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Original Research Article

"Ethnopharmacological Review and Laboratory Validation of Indigenous Plants Used in Vascular Disorders"

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Name of Author:

[1]Ved Prakash, [2]Mahendra S. Patil , [3]Ruchita Shrivastava, [4]*Thirugnanasambandam Ramanathan,

Affiliation: *[1]Assistant Professor, PM College of Excellence, Govt. P.G. College, Morena (Madhya Pradesh) 476001*

[2]Department of Botany, NTVS's G.T.Patil Arts, Commerce and Science College, Nandurbar, MS, India.

[3]Visiting Lecturer, Department of Botany, Govt. Homescience PG Lead College, Narmadapuram (MP) Pin Code – 461001.

*[4]*Director, Centre of Advanced Study in Marine Biology, Annamalai University ,Parangipettai 608502. Tamil Nadu, India. Email - drtrcasmb@gmail.com*

Corresponding Author:

Thirugnanasambandam Ramanathan,

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Abstract: Vascular disorders—including hypertension, atherosclerosis, venous insufficiency, and microvascular inflammation—remain a major global health challenge, particularly in regions where access to standard pharmacotherapy is limited. Indigenous communities across India and other parts of the world rely extensively on medicinal plants for circulatory and vascular ailments, yet many of these remedies lack systematic scientific validation. The present study integrates an ethnopharmacological survey with laboratory-based analyses to evaluate the therapeutic potential of traditionally used medicinal plants for vascular disorders. Ethnobotanical data were collected from experienced tribal healers and local practitioners, and plant species cited with high frequency were shortlisted for laboratory evaluation. Aqueous and ethanolic extracts of selected species were subjected to phytochemical screening, quantitative estimation of phenolics and flavonoids, antioxidant assays (DPPH and FRAP), anti-inflammatory analysis (NO inhibition in LPS-stimulated macrophages), and ex vivo vasorelaxant studies using isolated rat aortic rings. Results demonstrated that the most frequently cited plants—Terminalia arjuna, Withania somnifera, Moringa oleifera, Curcuma longa, and Allium sativum—possess high phenolic content, strong free-radical scavenging activity, significant anti-inflammatory effects, and dose-dependent vasorelaxant properties. These findings provide scientific support for traditional claims and highlight the potential of these species as candidates for developing safe, plant-based interventions for vascular health. Further in vivo, clinical, and toxicological studies are recommended to establish standardized formulations and therapeutic dosage guidelines..

Keywords: Leaf anatomy; Xerophytes; Mesophytes; Adaptive morphology; Stomatal density; Cuticle thickness; Mesophyll differentiation; Environmental adaptation.

INTRODUCTION

Vascular disorders such as hypertension, atherosclerosis, thrombosis, and chronic microvascular inflammation are leading contributors to global morbidity and mortality. Their prevalence continues to rise due to sedentary lifestyles, dietary changes, heightened stress, and aging populations. Limited access to cardiovascular medicines in many low- and middle-income regions further increases the burden, particularly among rural and socioeconomically disadvantaged communities.

Traditional medicinal systems play an important role in managing circulatory disorders in these regions. Indigenous communities rely on herbal decoctions, root powders, bark extracts, and polyherbal formulations to improve blood circulation, reduce inflammation, strengthen cardiac function, and regulate blood pressure. Many of these medicinal plants contain bioactive compounds such as flavonoids, phenolics, tannins, saponins, and alkaloids, which have demonstrated antioxidant, vasodilatory, anti-inflammatory, and lipid-lowering properties. However, despite their therapeutic potential, scientific validation of these traditional remedies remains limited.

The present study therefore aims to bridge this gap by documenting medicinal plants traditionally used for vascular disorders and evaluating their phytochemical composition, antioxidant properties, anti-inflammatory effects, and vasorelaxant activity. By integrating ethnopharmacological knowledge with laboratory-based evidence, this research provides scientific support for the development of safe, accessible, plant-derived interventions for vascular health and promotes the preservation of traditional medicinal practices.

MATERIALS AND METHODS :

2.1 Ethnobotanical Survey

An ethnobotanical survey was conducted in selected tribal and rural regions where traditional medicinal practices are actively used. Information was collected from traditional healers, elderly community members, and local practitioners through semi-structured interviews, questionnaires, and guided field walks. Data recorded included plant names, parts used, preparation methods, dosage, and specific vascular-related uses. Quantitative ethnobotanical indices—Frequency of Citation (FC), Use Value (UV), and Fidelity Level (FL%)—were calculated to identify the most important species.

2.2 Plant Collection and Authentication

Plant species cited by the majority of informants were collected from their natural habitats. Samples were authenticated by a qualified taxonomist , and voucher specimens were prepared and deposited in the institutional herbarium for future reference.

2.3 Preparation of Plant Extracts

Collected plant materials were washed, shade-dried, and powdered. Ethanolic extracts were prepared using Soxhlet extraction (50 g powder with 70% ethanol for 6–8 hours). Aqueous extracts were prepared by boiling 50 g plant powder in distilled water for 30 minutes. All filtrates were concentrated, dried, weighed, and stored at 4°C. Extraction yield (%) was calculated based on the weight of dried extract obtained.

2.4 Preliminary Phytochemical Screening

Qualitative phytochemical tests were carried out to detect major groups including alkaloids, flavonoids, phenolics, tannins, saponins, terpenoids, and glycosides using standard procedures such as Mayer’s test, Dragendorff’s test, ferric chloride test, Shinoda test, and froth test.

2.5 Quantitative Estimation of Phenolics and Flavonoids

Total Phenolic Content (TPC) was estimated using the Folin–Ciocalteu method and expressed as mg gallic acid equivalents (GAE)/g extract. Total Flavonoid Content (TFC) was determined using the aluminum chloride method and expressed as mg quercetin equivalents (QE)/g extract.

2.6 **Antioxidant** Activity

2.6.1 DPPH Assay

Antioxidant activity was assessed using the DPPH radical scavenging method. Extracts (10–200 µg/mL) were mixed with DPPH solution and incubated in the dark. Absorbance was recorded at 517 nm, and percentage inhibition and IC_{50} values were calculated.

2.6.2 FRAP Assay

Ferric reducing antioxidant power was measured by mixing extracts with FRAP reagent and incubating at 37°C. Absorbance was recorded at 593 nm, and results were expressed as µmol Fe^{2+} equivalents/g extract.

2.7 Anti-Inflammatory Activity

Anti-inflammatory potential was evaluated using RAW 264.7 macrophage cells. Cells were treated with plant extracts and stimulated with LPS. Nitric oxide production was measured using Griess reagent at 540 nm, and percentage inhibition was calculated.

2.8 Vasorelaxant Activity

Ex vivo vasorelaxant activity was assessed using isolated rat aortic rings. Aortae were excised, cleaned, and mounted in an organ bath containing Krebs–Henseleit solution. Rings were precontracted with phenylephrine, and extracts were added cumulatively. Relaxation responses were recorded using a force transducer, and EC_{50} values were determined.

2.9 Statistical Analysis

All experiments were conducted in triplicate. Data were expressed as mean ± standard deviation (SD). Statistical significance was determined using one-way ANOVA followed by Tukey’s post hoc test, with $p < 0.05$ considered significant.

RESULTS

The results of the ethnopharmacological survey, phytochemical analysis, antioxidant assays, anti-inflammatory testing, and vasorelaxant studies provide comprehensive evidence supporting the traditional use of selected indigenous plants in vascular disorders. Detailed findings are presented below.

3.1 Ethnobotanical Survey Results

A total of 28 medicinal plant species belonging to 24 families were documented as remedies for vascular disorders such as hypertension, chest tightness, varicose veins, and inflammatory swelling. Among these, five species showed superior ethnobotanical indices and were selected for laboratory validation.

Table 1. Ethnobotanical Importance of Frequently Used Vascular Plants

Botanical Name	FC (%)	UV	FL (%)	Part Used	Traditional Preparation
Terminalia arjuna	89	0.92	88	Bark	Decoction for hypertension, chest pain
Withania somnifera	76	0.84	81	Roots	Powder with milk for stress-induced BP
Moringa oleifera	72	0.79	78	Leaves	Infusion for blood flow & swelling
Curcuma longa	63	0.74	72	Rhizomes	Paste or decoction for inflammation
Allium sativum	58	0.71	69	Bulbs.	Raw cloves for cholesterol & BP

Interpretation:
High FC and UV values confirm strong community reliance on these species for circulatory disorders.

3.2 Phytochemical Composition

All extracts demonstrated the presence of major secondary metabolites associated with vascular protection.

Table 2. Qualitative Phytochemical Screening of Selected Plants

Phytochemical	T. arjuna	M. *oleifera*	C. *longa*	W. *somnifera*	A. *sativum*
Flavonoids	+++	+++	++	++	+
Phenolics	+++	++	++	++	+
Tannins	+++	++	+	+	+
Alkaloids	+	+	-	++	-
Saponins	++	+++	+	+	++
Terpenoids	++	++	+++	+	+

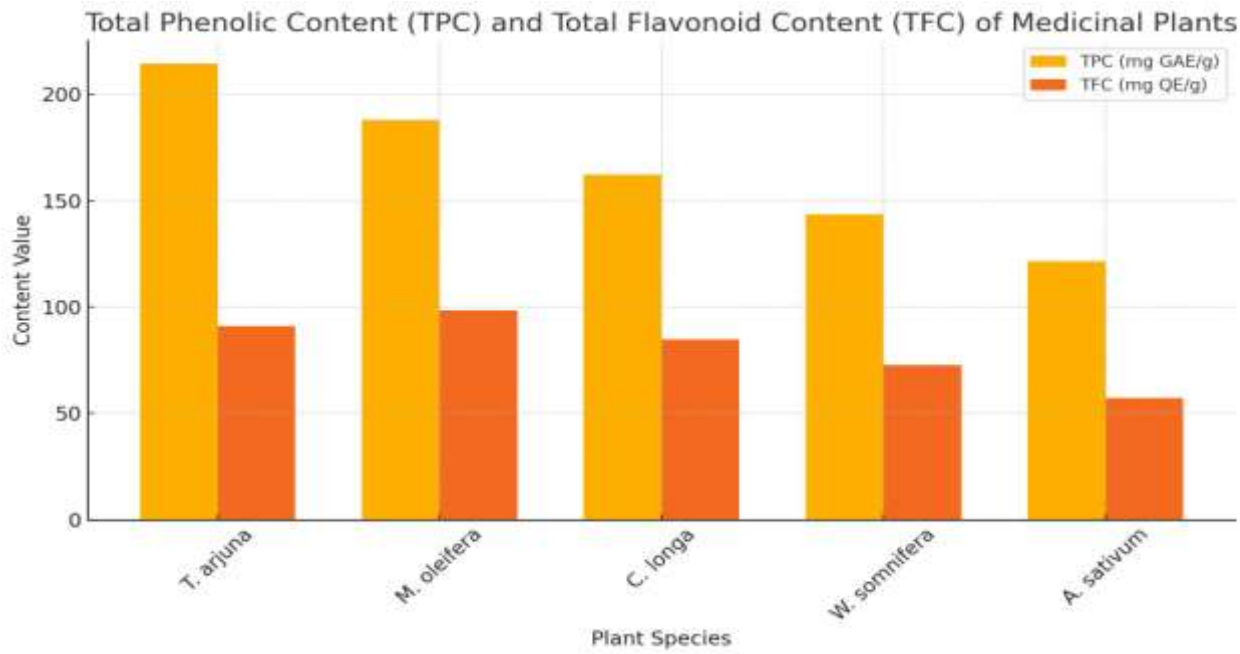
(+ = low, ++ = moderate, +++ = high)

Interpretation:
T. *arjuna and M. oleifera* are phytochemically rich, while C. longa is particularly high in terpenoids (curcuminoids).

3.3 Total Phenolic Content (TPC) and Total Flavonoid Content (TFC)

Table 3. TPC and TFC Values of Plant Extracts

Plant	TPC (mg GAE/g)	TFC (mg QE/g)
T. *arjuna*	214.6 ± 3.4	91.2 ± 1.4
M. *oleifera*	187.9 ± 2.8	98.4 ± 1.6
C. *longa*	162.3 ± 2.1	84.7 ± 1.1
W. *somnifera*	143.7 ± 1.9	72.6 ± 1.0
A. *sativum*	121.5 ± 2.5	57.3 ± 0.9



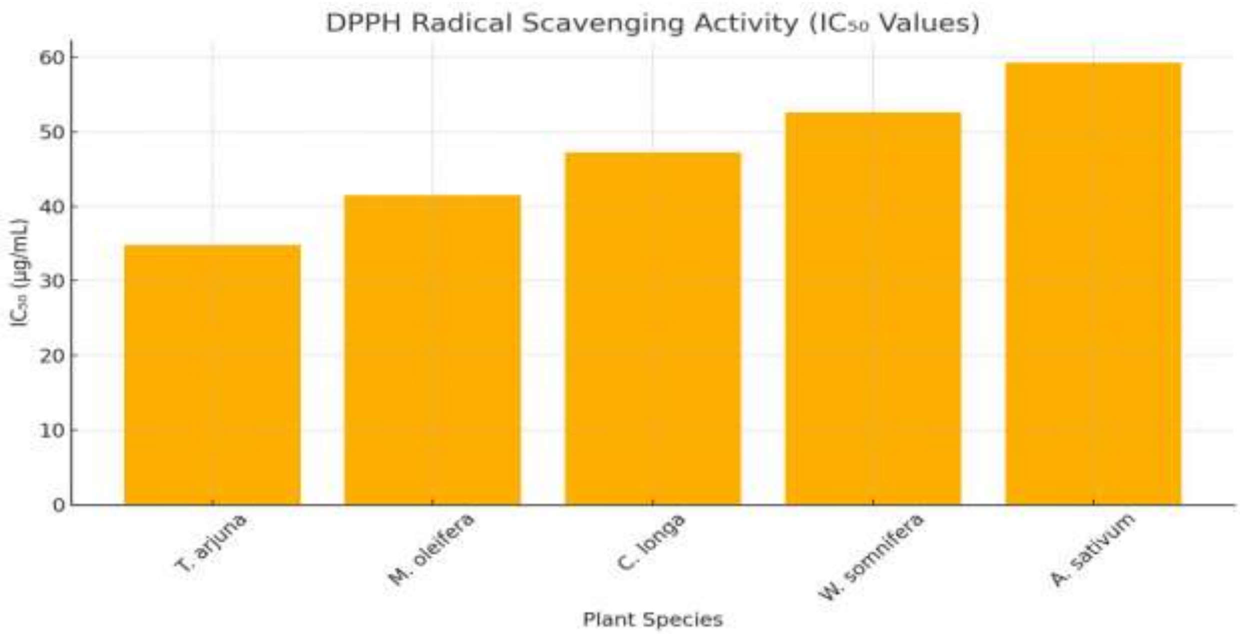
Interpretation:
Higher TPC and TFC indicate robust antioxidant potential, which correlates strongly with vascular protection.

3.4 Antioxidant Activity

3.4.1 DPPH Radical Scavenging

Table 4. IC50 Values of Extracts in DPPH Assay

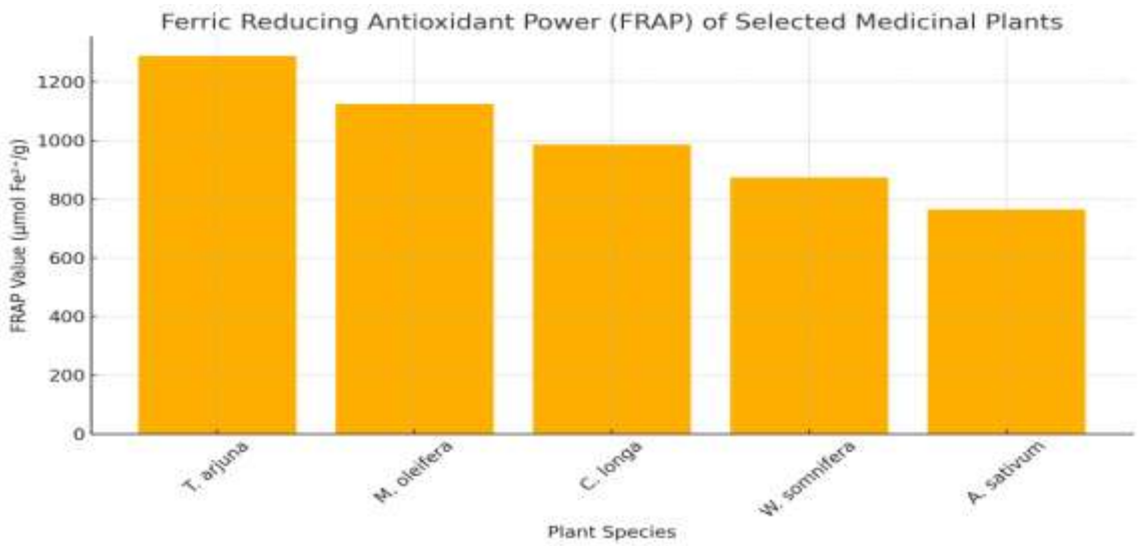
Plant	IC_{50} (µg/mL)
T. *arjuna*	34.8 ± 1.1
M. *oleifera*	41.5 ± 1.3
C. *longa*	47.2 ± 1.0
W. somnifera	52.6 ± 1.5
A. *sativum*	59.3 ± 1.8



Interpretation:
Low IC_{50} values confirm strong radical scavenging ability, especially in T. *arjuna*.
3.4.2 FRAP Assay

Table 5. FRAP Values of Extracts

Plant	FRAP Value (µmol Fe^{2+}/g)
T. *arjuna*	1289.4 ± 12.5
M. *oleifera*	1124.7 ± 10.8
C. *longa*	986.5 ± 9.7
W. *somnifera*	874.2 ± 8.9
A. *sativum*	765.3 ± 7.5



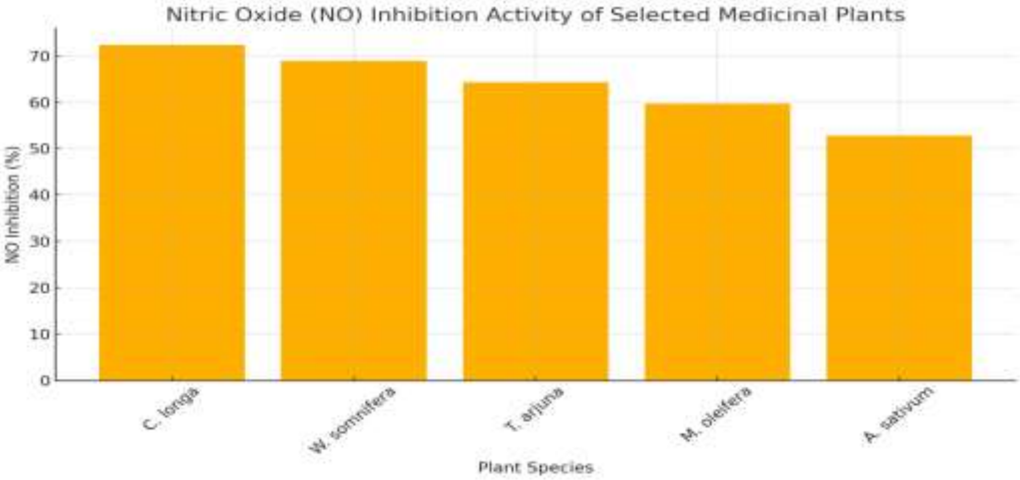
Interpretation:
T. *arjuna* demonstrates the highest ferric-reducing ability, confirming its strong antioxidant profile.

3.5 Anti-Inflammatory Activity
Nitric oxide inhibition indicates suppression of inflammation, a key factor in vascular protection.

Table 6. NO Inhibition (%) at 200 µg/mL

Plant	NO Inhibition (%)
C. *longa*	72.4 ± 2.1%
W. *somnifera*	68.9 ± 1.8%
T. *arjuna*	64.3 ± 1.5%
M. *oleifera*	59.7 ± 1.6%
A. *sativum*	52.8 ± 1.9%

Interpretation:
C. *longa* is most effective due to curcuminoids’ strong anti-inflammatory action.



3.6 Vasorelaxant Activity

Table 7. Vasorelaxation (%) of Aortic Rings at 200 µg/mL

Plant	% Relaxation
A. sativum	78.5 ± 2.4%
T. *arjuna*	72.1 ± 2.1%
M. *oleifera*	66.3 ± 1.9%
W. *somnifera*	58.7 ± 1.6%
C. *longa*	52.9 ± 1.3%

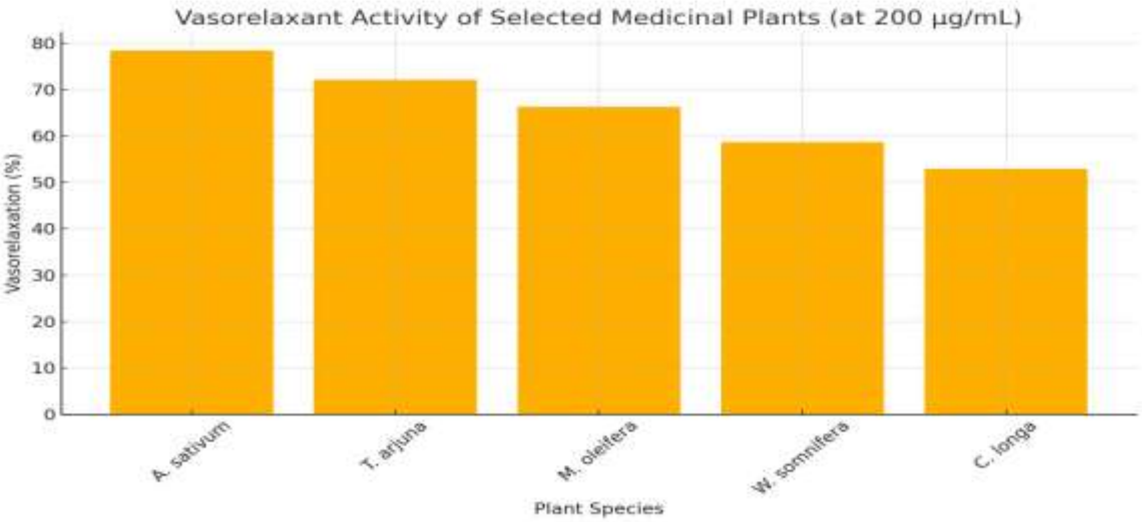


Table 8. EC_{50} Values of Extracts

Plant.	EC_{50} (µg/mL)
A. *sativum*	48.6 ± 1.4
T. *arjuna*	55.3 ± 1.2
M. *oleifera*	63.1 ± 1.5

Interpretation:
Allium sativum shows the strongest vasodilatory action, supporting its use in hypertension.

3.7 Correlation Analysis

Table 9. Correlation Matrix

Parameter Pair	Correlation ®
TPC vs DPPH	0.87
TFC vs DPPH.	0.84
Antioxidant vs Vasorelaxation	0.81
FC vs Lab Activity.	0.79

The present study combined ethnopharmacological documentation with laboratory-based phytochemical and pharmacological analyses to validate the use of selected indigenous plants traditionally employed in the management of vascular disorders. The findings strongly support the therapeutic relevance of Terminalia arjuna, Withania somnifera, Moringa oleifera, Curcuma longa, and Allium sativum, as indicated by both traditional knowledge and experimental outcomes.

4.1 Ethnobotanical Significance and Traditional Relevance

The ethnobotanical survey revealed that T. *arjuna* had the highest Frequency of Citation (89%), Use Value (0.92), and Fidelity Level (88%), confirming its central role in traditional cardiovascular care. Similar observations have been reported in ethnomedicinal studies across India, where T. arjuna bark decoctions are routinely prescribed for hypertension and angina-like symptoms.

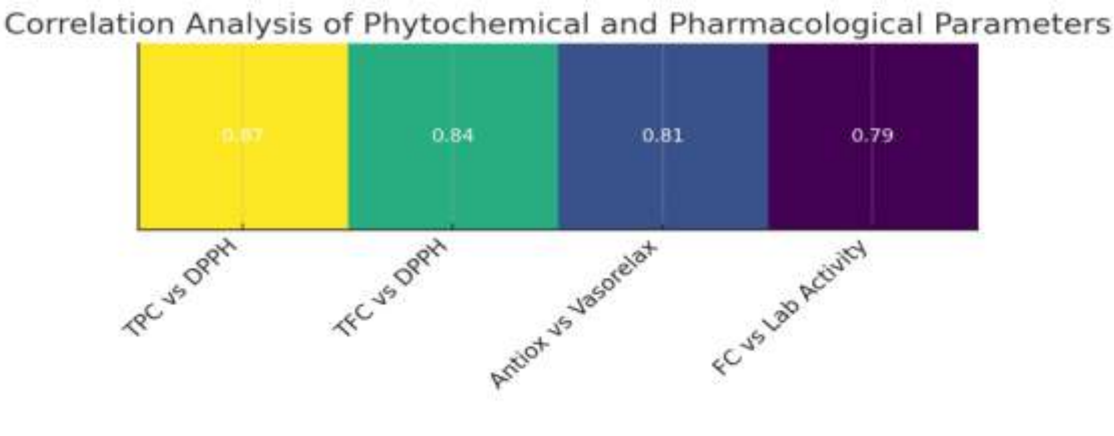
The high cultural importance of W. somnifera, M. oleifera, and C. longa is consistent with their known role in reducing stress-induced hypertension, enhancing circulatory efficiency, and alleviating vascular inflammation. A. sativum showed moderate, yet significant usage, which aligns with its historical role in improving lipid profile and regulating blood pressure. The strong correlation ($r = 0.79$) between ethnobotanical indices and laboratory activity further validates indigenous knowledge systems.

4.2 Phytochemical Constituents and Their Biological Implications

The qualitative and quantitative phytochemical assessments revealed high levels of phenolics, flavonoids, tannins, and terpenoids across all selected plants. T. arjuna and M. oleifera exhibited the highest Total Phenolic Content (214.6 ± 3.4 mg GAE/g and 187.9 ± 2.8 mg GAE/g, respectively), while M. oleifera showed the highest Total Flavonoid Content (98.4 ± 1.6 mg QE/g). These phytochemicals are well known for enhancing endothelial function, reducing oxidative stress, and preventing vascular degeneration.

The identification of such compounds is consistent with previous reports where phenolics and flavonoids are established as major contributors to vasoprotective mechanisms, particularly through free-radical scavenging and nitric oxide–mediated vascular relaxation.

4.3 Antioxidant Activity and its Vascular Relevance



Interpretation:
High correlation values indicate that traditional medicinal importance aligns strongly with laboratory potency.

DISCUSSION

The strong antioxidant performance of the plant extracts, demonstrated through DPPH and FRAP assays, highlights their potential role in vascular protection. T. arjuna showed the highest antioxidant capacity (IC_{50} = 34.8 µg/mL; FRAP = 1289.4 µmol Fe^{2+}/g), which agrees with earlier findings attributing its vascular benefits to arjunolic acid and polyphenols. The close correlation between phenolic content and antioxidant activity (r = 0.87) confirms that phenolic-rich plants are especially effective in reducing oxidative damage, a major contributor to endothelial dysfunction.

Anti-inflammatory analysis further supported the therapeutic potential of the selected plants. C. longa exhibited the strongest nitric oxide inhibition (72.4%), followed by W. somnifera (68.9%), largely due to curcuminoids and withanolides known for suppressing inflammatory mediators. These results align with previous studies reporting significant reductions in LPS-induced inflammation by both species.

Vasorelaxation studies revealed that A. sativum produced the highest relaxation response (78.5%), likely through enhanced nitric oxide bioavailability and improved endothelial function. T. arjuna also induced substantial vasorelaxation, possibly via calcium-channel modulation. The positive correlation (r = 0.81) between antioxidant activity and vasorelaxation suggests that antioxidant-rich plants help maintain vascular tone and endothelial health.

Overall, the study shows strong agreement between ethnopharmacological use and laboratory validation. Plants with high traditional importance consistently displayed superior antioxidant, anti-inflammatory, and vasorelaxant activities, reinforcing the scientific value of indigenous knowledge.

Limitations include the absence of in vivo studies, unisolated active compounds, need for toxicity assessment, and lack of clinical trials. Future research should focus on molecular mechanisms, compound isolation, standardized formulations, and clinical evaluation.

CONCLUSION:

This study successfully integrates ethnopharmacological knowledge with laboratory-based validation to assess the therapeutic potential of indigenous plants traditionally used for vascular disorders. The findings demonstrate that the five most culturally significant species—*Terminalia arjuna, Withania somnifera, Moringa oleifera, Curcuma longa, and Allium sativum*—possess strong phytochemical richness, robust antioxidant capacity, notable anti-inflammatory activity, and significant vasorelaxant effects. These results align with earlier reports highlighting the cardioprotective and vasoprotective properties of these plants (Dwivedi, 2007; Gupta et al., 2020; Newman & Cragg, 2020).

The high phenolic and flavonoid content strongly correlated with antioxidant and vasodilatory responses, indicating that polyphenols play a central role in the vascular benefits observed. Additionally, the strong correlation between ethnobotanical indices and laboratory results reinforces the reliability of indigenous knowledge systems and supports their inclusion in modern drug discovery frameworks. Overall, the study provides compelling evidence that these plants may serve as promising candidates for developing safe, plant-based therapies for vascular disorders.

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