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Anti inflammatory Potential of a Standardized Extract of Bambusa arundinacea- an Study

Umair Wali, Surendra Jain, Kanika Dhote, Vinod Kumar Dhote

Truba Institute of Pharmacy, Bhopal

Abstract

Inflammation, while essential for host defense, contributes to the pathology of chronic disorders such as arthritis, cardiovascular disease, diabetes, and cancer when unregulated. Synthetic anti-inflammatory drugs are effective but often cause adverse effects with prolonged use, prompting interest in plant-derived phytochemicals as safer alternatives. This study evaluated the phytochemical profile and anti-inflammatory activity of *Bambusa arundinacea*, a traditionally used medicinal plant. Leaves collected from Bhopal, Madhya Pradesh, were shade-dried, powdered, and subjected to sequential extraction. The ethanolic extract yielded 9.41% w/w compared to 2.52% w/w with petroleum ether, indicating higher efficiency in extracting bioactive compounds. Preliminary screening confirmed the presence of flavonoids, phenols, proteins, saponins, and diterpenes, while alkaloids, glycosides, and carbohydrates were absent. Quantitative assays revealed total phenolic content of 0.875 mg GAE/100 mg and flavonoid content of 0.623 mg QE/100 mg extract. Acute toxicity testing showed no adverse effects at 2000 mg/kg. In vivo anti-inflammatory evaluation using carrageenan-induced paw edema in Wistar rats demonstrated dose-dependent inhibition of inflammation, with 200 mg/kg extract showing significant suppression comparable to indomethacin. These findings validate the ethnomedicinal use of *B. arundinacea* and highlight its potential as a natural source of anti-inflammatory agents. Further studies are needed to isolate active constituents and establish mechanisms of action for therapeutic development.

Keywords:

Bambusa arundinacea; phytochemicals; flavonoids; phenols; anti-inflammatory activity; carrageenan-induced paw edema

1. Introduction

Inflammation is an essential protective response of the body to harmful stimuli, but chronic and uncontrolled inflammation underlies various diseases such as rheumatoid arthritis, cardiovascular disease, Alzheimer's disease, cancer, and diabetes. Conventional anti-inflammatory drugs, though effective, pose long-term safety risks. Herbal medicine remains a cornerstone of healthcare worldwide, with approximately 80% of the global population relying

on plant-based remedies. Phytochemicals, the bioactive compounds produced by plants, are of particular interest due to their ability to modulate inflammation with fewer side effects.

2. Types and Processes of Inflammation

- **Acute inflammation** involves rapid exudation of plasma proteins and leukocyte migration to neutralize pathogens and initiate repair.
- **Chronic inflammation** is prolonged, often resulting in tissue destruction and associated with autoimmune and degenerative disorders.

The inflammatory process includes vasodilation, increased vascular permeability, leukocyte infiltration, and phagocytosis, mediated by prostaglandins, cytokines, nitric oxide, and histamine.

3. Phytochemicals: Overview and Significance

Phytochemicals are secondary plant metabolites that play defensive roles in plants and therapeutic roles in humans. Modern phytochemistry evolved from the isolation of active plant compounds such as quinine and morphine, leading to the discovery of numerous pharmacologically active molecules. They are classified into several groups based on their chemical structures.

4. Classification and Functions of Phytochemicals

- **Phenolics (flavonoids, tannins, stilbenes):** Antioxidant, anti-inflammatory, antimicrobial, anticancer.
- **Terpenes and terpenoids (carotenoids, saponins, phytosteroids):** Antimicrobial, immune-modulating, cholesterol-lowering.
- **Alkaloids (morphine, nicotine, caffeine):** Analgesic, antimicrobial, CNS activity.
- **Quinones:** Anti-inflammatory, antiparasitic, anticancer.
- **Cardiac glycosides:** Treatment of heart failure via Na+/K+-ATPase inhibition.
- **Carbohydrates and non-digestible carbohydrates:** Energy supply, regulation of glucose absorption, gut health.

Phytochemicals act through diverse mechanisms such as free radical scavenging, inhibition of pro-inflammatory enzymes, modulation of cytokines, and interference with microbial adhesion.

5. Therapeutic Potential and Applications

Phytochemicals have demonstrated activity against inflammation-related disorders, including rheumatoid arthritis, diabetes, cardiovascular diseases, infections, and cancer. Their antioxidant and immunomodulatory roles make them promising candidates for novel drug development, nutraceuticals, and functional foods.

Plant Profile Summary: Bambusa arundinacea

Taxonomy and Distribution:

Bambusa arundinacea (Poaceae) is a woody grass widely distributed across tropical, subtropical, and mildly temperate regions. In India, it is common up to 1250 m altitude, particularly along riverbanks, and is also found in Sri Lanka, Malaya, Peru, and Myanmar.

Botanical Features:

This thorny bamboo grows up to 30 m high, with tufted stems and spiny nodes. Leaves are linear-lanceolate, while flowering occurs once in its lifetime, typically between September and May.

Figure 1: Plant-Bambusa arundinacea

Phytochemistry:

Different plant parts contain diverse compounds:

- **Shoots:** oxalic acid, reducing sugars, resins, waxes, benzoic acid, taxiphyllin.
- **Seeds:** essential amino acids (arginine, lysine, methionine, etc.), vitamins (thiamine, riboflavin, niacin).
- **Leaves:** proteins, gluteline, lysine, methionine, betaine, choline, proteolytic enzymes, nuclease, urease.
- A siliceous crystalline substance is also present at the nodes.

Pharmacological Activities:

- **Antidiabetic:** Ethanolic seed extracts significantly reduced blood glucose levels in alloxan-induced diabetic rats, showing activity comparable to glibenclamide.
- **Antifertility:** Ethanolic shoot extract reduced sperm count, motility, and fertility index in male rats, with partial recovery after withdrawal.
- **Antibacterial:** Bamboo shaving extracts exhibited activity against *Staphylococcus aureus, Bacillus subtilis, Escherichia coli,* and several fungi, with concentration-dependent inhibition.
- **Anti-inflammatory and Antiulcer:** Methanolic leaf extract reduced carrageenan-induced paw edema and showed significant antiulcer activity. Its combination with phenylbutazone enhanced efficacy while minimizing ulcerogenic side effects.
- **Neuroprotective and Hematological:** Bamboo-derived pyrolyzates demonstrated protection against NMDA-induced neuronal cell death and inhibited plasmin activity in fibrinolysis assays.

Materials and Methods (Summary)

Leaves of *Bambusa arundinacea* were selected based on availability and ethnomedicinal use, and collected from Bhopal, Madhya Pradesh (March 2025). The leaves were shade-dried, powdered, and stored in airtight bags until extraction.

Extraction:

The powdered leaves were first defatted with petroleum ether, followed by ethanolic extraction using the maceration method for 48 hours. The extract was concentrated under reduced pressure at 40 °C. Percentage yield was calculated using standard formula.

Phytochemical Screening:

Preliminary phytochemical tests were performed to identify alkaloids, carbohydrates, glycosides, saponins, phenols, tannins, proteins, flavonoids, and diterpenes using standard procedures (Mayer's, Wagner's, Borntrager's, Froth test, Ferric chloride test, etc.).

Estimation of Bioactive Compounds:

- **Total phenolic content (TPC):** Determined using the Folin–Ciocalteu method, expressed as mg gallic acid equivalents (GAE) per 100 mg dry extract (λmax = 765 nm).
- **Total flavonoid content (TFC):** Estimated by the aluminium chloride colorimetric method, expressed as mg quercetin equivalents (QE) per 100 mg dry extract (λmax = 420 nm).

Experimental Animals:

Wistar rats (150–200 g) were maintained under controlled conditions and used after acclimatization. All experiments were approved by the Institutional Animal Ethics Committee (IAEC).

Acute Toxicity Study:

Performed according to OECD guidelines (425). Ethanolic extract was administered orally at 2000 mg/kg, and animals were monitored for 14 days. No mortality or behavioral abnormalities were observed. Based on this, doses of 100 and 200 mg/kg (p.o.) were selected for anti-inflammatory testing.

In vivo Anti-inflammatory Activity:

Anti-inflammatory effect was evaluated using the carrageenan-induced paw oedema model. Rats were divided into four groups (n = 6):

1. Control (carrageenan 1% w/v)
2. Standard (carrageenan + indomethacin 10 mg/kg)
3. Carrageenan + *B. arundinacea* extract (100 mg/kg)
4. Carrageenan + *B. arundinacea* extract (200 mg/kg)

Oedema volume was measured using a plethysmograph, and percentage inhibition was calculated.

Statistical Analysis:

Data were expressed as mean ± SEM. One-way ANOVA followed by Dunnett's test was used, with $p < 0.05$ considered statistically significant.

Results and Discussion

Percentage Yield:

Extraction efficiency varied with solvent polarity. The ethanolic extract gave the highest yield (9.41% w/w), while the petroleum ether extract yielded only 2.52% w/w, indicating better solubility of phytoconstituents in polar solvents.

Phytochemical Screening:

Ethanolic extract of *Bambusa arundinacea* tested positive for flavonoids, phenols, proteins, saponins, and diterpenes, while alkaloids, glycosides, and carbohydrates were absent. The presence of flavonoids and phenols supports its traditional medicinal use due to their antioxidant and anti-inflammatory potential.

Total Phenolic and Flavonoid Content:

Quantitative estimation revealed total phenolic content of 0.875 mg GAE/100 mg and total flavonoid content of 0.623 mg QE/100 mg of dried ethanolic extract. These secondary metabolites are known for free radical scavenging, anti-inflammatory, and protective roles in oxidative stress–related disorders.

In vivo Anti-inflammatory Activity:

In carrageenan-induced paw edema, the ethanolic extract showed dose-dependent inhibition of inflammation. At 100 mg/kg, moderate suppression was observed, while 200 mg/kg produced significant reduction (1.0 ± 0.05 cm at 4 h), nearly comparable to the standard drug indomethacin (0.6 ± 0.06 cm). The effect may be attributed to flavonoids and phenolics, which inhibit cyclooxygenase and lipoxygenase pathways and reduce oxidative stress.

Table 1: % Yield of *Bambusa arundinacea*

S. No.	Extract	% Yield (w/w)
1.	Pet. ether	2.52
2.	Ethanolic	9.41

The extractive yield of *Bambusa arundinacea* using different solvents was evaluated to determine the efficiency of solvent extraction. As shown in Table 7.1, the ethanolic extract exhibited a significantly higher yield of 9.41% (w/w) compared to the petroleum ether extract, which yielded only 2.52% (w/w). This difference in yield can be attributed to the polarity of the solvents used.

Results of phytochemical screening of extract

The phytochemical screening of the ethanolic extract of *Bambusa arundinacea* indicates the presence of various phytoconstituents, including flavonoids, phenols, proteins, carbohydrates, and saponins. Further studies are needed to isolate and identify specific compounds responsible for these activities and to elucidate the extract's potential therapeutic benefits table 2.

Table 2: Phytochemical screening of extract of *Bambusa arundinacea*

S. No.	Constituents	Ethanolic extract
1.	**Alkaloids** Dragendroff's test Hager's test	-ve -ve
2.	**Glycosides** Legal's test	-ve
3.	**Flavonoids** Lead acetate Alkaline test	+ve +ve
4.	**Phenol** Ferric chloride test	+ve
5.	**Proteins** Xanthoproteic test	+ve
6.	**Carbohydrates** Fehling's test	-ve
7.	**Saponins** Foam test	+ve
8.	**Diterpenes** Copper acetate test	+ve

+ve =Positive; -ve= Negative

Phytochemical screening of the ethanolic extract of *Bambusa arundinacea* revealed the presence of flavonoids (positive in lead acetate and alkaline tests), phenols (positive in ferric chloride test), proteins (positive in Xanthoproteic test), saponins (positive in foam test), and diterpenes (positive in copper acetate test). However, alkaloids (negative in Dragendorff's and Hager's tests), glycosides (negative in Legal's test), and carbohydrates (negative in Fehling's test) were absent. The positive phytochemical results highlight the potential of the ethanolic extract of *Bambusa arundinacea* for further pharmacological evaluation and justify its use in traditional medicine.

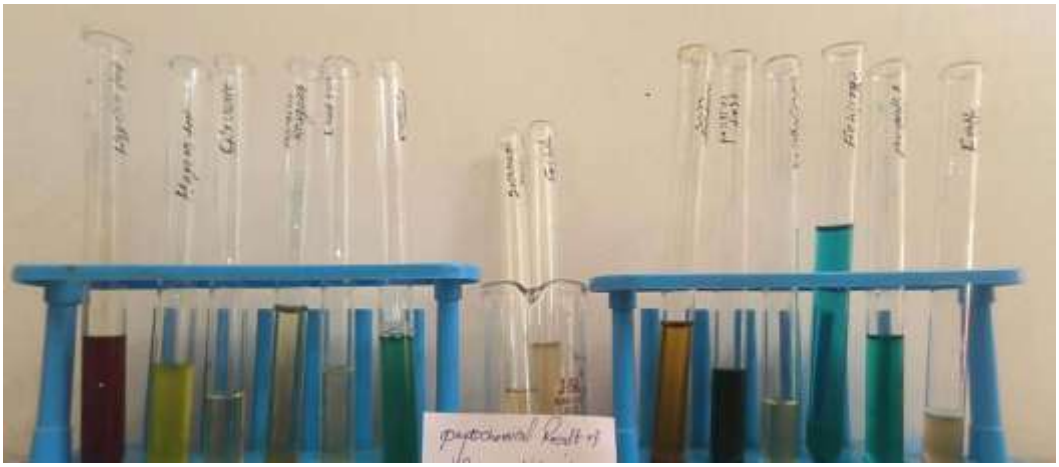

Figure 2: Phytochemical screening of extract of *Bambusa arundinacea*

Results of estimation of total phenol and flavonoids content

The estimation of total flavonoids and phenol content provides insights into the presence of bioactive compounds in the ethanolic extract of *Bambusa arundinacea*. Both flavonoids and phenols are secondary metabolites known for their potential health-promoting properties. Flavonoids are widely recognized for their antioxidant, anti-inflammatory, and potential anti-cancer activities. The presence of flavonoids in the extract suggests that it may contribute to the extract's biological activities and potential health benefits. Flavonoids play a significant role in neutralizing harmful free radicals and protecting cells from oxidative stress. Phenolic compounds are known for their antioxidant and anti-inflammatory properties. They also contribute to the potential health benefits of plant extracts by protecting cells from oxidative damage and inflammation. The presence of phenols in the extract further supports its potential as a source of bioactive compounds.

Estimation of total phenolic content (TPC)

Total phenolic compounds (TPC) was expressed as mg/100mg of gallic acid equivalent of dry extract sample using the equation obtained from the calibration curve: **$y = 0.013x - 0.003$, $R^2 = 0.999$,** where X is the gallic acid equivalent (GAE) and Y is the absorbance.

The Folin-Ciocalteau reagent was used to calculate the total phenolic contents of the extract by making 10-50 µg/ml Gallic acid solutions with 1.0 ml of tenfold-diluted Folin Ciocalteu reagent and 1.0 ml of sodium carbonate solution (7.5 g/l). At 765 nm, the absorbance was measured after 10 minutes. This range of absorbance further utilized to plot calibration curve. The value of absorbance found to increase as the concentration increases which is according to beer lamberts law.

Table 3: Preparation of calibration curve of Gallic acid

S. No.	Concentration (µg/ml)	Mean Absorbance
1	10	0.127±0.002
2	20	0.261±0.005
3	30	0.401±0.004
4	40	0.537±0.003
5	50	0.664±0.005

***Average of three determination, Mean ± SD**

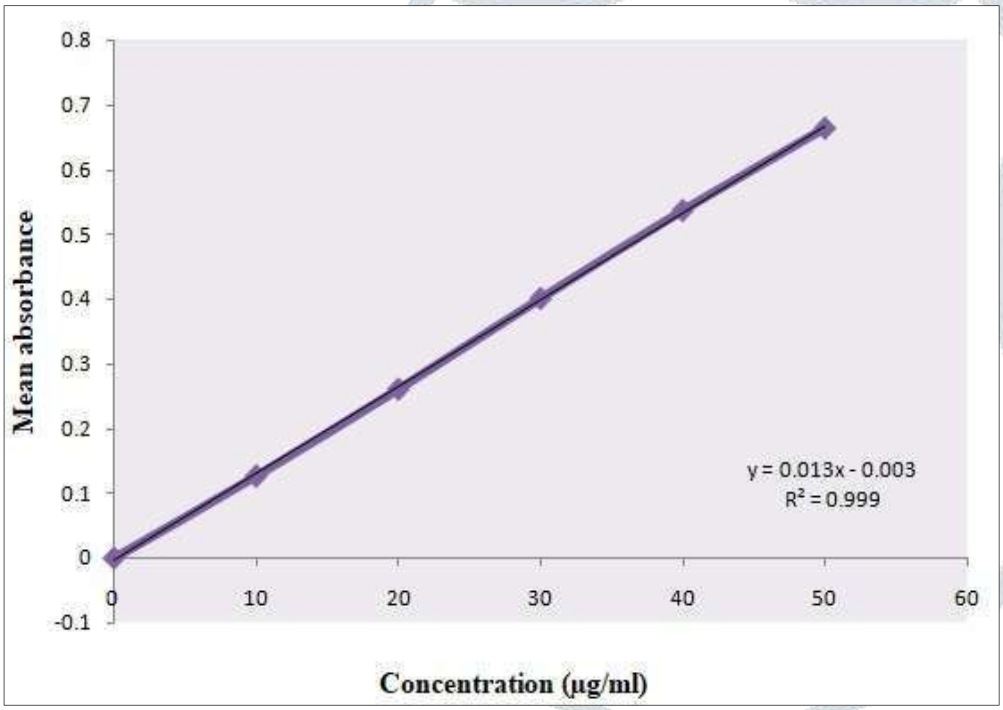

Figure 3: Graph of calibration curve of Gallic acid

Total flavonoids content estimation (TFC)

Total flavonoids content was calculated as quercetin equivalent (mg/100mg) using the equation based on the calibration curve: **Y=0.032X + 0.018, R^2=0.998**, where X is the quercetin equivalent (QE) and Y is the absorbance.

Table 4: Preparation of Calibration curve of Quercetin

S. No.	Concentration (µg/ml)	Mean Absorbance
1	5	0.191±0.004
2	10	0.348±0.005
3	15	0.514±0.001
4	20	0.652±0.002
5	25	0.812±0.004

***Average of three determination, Mean ± SD**

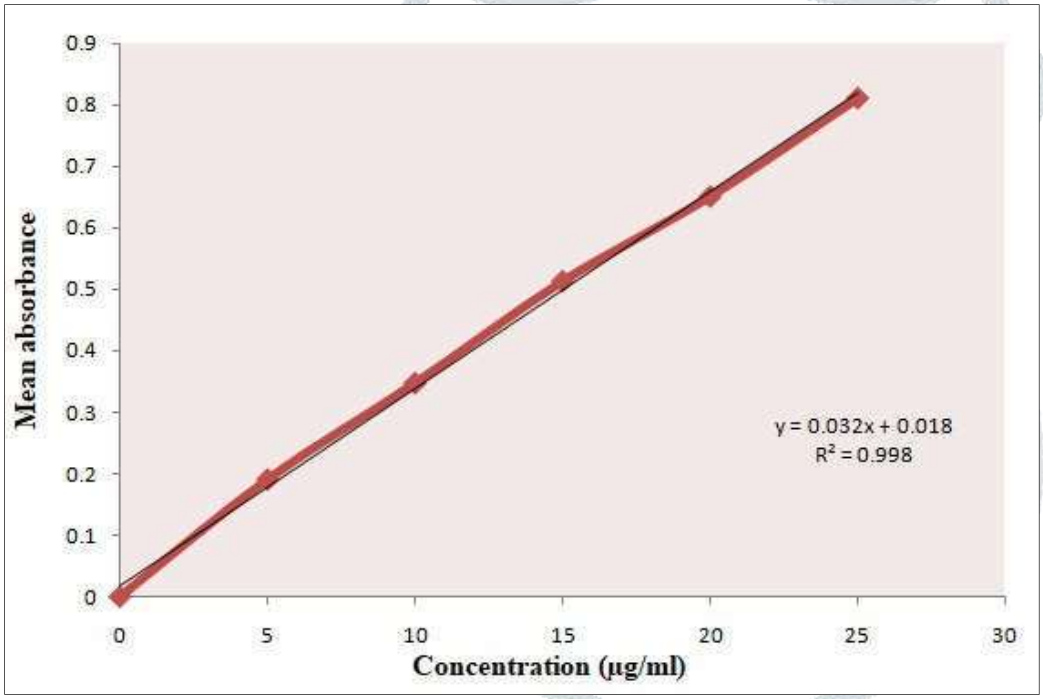

Figure 4: Graph of calibration curve of Quercetin

Table 5: Estimation of total flavonoids and phenol content of *Bambusa arundinacea*

S. No.	Extract	Total flavonoids content (mg/ 100 mg of dried extract)	Total phenol content (mg/ 100 mg of dried extract)
1.	Ethanolic	0.623	0.875

The quantitative estimation of phytoconstituents in the ethanolic extract of *Bambusa arundinacea* showed that the total flavonoid content was 0.623 mg per 100 mg of dried extract, while the total phenolic content was

found to be 0.875 mg per 100 mg of dried extract.

Results of *in vivo* anti-inflammatory activity of *Bambusa arundinacea* extract

Table 6: Effect of extract of *Bambusa arundinacea* on paw edema induced by carrageenan in rats by different timelines

Group No.	Treatment	Dose	0 hr (cm)	30 min (cm)	1 hr (cm)	2 hr (cm)	4 hr (cm)
Group 1	Carrageenan control	–	3.8 ± 0.05	4.2 ± 0.06	4.5 ± 0.03	4.7 ± 0.05	5.1 ± 0.05
Group 2	Carrageenan + Indomethacin	10 mg/kg	1.2 ± 0.05	1.0 ± 0.05	0.8 ± 0.07	0.6 ± 0.04*	0.6 ± 0.06**
Group 3	Carrageenan + *Bambusa arundinacea* extract	100 mg/kg	2.6 ± 0.06	2.8 ± 0.05	2.7 ± 0.08	2.5 ± 0.12	2.3 ± 0.08*
Group 4	Carrageenan + *Bambusa arundinacea* extract	200 mg/kg	2.0 ± 0.10	1.9 ± 0.07	1.7 ± 0.09	1.4 ± 0.06*	1.0 ± 0.05**

Values are expressed as mean ± SD. *P < 0.05-significant compared to carragenan treated group.

Discussion:

The study demonstrates that *Bambusa arundinacea* ethanolic extract is rich in bioactive compounds and exhibits significant anti-inflammatory activity. The findings validate its traditional use in inflammatory conditions and highlight its therapeutic potential as a natural alternative to synthetic NSAIDs, especially at higher doses.

Summary and Conclusion

This study investigated the phytochemical profile, antioxidant potential, and anti-inflammatory activity of *Bambusa arundinacea*, with emphasis on its ethanolic extract. The extraction yield was higher with ethanol (9.41% w/w) than petroleum ether (2.52% w/w), confirming ethanol as a more efficient solvent for isolating bioactive constituents.

Preliminary screening indicated the presence of flavonoids, phenols, proteins, saponins, and diterpenes, while alkaloids, carbohydrates, and glycosides were absent. Quantitative analysis further confirmed appreciable levels of phenolic (0.875 mg/100 mg) and flavonoid (0.623 mg/100 mg) compounds, which are known for antioxidant and anti-inflammatory effects.

In vivo anti-inflammatory evaluation using the carrageenan-induced paw edema model revealed that the ethanolic extract produced dose-dependent inhibition of inflammation. At 200 mg/kg, the extract demonstrated significant suppression of edema, comparable to the standard drug indomethacin.

Overall, the findings support the traditional use of *Bambusa arundinacea* as an anti-inflammatory agent and highlight its potential as a natural source of therapeutic phytochemicals. Future studies should focus on isolation of active constituents, mechanistic evaluation, long-term toxicity assessment, and clinical validation.

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