects in Disease Models:** Preclinical research has looked into the possible therapeutic uses of *Bauhinia variegata* flower extract in several illness models, including autoimmune disorders, asthma, and arthritis. These

studies have focused on the flower extract's immunomodulatory effects in disease models. Researchers have looked into the extract's immunomodulatory activities to see whether they can help treat disease symptoms and speed up recovery.

**TABLE 2: PRECLINICAL STUDIES RELATED TO *BAUHINIA VARIEGATA***

| Study Title | Authors | Year | Key Findings | Journal |
|---|---|---|---|---|
| A study on the standardization parameters of *Bauhinia variegata* | P. Khare, K. Kishore, D. Sharma [39] | 2017 | Investigated pharmacognostic, phytochemical analysis, and pharmacological properties of *B. variegata*. | Asian Journal of Pharmaceutical and Clinical Research |
| *Invivo* Study for Anti-inflammatory Activity of *Bauhinia variegata* L. Leaves | S. Saha, E. Subrahmanyam, K. Chandrashekar, Shashidhara C. Shastry[40] | 2011 | Evaluated anti-inflammatory activity using animal models; extracts showed significant activity. | - |
| A Concise Study of Pharmacognostic and Antioxidant Potential of Stem bark from *Bauhinia variegata* Linn. | T. Pethani, M. Thumar, Devendra Vaishnav, A. Dudhrejiya[41] | 2018 | Investigated in vitro antioxidant activity of different solvent extracts from the stem bark. | Research Journal of Pharmacy and Technology |
| Morphoanatomical and physiological changes in *Bauhinia variegata* L. as indicators of herbicide diuron action. | De Lima, C. Müller, A. C. Costa, P. F. Batista, V. C. Dalvi, M. Domingos [42] | 2017 | Evaluated the effects of diuron herbicide on *B. variegata*, showing anatomical and physiological injuries. | Ecotoxicology and Environmental Safety |
| Preliminary Phytochemical and Pharmacognostical Analysis of *Bauhinia variegata* Linn. Leaves | G. Gunalan, A. Saraswathy, K. Vijayalakshmi [43] | 2011 | Conducted pharmacognostical and preliminary phytochemical analysis of leaves. | Research Journal of Pharmacognosy and Phytochemistry |
| Preliminary phytochemical screening and *in-vitro* antibacterial activity of *Bauhinia variegata* Linn. against human pathogens | Sonam Pandey [44] | 2015 | Investigated the antimicrobial and phytochemical properties of *B. variegata* against human pathogens. | Asian Pacific Journal of Tropical Disease |

**Clinical Studies:** A study investigated the phytochemical profile, antimicrobial, antioxidant, and anticancer properties of *Bauhinia variegata* leaf extracts. Polar extracts contained reducing sugar, anthraquinone, and saponins, while nonpolar and ethanol extracts had terpenoids and alkaloids. Total flavonoid content ranged from 11 to 222.67 mg QE/g in various extracts. The petroleum ether and chloroform fractions showed significant inhibition against *Klebsiella pneumoniae*, and other extracts exhibited antibacterial activity against E. coli, Proteus spp., and Pseudomonas spp. Minimum bactericidal concentration values ranged from 3.5 to 28.40 mg/mL. Ethanol extract showed the lowest MBC (3.5 mg/mL) against Pseudomonas spp. The extracts displayed dose-dependent reducing power and metal ion chelating activity. The AQ fraction of *B. variegata* exhibited notable cytotoxicity (90-99% cell growth inhibition) against several human cancer cell lines, including DU-145, HOP-62, IGR-OV-1, MCF-7, and THP-1, while the ethyl acetate fraction also showed significant cytotoxicity against MCF-7 and THP-1 cell lines. This study highlights the significant antibacterial, antioxidant, and anticancer activities of *B. variegata* leaf extracts [10].

**Support for the Immune System:** A few clinical research have looked into the ability of *Bauhinia variegata* flower extract to support the human immune system. This research looked at the extract's effects on cytokine levels, lymphocyte proliferation, and immune cell activation, among other aspects of the immune system. Positive results from these tests show the extract's potential to improve immunological function and the body's natural defenses.

**Adjuvant Therapy for Infectious Disorders:** The immunomodulatory properties of the extract may boost the body's immunological response and hasten the healing of infections.

**Potential Therapeutic Applications:** Based on limited preclinical and clinical research, *Bauhinia*

*variegata* flower extract has many interesting therapeutic uses. The following are some potential medicinal uses for the extract, though further research is needed to determine its effectiveness and safety in humans:

**Support for the Immune System:** The extract can boost the body's immune system and promote immunological health by enhancing immune cell activity, cytokine modulation, and antioxidant capabilities [22, 23].

**Adjuvant Therapy for Infections:** The extract may help to strengthen the immune system and hasten the recovery from infections when used in conjunction with traditional therapies [24].

**Disorders of Inflammation:** In some cases, like arthritis and respiratory inflammatory illnesses, it may be used with other treatments to reduce inflammation and treat symptoms [25, 26].

**Autoimmune Illnesses:** The extract's immunomodulatory qualities may help treat autoimmune illnesses. The extract's capacity to control immune responses may lessen the overactive immune responses typical of autoimmune illnesses, while more research is required.

**Antioxidant Therapy:** The extract may be used in antioxidant therapy due to its strong antioxidant activity. Taking out free radicals and lowering oxidative stress may help to shield cells and tissues from oxidative processes' damaging effects.

**The Health of the Respiratory System:** The immunomodulatory properties of the extract may be used to promote respiratory health and reduce the signs and symptoms of allergies and respiratory infections.

**Wound Healing and Tissue Repair:** In wound healing formulations and regenerative medicine strategies, the extract's potential effects on macrophage activity and tissue repair may be investigated.

**Safety Considerations:** The right dosage and administration of *Bauhinia variegata* flower extract are essential to prevent potential side effects. The potency of the extract may vary depending on formulations and extraction techniques. Clinical trials are required to establish safe and effective dosages for certain therapeutic purposes [4-8].

**Allergic Reactions:** The extract from *Bauhinia variegata* flowers may cause allergic reactions in people with a history of sensitivities to Fabaceae plants (legumes).

**Drug Interactions:** The flower extract from *Bauhinia variegata* may affect some medicines. For instance, its immunomodulatory effects might conflict with immunosuppressive medications taken by people with autoimmune illnesses or organ transplant recipients.

**Effects on the Gut:** Some natural extracts may have gastrointestinal side effects in high doses, including nausea, vomiting, and diarrhea. It is best to use cautious dose and progressive titration to reduce the possibility of these side effects.

**Liver and Kidney Function:** People with impaired liver or kidney function should use caution while using *Bauhinia variegata* flower extract since natural compounds may be metabolized in the liver and eliminated by the kidneys. In rare circumstances, routine kidney and liver function evaluation may be required.

**Neurotoxicity:** Some natural compounds have been linked to neurotoxicity when used in high dosages or over an extended period. Given the extract's potential medicinal uses, additional research into how it affects the neurological system is necessary.

**Quality and Contamination:** To avoid contaminants or adulterants that could harm human health, it is essential to guarantee the purity and quality of the *Bauhinia variegata* flower extract. Extracts must come from reliable sources and be produced according to industry standards.

**Age Considerations:** The extract's safety profile may change depending on age. When using it on kids, the elderly, and people with certain medical conditions, caution should be taken.

**Future Perspectives:** Future Perspectives: Despite the encouraging results regarding the immunomodulatory action of the *Bauhinia*

*variegata* flower extract, several directions still need to be investigated. Future views to take into account include:

It is essential to pinpoint the precise bioactive substances in charge of the immunomodulatory actions. The isolation and characterization of these compounds will facilitate the creation of standardized extracts or isolated compounds for therapeutic application, improving our understanding of their mechanisms of action.

Additional mechanistic research is required to identify the particular cellular targets and mechanisms by which the flower extract modulates the immune system. The ability to comprehend these systems will enable more focused and efficient therapeutic actions.

Exploring possible synergistic interactions between the flower extract and other herbal or conventional immunomodulatory drugs may help to build more effective and all-encompassing treatments.

The flower extract's bioavailability and targeted transport to particular immune cells or tissues could be enhanced by formulating it into other delivery systems, such as nanoparticles, liposomes, or microspheres.

**CONCLUSION:** The comprehensive review on the immunomodulatory potential of *Bauhinia variegata* flower extract underscores its significant therapeutic promise based on traditional uses and scientific investigations. This botanical species, with its rich history in various traditional medicine systems and supported by bioactive compounds like flavonoids, alkaloids, and tannins, has demonstrated notable antioxidant, anti-inflammatory, and immunomodulatory activities. Through *in-vitro*, *in-vivo*, and preliminary clinical studies, the extract has shown potential in modulating immune responses, suggesting its applicability in treating infections, inflammatory conditions, and as an adjunct in cancer therapy.

However, the article also highlights the necessity for further research to establish standardized dosages, understand the precise mechanisms of action, and confirm the safety and efficacy of *Bauhinia variegata* in diverse human populations. The promising outcomes encourage ongoing investigation into this plant's potential as a natural immunomodulatory agent, paving the way for new therapeutic avenues in immunotherapy and related fields.

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**CONFLICTS OF INTEREST:** The authors declare no conflict of interest.

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