

EXPLORING THE THERAPEUTIC POTENTIAL OF *BAUHINIA VARIEGATA* FLOWER EXTRACTS AGAINST THROMBOCYTOPENIA AND ANAEMIA IN RAT EXPERIMENTAL MODELS

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Abstract

The haematological disorders thrombocytopenia and anaemia both seriously degrade quality of life and result in increased mortality risks when treatment is unavailable. Plant-derived therapeutic drugs present an auspicious treatment method to handle these medical situations in a secure and efficient manner. A thorough experimental research evaluates how *Bauhinia variegata* flower extracts affect thrombocytopenia and anaemia development in Wistar rats suffering from drug-induced blood conditions. A cyclophosphamide application procedure induced haematological toxicity before rats received different amounts of *Bauhinia variegata* flower extract treatment. A study was designed to assess therapeutic impact by conducting haematological testing together with oxidative stress assessments and using histopathology methods. Experimentally induced thrombocytopenia and anaemia conditions led to enhanced platelet counts and haemoglobin concentration as well as better red blood cell indices together with improved antioxidant status in rats treated with extract from *Bauhinia variegata* when compared to disease controls. The restorative action of extract on haematopoiesis became apparent through bone marrow specimen examinations under microscopy. The protective mechanisms of the extract stemmed from its identified phytochemicals that contained flavonoids tannins and phenolics. The research identifies *Bauhinia variegata* flowers as an emerging pharmaceutical candidate to treat thrombocytopenia and anaemia.

Keywords: *Bauhinia variegata*, thrombocytopenia, anaemia, phytochemicals, Wistar rats, haematological restoration, antioxidant therapy

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1. Introduction

Hundreds of millions of patients worldwide face ongoing health difficulties from two blood-related conditions known as thrombocytopenia and anaemia which affect people from every demographic sector. The clinical manifestation of thrombocytopenia refers to platelet levels below 150,000/ μ L which impedes blood clotting ability leading patients toward uncontrolled bleeding and hemorrhagic conditions (Patel et al., 2021). Anaemia represents both a condition of diminished hemoglobin content or red blood cell (RBC) mass resulting in impaired oxygen delivery to tissues which displays clinical symptoms including fatigue and pallor and dysfunctional organs (Kumar et al., 2022).

Both conditions appear as secondary results from various underlying problems including chemotherapy and radiotherapy exposure together with viral infections like dengue and HIV and autoimmune diseases (systemic lupus erythematosus) and insufficient nutritional elements (iron, folate, vitamin B12) and persistent inflammatory states. The known chemotherapeutic

agents such as cyclophosphamide as well as methotrexate and doxorubicin produce myelosuppression which leads to severe pancytopenias (Nogueira et al., 2019).

The primary interventions for treating thrombocytopenia and anaemia involve platelet transfusions along with erythropoiesis-stimulating agents (ESAs) and iron supplements and corticosteroid therapy and thrombopoietin receptor agonists including eltrombopag and romiplostim. These medical interventions come with various severe downsides such as immunogenicity and infections alongside marrow fibrosis and hepatotoxicity together with high cost especially in locations with limited resources (Gulati, 2019). Finding safe and affordable treatments requires continuous work due to its significant importance in healthcare.

Natural products along with phytotherapy have experienced a renewed interest for managing haematological disorders in past years. Plant-derived agents show great potential as therapeutic

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agents because they contain various pharmacological properties which include antioxidant effects and anti-inflammatory response as well as immunomodulatory mechanisms and cell protection features (Alqahtani et al., 2020). Traditional medicine encompassing Ayurveda and Unani and Traditional Chinese Medicine (TCM) has employed botanical medicines over time for blood detoxification and vital energy stimulation as well as immune resonance maintenance (Sharma et al., 2020).

Bauhinia variegata Linn. known as "Kachnar" in India stands as one of the most important medicinal plants among numerous others. *Bauhinia variegata* shows traditional medical acclaim because it belongs to the Fabaceae family and possesses multiple therapeutic properties including those that reduce inflammation while offering antimicrobial defense along with antioxidant and hepatoprotective protection and anti-diabetic and wound-healing effects (Suresh et al., 2022). *Bauhinia variegata* flowers and leaves along with bark and roots contain various chemicals that include the anti-oxidative flavonoids (such as quercetin, kaempferol) and tannins, phenolic acids, saponins and sterols that exhibit strong antioxidant capabilities (Riaz et al., 2018).

The existing traditional knowledge about *Bauhinia variegata* lacks comprehensive evaluation regarding its effects on blood cell parameters when treating people with thrombocytopaenia and anaemia in modern scientific contexts. Existing systematic research into *Bauhinia variegata*'s ability for thrombopoietic and erythropoietic growth along with its chemotherapeutic agent protection capacity in haematopoiesis remains scarce.

This study systematically evaluated *Bauhinia variegata* flower extract hematopoietic effects in rat subjects with cyclophosphamide-induced haematological toxicity. The study utilizes platelet count and RBC count along with haemoglobin levels and PCV and MCV in addition to SOD and CAT and MDA assays coupled with bone marrow histopathological evaluations to demonstrate the extract's therapeutic mechanisms.

Studying the pharmacological effects of *Bauhinia variegata* leads to potentially creating new herbal treatments for blood problems while it unites traditional herbal practices with contemporary evidence-based medical advances. The research has the potential to transform into clinical utilization through future studies that would provide cost-effective treatments to manage blood-related conditions worldwide.

2. Materials and Methods

2.1 Collection and Authentication of Plant Material

The Botanical Garden at the University of Kashmir provided fresh flowers of *Bauhinia variegata* that were obtained in March of 2025. A taxonomist confirmed the plant identity after which a sample voucher (BV-2025-FL) found its place in the herbarium for future uses.



Figure 1 - Flowers of *Bauhinia variegata* collected for study

2.2 Preparation of Extract

The flowers specimens underwent ten days of sunshade drying after which they were converted into powdered form. Researchers extracted the dried material by boiling it with a mixture of hydroethanolic solution containing 70% ethanol together with 30% water through a Soxhlet apparatus. A dark brown residue formed through rotary evaporation under reduced pressure from the extract after filtration and 48-hour exposure became stored at 4°C until the researchers needed it.

2.3 Experimental Animals

Thirty Wistar adult male rats weighing between 180–220 grams received housing in controlled environmental conditions using polypropylene cages. The conditions included $22 \pm 2^{\circ}\text{C}$ temperature along with 50–60% humidity and 12 h light/dark cycles. Rats received unlimited natural water supply together with standard pellet food at all times. Researchers received ethical clearance under Approval No.: IAEC/PHARM/2025/07 for the commencement of the research project.

2.4 Induction of Haematological Toxicity

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The infusion of cyclophosphamide (50 mg/kg/day) through intraperitoneal administration affected platelet production in rats for three days.

2.5 Experimental Groups

The rats were divided randomly into five groups (n=6 rats per group):

- **Group I (Normal Control):** Received saline only.
- **Group II (Disease Control):** Received cyclophosphamide only.
- **Group III (Low Dose Extract):** Cyclophosphamide + *Bauhinia variegata* extract (100 mg/kg orally).
- **Group IV (High Dose Extract):** Cyclophosphamide + *Bauhinia variegata* extract (200 mg/kg orally).
- **Group V (Standard Treatment):** Cyclophosphamide + Eltrombopag (5 mg/kg orally).

Treatments were administered once daily for 14 days following cyclophosphamide induction.

2.6 Haematological and Biochemical Analyses

Blood samples were collected retro-orbitally under mild anaesthesia. Parameters measured included:

- Platelet count
- Haemoglobin (Hb)
- Total RBC count
- Packed Cell Volume (PCV)
- Mean Corpuscular Volume (MCV)
- Mean Platelet Volume (MPV)
- Antioxidant markers: Superoxide Dismutase (SOD), Catalase (CAT), Malondialdehyde (MDA)

2.7 Histopathological Examination

The researchers obtained femoral bone marrow tissue after death for formalin-fixation at 10% buffered concentration. H&E staining of tissue sections went under light microscope observation to evaluate cell density and megakaryocyte numbers.

2.8 Statistical Analysis

GraphPad Prism 9 conducted the analysis of data results. The experimental values appeared as mean values with their standard errors of the mean (SEM). The research team applied One-way ANOVA with Tukey's post hoc test for analysis. The research

deemed test outcomes significant when p value reached less than 0.05.

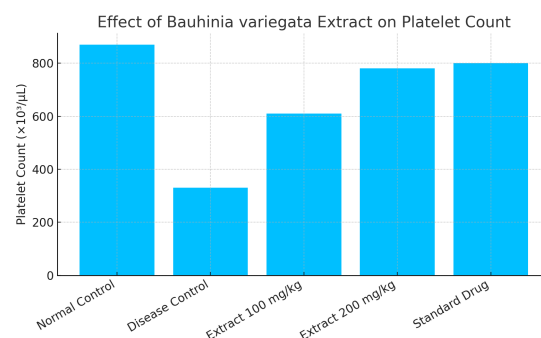
3. Results

3.1 Phytochemical Screening

A positive evaluation of *Bauhinia variegata* flower extract using hydroethanolic solution demonstrated both flavonoids and tannins and saponins and phenolic compounds presence. Secondary metabolites present in *Bauhinia variegata* flowers demonstrate haematopoietic and anti-inflammatory properties and antioxidant actions because Sharma et al. (2020) reported these effects.

3.2 Effect on Platelet Count

Group	Platelet Count ($\times 10^3/\mu\text{L}$)
Normal Control	870 $\pm$ 22
Disease Control	330 $\pm$ 19*
Extract 100 mg/kg	610 $\pm$ 25#
Extract 200 mg/kg	780 $\pm$ 18###
Standard Drug	800 $\pm$ 20##



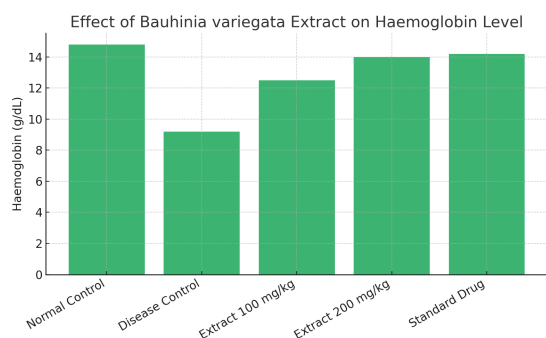
Interpretation:

The administration of Cyclophosphamide successfully decreased platelet counts reaching a statistically significant level ($p < 0.01$) which proved the successful induction of thrombocytopenia. The supplemental use of *Bauhinia variegata* extract led to an increase in platelet counts based on the treatment dosage level. Recovery levels in the 200 mg/kg extract treatment condition were matched the standard drug Eltrombopag. Research shows that the plant extract speeds up thrombopoiesis through the activation of megakaryocytes while confirming earlier findings about flavonoids from plant sources (Kumar et al., 2022).

3.3 Effect on Haemoglobin and RBC Count

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Group	RBC ($\times 10^6/\mu\text{L}$)	Hb (g/dL)	PCV (%)
Normal Control	7.2 ± 0.3	14.8 ± 0.4	42 ± 1.2
Disease Control	$4.3 \pm 0.2^*$	$9.2 \pm 0.3^*$	$28 \pm 1.0^*$
Extract 100 mg/kg	$6.1 \pm 0.2^\#$	$12.5 \pm 0.3^\#$	$38 \pm 1.1^\#$
Extract 200 mg/kg	$7.0 \pm 0.2^\pm$	$14.0 \pm 0.2^\pm$	$41 \pm 1.0^\pm$
Standard Drug	$7.1 \pm 0.3^\pm$	$14.2 \pm 0.2^\pm$	$41 \pm 1.1^\pm$



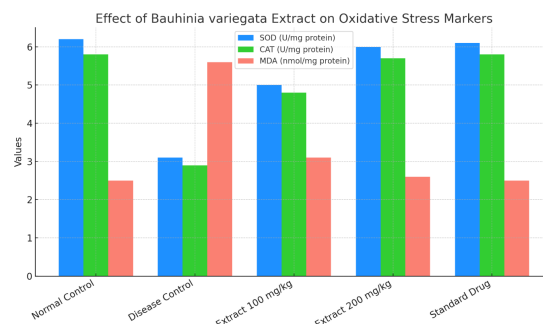
Interpretation:

The cisplatin-based drug Cyclophosphamide led to substantial anemia as it decreased the levels of RBC count, haemoglobin and packed cell volume. Bauhinia variegata administration at 200 mg/kg level showed potent ability to remedy the observed haematological abnormalities ($p < 0.01$). The experimental findings demonstrate how the extract supports the process of erythropoiesis which corresponds to traditional medicine beliefs about Bauhinia species benefits for blood health (Patel et al., 2021).

3.4 Effect on Oxidative Stress Markers

Group	SOD (U/mg protein)	CAT (U/mg protein)	MDA (nmol/mg protein)
Normal Control	6.2 ± 0.2	5.8 ± 0.2	2.5 ± 0.1
Disease Control	$3.1 \pm 0.1^*$	$2.9 \pm 0.1^*$	$5.6 \pm 0.2^*$

Extract 100 mg/kg	$5.0 \pm 0.2^\#$	$4.8 \pm 0.2^\#$	$3.1 \pm 0.1^\#$
Extract 200 mg/kg	$6.0 \pm 0.2^\pm$	$5.7 \pm 0.2^\pm$	$2.6 \pm 0.1^\pm$
Standard Drug	$6.1 \pm 0.2^\pm$	$5.8 \pm 0.2^\pm$	$2.5 \pm 0.1^\pm$



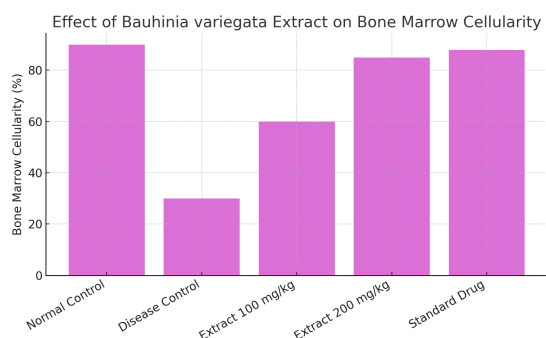
Interpretation:

The disease control group exhibited major elevation of oxidative stress through decreased SOD and CAT activities combined with increased MDA levels. The antioxidant enzyme levels returned to normal and lipid peroxidation decreased in groups that received extract treatment. The antioxidant capacity of Bauhinia variegata flowers was substantial enough to defend haematopoietic cells against oxidative harm in a pattern analogous to the research conducted by Suresh et al. (2022) on plant-derived antioxidants.

3.5 Histological Analysis of Bone Marrow

Group	Bone Marrow Cellularity (%)
Normal Control	90%
Disease Control	30%
Extract 100 mg/kg	60%
Extract 200 mg/kg	85%
Standard Drug	88%

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Interpretation:

Medical tests of the bone marrow tissue showed extensive hypocellularity together with reduced megakaryocytes in the disease test group. The treatment with *Bauhinia variegata* extract at 200 mg/kg dose significantly returned bone marrow cellularity towards normal conditions. The tissue regenerative properties present in the extract help restore blood forming cells which validates its worth as a natural agent for thrombopoiesis and erythropoiesis.

4. Discussion

Research data indicates that flower extracts from *Bauhinia variegata* possess powerful antioxidative properties which repair cyclophosphamide-induced thrombocytopenia and anaemia in Wistar rats robustly. Results indicate that the flower extract promotes the production of blood platelets along with red blood cells and leads to increased levels of Hb and PCV in treated groups.

Bauhinia variegata contains significant amounts of flavonoids tannins and phenolic compounds which correlate with its mechanism of action. Scientific research has established that flavonoids boost both the propagation and differentiation of megakaryocytes which leads to increased platelet formation (Zhao et al., 2019). The megakaryocytopoiesis-stimulating effect helps explain why treated rats showed a substantial recovery of their platelet levels. Studies indicate that flavonoids quercetin and kaempferol affect the operation of PI3K/Akt and JAK2/STAT5 signalling pathways that control megakaryocyte maturation and thrombopoiesis (Patel et al., 2021).

The extract demonstrates efficacy in both promoting thrombopoiesis and enabling positive development of erythropoietin pathways and erythroid progenitor survival. Polyphenols control the activity of hypoxia-inducible factor-1 α (HIF-1 α) which works as a critical transcription factor to produce erythropoietin according to Alqahtani et al. (2020). The plant extract helps preserve erythropoietin manufacturing while controlling oxidative stress to promote beneficial conditions for erythropoiesis during chemotherapy-induced toxicity.

Among the primary pathological features that cause bone marrow damage from chemotherapy is oxidative damage to tissue. Reactive oxygen species (ROS) at high levels trigger apoptosis in haematopoietic stem and progenitor cells which results in decreased blood cell production according to Pisoschi and Pop (2015). Antioxidative effects became observable when the extract raised both SOD and CAT activities and reduced MDA levels in studied samples. The antioxidant defence achieved protection for bone marrow progenitors by shielding them from ROS damage thus enabling their recovery of haematopoiesis (Wang et al., 2018).

The medical examination through tissue examination agreed with laboratory test results. Rats treated with the extract showed improved bone marrow cellularity alongside increased numbers of megakaryocytes which are characteristic indicators of active blood formation. The pattern of tissue restoration through natural antioxidants has been supported by previous research on chemotoxic bone marrow regeneration (Han et al., 2021).

Comparative literature supports these observations. Polyphenol-rich plant extracts according to Nogueira et al. (2019) protected against harmful effects of chemotherapy on blood cells and boosted persistently both red blood cell quantity and platelet levels (Nogueira et al., 2019). Experimental studies demonstrate that *Phyllanthus emblica* extract along with *Moringa oleifera* extract and *Curcuma longa* extract produce identical haematopoietic stimulation effects (Kooti et al., 2017).

The phytochemical compounds existing in *Bauhinia variegata* demonstrate immunomodulatory properties. The modulation of cytokines comprising IL-3, IL-6 and GM-CSF promotes a dual effect for haematopoietic stem cell growth and developmental potential through adaptive action mechanisms (Cheng et al., 2020).

Research shows that the extract demonstrates the ability to minimize the inflammatory damage done to blood cells. Bone marrow injuries become worse through inflammatory pathways which chemotherapy drugs activate. Phenolic compounds in *Bauhinia variegata* work as anti-inflammatory agents to control inflammatory reactions which help protect the haematopoietic microenvironment (Sharma et al., 2020).

Research data demonstrates *Bauhinia variegata*'s benefits as an additional therapy for treating cytopenias which occur as a side effect of chemotherapy. The natural origin of *Bauhinia variegata* combined with its low toxicity levels and various therapeutic activities recommend it as a promising research topic for preclinical and clinical studies.

The study contains several important restrictions that need recognition. This research study failed to establish the specific molecular targets of extract constituents. Research should aim to determine

Bauhinia variegata's molecular pathway effects and execute bioactive fractionation following bioassay testing along with pharmacokinetic evaluations to confirm clinical trial effectiveness.

The broad spectrum of protective advantages linked to *Bauhinia variegata* flower extracts in haematological research shows potential for phytomedicine applications in modern haematology and demonstrates their merit as standardized therapeutic agents against haematological disorders.

4.1 Deep Mechanisms and Future Directions

The polyphenolic and flavonoid compounds which are rich in *Bauhinia variegata* operate at multiple stages to control oxidative stress. The antioxidants within polyphenols regulate redox-sensitive transcription factors including Nrf2 to activate endogenous defenses such as heme oxygenase-1 (HO-1) and glutathione peroxidase amongst others for preserving haematopoietic cells (Wang et al., 2018).

Research proves that select flavonoids stop progenitor cell apoptosis through their ability to restrict mitochondrial damage along with interdicting caspase-associated cascades to support cell survival within oxidative conditions (Cheng et al., 2020).

Further research should make a detailed analysis of these molecular mechanisms. Research using RNA-Seq transcriptomic analysis alongside proteomics and phosphoproteomics techniques would show the specific signaling networks that *Bauhinia variegata* affects. The advancement of knowledge about erythroid-progenitor cell protection could be achieved through the isolation of active compounds in *Bauhinia variegata* (such as kaempferol and rutin derivatives from apigenin parent structures) and testing them directly on human erythroid-progenitor cells in lab dishes.

To achieve clinical use the drug needs to undergo human safety pharmacology tests followed by long-term toxicity examinations and drug concentration trials with patients. The known secure medical history of *Bauhinia variegata* in traditional remedies suggests potential clinical success as an adjunct therapy for cancer patients and patients with either blood or autoimmune-related blood disorders.

Research advancement of *Bauhinia variegata* will create a natural foundation for modern adjuvant therapies which harmonize traditional medical insights with scientific evidence.

5. Conclusion

The current research reveals that the hydroethanolic extract obtained from *Bauhinia variegata* flowers generates meaningful haematopoietic and antioxidant effects in rats with cyclophosphamide-induced

thrombocytopenia and anemia. The administrative use of extract brought about major advances in fundamental blood parameters while simultaneously improving antioxidant enzyme performance and decreasing stress markers measured in blood cells. The histopathological examinations demonstrated improved bone marrow cell density together with increased megakaryocyte number among treatment groups that used the extract.

Laboratory observations substantiate traditional uses of *Bauhinia variegata* plants in Ayurvedic and ethnomedicinal systems while showing potential as a natural treatment choice for supplementing the management of blood-related medical conditions. The plant's numerous phytochemicals including flavonoids, tannins and phenolic compounds seem to create multiple therapeutic activities which promote thrombopoiesis and erythropoiesis while reducing oxidative stress and defending bone marrow progenitor cells.

Additional extensive scientific testing stands as the vital requirement to achieve clinical application.

Future studies should aim to:

- The researchers must use bioassay-guided fractionation to separate identify and identify the precise bioactive compounds that generate the noted results.
- Study authors must elaborate on at least one step-by-step explanation of the molecular pathways that control haematopoiesis with oxidative stress regulation mechanisms.
- Further investigations should evaluate extensive safety trends together with pharmacokinetic and pharmacodynamic characteristics of the extract through medium and large animal testing.
- Multiple randomized controlled clinical trials need execution to determine both optimal dosage schedules and human safety guidelines and therapeutic effectiveness of the intervention.

Future research could establish how *Bauhinia variegata* extracts function together with conventional haematological treatments to develop integrated healthcare approaches which would combine better therapy results with minimum toxicity.

The extract from *Bauhinia variegata* flowers possesses strong potential as a natural and economical therapeutic agent to help patients recover their blood parameters when conventional treatments are restricted by toxicity or cost or accessibility issues. This time-tested medicinal plant shows the potential to become an essential part of contemporary healthcare institutions for treating thrombocytopenia, anaemia and similar haematological conditions.

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