



Phytochemical Profiling and Biological Evaluation of Selected *Terminalia* Species: A Review

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ABSTRACT

Plants of the genus *Terminalia* are amongst the most widely used plants for traditional medicinal purposes world-wide. Many *Terminalia* species have significant roles in traditional medicine, particularly in Ayurveda and other Asian medicinal systems, due to their diverse pharmacological properties. This review focuses on the published evidence concerning phytochemical profiles, antioxidant potential and biological efficacy of six selected *Terminalia* species: *Terminalia arjuna*, *T. chebula*, *T. bellirica*, *T. catappa*, *T. elliptica* and *T. pendula*. Particular attention is given to phenolics, flavonoids and tannins, commonly used antioxidant assays such as DPPH, ABTS and reducing power assays, and reported antimicrobial, anti-inflammatory, antidiabetic, hepatoprotective, wound healing and cytotoxic activities. *T. arjuna* is widely recognized for its cardioprotective potential and is rich in tannins and triterpenoids. *T. chebula* and *T. bellirica*, two important components of the Ayurvedic formulation Triphala are characterized by high phenolic content and diverse reported biological activities. *T. catappa*, commonly known as tropical almond, is a pantropical tree associated with antioxidant, antimicrobial and anti-inflammatory activities. *T. elliptica* and *T. pendula* have also been investigated for their phytochemical constituents, antioxidant potential and selected biological properties, although the available literature is comparatively limited. Various plant parts, including leaves, bark, stems, fruits and flowers, have been reported to possess bioactive constituents and biological potential. This review provides a comparative synthesis of published literature on the phytochemical composition, antioxidant properties and biological efficacy of selected *Terminalia* species and highlights existing research gaps and future research perspectives.

Keywords: *Terminalia*; phytochemicals; antioxidant potential; DPPH; biological efficacy; phenolics; tannins; flavonoids; medicinal plants.

INTRODUCTION

200–250 species widely distributed across tropical and subtropical regions of Asia, Australia and Africa. Medicinal plants are important sources of structurally diverse secondary metabolites and continue to provide leads for pharmaceutical, nutraceutical and traditional medicine research. Among medicinally important genera, *Terminalia* L. (Combretaceae) has received extensive scientific attention because several species are traditionally used and contain chemically diverse

constituents. The genus *Terminalia* comprises around 368 reported compounds, including terpenoids, tannins, flavonoids, lignans, phenols, and glycosides. This chemical diversity highlights the richness of the genus (Zhang *et al.*, 2019).

Medicinal potential is attributed to diverse bioactive phytoconstituents, particularly phenolic compounds, flavonoids, tannins, terpenoids and other secondary metabolites. These constituents are associated with antioxidants and several other biological activities. Numerous studies demonstrated that oxidative stress resulting from an imbalance between free radicals and antioxidant defence mechanisms can cause cellular damage and contribute to various health disorders. Therefore, natural antioxidants obtained from medicinal plants have attracted attention with their high content of secondary metabolites. The selected *Terminalia* species are of particular interest because of their reported richness in phenolic and tannin constituents and their antioxidant potential. Various studies have also reported antimicrobial, anti-inflammatory, antidiabetic, hepatoprotective and other biological activities in these species. However, phytochemical composition and biological potential may vary according to species, plant part, extraction method and geographical conditions. Phytochemicals such as phenolic acids, flavonoids and tannins are particularly relevant to antioxidant research because their hydroxyl groups and redox properties can contribute to radical-scavenging and reducing activities. Antioxidant capacity is commonly investigated using assays including DPPH, ABTS, ferric-reducing methods and related radical-scavenging systems. Importantly, antioxidant activity observed in a chemical assay should not automatically be interpreted as clinical therapeutic efficacy; biological activity depends on absorption, metabolism, dose, target interactions and safety. The present review focuses on six selected species—*T. catappa*, *T. chebula*, *T. bellirica*, *T. arjuna*, *T. elliptica* and *T. Pendula* with emphasis on the relationship between phytochemical composition, antioxidant potential and reported biological efficacy. Although several studies have reported the phytochemical composition, antioxidant potential and biological activities of different *Terminalia* species, the available information is scattered across individual studies. Comparative evaluation of phytochemical profiles, antioxidant activities and biological efficacy among selected *Terminalia* species remains limited. In particular, some species, such as *T. elliptica* and *T.*

pendula have received comparatively review of the available evidence needed to identify research gaps and future research directions. More investigation is required to determine the full extent of their medicinal use and phytochemistry.

PHYTOCHEMICAL PROFILING

Phytochemical profiling refers to the qualitative and quantitative characterization of bioactive chemical constituents present in a plant. *Terminalia* species are known to contain diverse groups of secondary metabolites, including phenolic compounds, flavonoids, tannins, terpenoids, triterpenoids, saponins, alkaloids and glycosides.

Terminalia arjuna

Terminalia arjuna is rich in secondary metabolites such as triterpenoids, tannins, flavonoids and glycosidic constituents. Arjunolic acid, arjunic acid and related triterpenoids are among its characteristic phytochemicals. Flavonoids and tannins have also been reported from different plant parts, especially the bark. Recent reviews continue to describe arjunolic acid and other triterpenoids as important constituents of this species (Bhujel *et al.*, 2026).

Terminalia chebula

Phytochemical studies of *Terminalia chebula* have revealed a diverse range of secondary metabolites, including tannins, phenolic acids, lignans, triterpenoids, flavonoids and volatile compounds. To date, approximately 149 compounds have been identified from *T. chebula*, with tannins representing the major group of phytoconstituents (Wang *et al.*, 2024).

Terminalia catappa L.

Terminalia catappa contains a wide range of phytochemicals, particularly phenolic compounds, flavonoids, tannins and terpenoids. Studies of its leaves have reported flavonoids, tannins, saponins, steroids, alkaloids, cardiac glycosides and coumarins. Important compounds reported from different plant parts include quercetin, naringenin, caffeic acid, gallic acid and tannic acid. Hydrolysable tannins such as punicalin and punicalagin have also been reported, particularly from the leaves (Zannou *et al.*, 2026).

Terminalia bellirica:

Terminalia bellirica contains several classes of bioactive phytoconstituents, including tannins,

Table 1: Comparative phytochemical profile of selected *Terminalia* species.

<i>Terminalia</i> species	Major phytochemicals	Representative compounds
<i>T. arjuna</i>	Triterpenoid, tannins, flavonoids, glycosides	Arjunolic acid, arjunic acid, gallic acid
<i>T. Chebula</i>	Tannins, phenolic acids, flavonoids, triterpenoids	Chebulagic acid, chebulinic acid, gallic acid, ellagic acid, corilagin, quercetin, luteolin, maslinic acid
<i>T. bellirica</i>	Triterpenoids, flavonoids, phenolics, tannins	Gallic acid, Ellagic acid, Corilagin, Quercetin and arjunolic acid
<i>T. catappa</i>	Phenolics, flavonoids, tannins, terpenoids	Quercetin, naringenin, caffeic acid, gallic acid, tannic acid, punicalin, punicalagin
<i>T. elliptica</i>	Flavonoids, phenolic constituents, tannins	Chebolic acid, rutin and naringin
<i>T. pendula</i>	Phenolics, flavonoids, tannins, terpenoids	Phytol acetate, lupeol, squalene, stigmasterol, n-Hexadecanoic acid etc

phenolic compounds, flavonoids, terpenes and glycosides derivatives. Phytochemical investigations of its fruits have reported a diverse chemical profile, with triterpenoids, flavonoids, lignan-related constituents and simple phenolics among the major groups. The species has been extensively investigated for its phytochemical and biological properties (Gupta *et al.*, 2020).

Terminalia elliptica:

Terminalia elliptica has been comparatively less investigated than some of the traditionally prominent *Terminalia* species. Available phytochemical literature indicates the presence of flavonoids and other phenolic constituents. A genus-level review reported 36 compounds from *T. elliptica*, with flavonoids identified as an important chemical group. This comparatively smaller body of phytochemical information indicates the need for further detailed characterization of its chemical constituents (Zhang *et al.*, 2019).

Terminalia pendula:

Terminalia pendula leaves and stem have reported alkaloids, flavonoids, glycosides, phenolics, quinones, tannins, steroids and terpenoids. Classes of compounds are commonly associated with antioxidant and other biological activities reported in the genus (Kumari and Sidhu, 2025).

ANTIOXIDANT POTENTIAL:

Antioxidants are compounds that help neutralize free radicals and reduce oxidative stress by scavenging reactive oxygen species and other reactive molecules.

The antioxidant potential of *Terminalia* species has been widely investigated and is commonly evaluated using in vitro assays such as DPPH, ABTS, nitric oxide scavenging, hydrogen peroxide scavenging, ferric reducing antioxidant power (FRAP), and reducing-power assays. The antioxidant activity reported in *Terminalia* species is frequently associated with their high content of phenolic compounds, flavonoids and tannins.

Terminalia arjuna:

Terminalia arjuna, particularly its bark, has been extensively investigated for antioxidant activity. Bark extracts and different solvent fractions have demonstrated DPPH, ABTS, hydroxyl-radical and nitric-oxide scavenging activities. Recent research has also reported substantial phenolic and flavonoid contents in *T. arjuna* bark extracts, supporting their antioxidant potential (Bhujel *et al.*, 2026).

Terminalia chebula:

Terminalia chebula is one of the extensively studied *Terminalia* species for antioxidant activity. Fruit and bark extracts have shown DPPH radical-scavenging activity, while studies have also reported nitric oxide and superoxide scavenging activities. Its antioxidant potential is strongly associated with phenolic compounds, hydrolysable tannins and compounds such as chebulagic acid, chebulinic acid, gallic acid, ellagic acid and corilagin (Sultan *et al.*, 2023)

Terminalia bellirica:

Terminalia bellirica has demonstrated antioxidant activity in several experimental studies. Fruit and other extracts have been evaluated using DPPH, ABTS

Table 2: Comparative antioxidant profile

Species	Plant parts	Antioxidant property	Observations
<i>T. arjuna</i>	Bark, fruits	DPPH, ABTS, FRAP, NO,	Antioxidant activity associated with phenolics and flavonoids
<i>T. chebula</i>	Fruits, bark, leaves	DPPH, ABTS superoxide, FRAP	Strong radical-scavenging activity associated with phenolics, tannins
<i>T. bellirica</i>	Fruits, aerial parts	DPPH, ABTS, TEAC	Antioxidant activity associated with phenolics, tannins and flavonoids
<i>T. catappa</i>	Leaves, fruits	DPPH and FRAP, ABTS	Antioxidant activity associated with phenolics, tannins and flavonoids
<i>T. elliptica</i>	Leaves extract	DPPH, FRAP	Antioxidant associated with phenolics, flavonoids
<i>T. pendula</i>	Flowers	DPPH	Antioxidant associated with phenolics, flavonoids, tannins

Table 3: Comparative biological activity

Species	Biological activity	Plant parts
<i>T. arjuna</i>	Cardioprotective, anti-inflammatory, hepatoprotective etc.	Bark, other parts
<i>T. chebula</i>	Antimicrobial, anti-inflammatory, antidiabetic, cytotoxic etc	Fruits and other parts
<i>T. bellirica</i>	Antimicrobial, anti-inflammatory, antidiabetic.	Fruits, bark, other parts
<i>T. catappa</i>	Antimicrobial, anti-inflammatory, antitumor, hepatoprotective, hyperlipidemic, antidiabetic.	Leaves, fruits, other parts
<i>T. elliptica</i>	Wound-healing	Leaves
<i>T. pendula</i>	Anti-inflammatory, anti-antimicrobial, hepatoprotective	Flowers and other parts

and other antioxidant assays. Phenolic compounds, tannins and flavonoids are considered important contributors to its antioxidant properties. Reported constituents associated with its antioxidant activity include gallic acid, ellagic acid, tannic acid, methyl gallate, catechin and rutin (Gupta *et al.*, 2020).

***Terminalia catappa*:**

Terminalia catappa has demonstrated antioxidant activity in different plant parts, particularly leaves and fruits. Its antioxidant properties have been associated with phenolic compounds and flavonoids. Flavonoid glycosides isolated from the leaves have also demonstrated antioxidative effects in experimental assays. The presence of phenolic constituents and other bioactive compounds may contribute to its free-radical-scavenging potential (Zannou *et al.*, 2026).

***Terminalia elliptica*:**

Terminalia elliptica has demonstrated antioxidant potential in experimental studies. Ethanolic leaf extract showed antioxidant activity in the DPPH assay and strong reducing power in the FRAP assay (Popeta and Thakur., 2026).

***Terminalia pendula*:**

Terminalia pendula is also comparatively less investigated for antioxidant properties. A recent study specifically evaluated the antioxidant potential of its flowers using the DPPH radical-scavenging assay, comparing methanolic and ethanolic extracts with quercetin as a reference standard. This indicates that the species has measurable antioxidant potential, although its detailed phytochemical basis requires further investigation (Hossain *et al.*, 2026)

BIOLOGICAL EFFICACY

Terminalia species have been investigated for a wide range of biological activities due to the presence of diverse bioactive phytoconstituents. Reported biological effects include antimicrobial, anti-inflammatory, antidiabetic, hepatoprotective, wound-healing, cytotoxic and other pharmacological activities. The biological efficacy varies among species, plant parts, extraction solvents, experimental models and concentrations used. Therefore, comparative evaluation of these activities provides useful

information regarding the therapeutic potential of different *Terminalia* species.

Relationship between Phytochemical Profiling, Antioxidant Potential and Biological Efficacy

Phytochemical profiling helps identify bioactive compounds such as phenolics, flavonoids, and tannins, which may contribute to the antioxidant potential of *Terminalia* species. These antioxidants and other bioactivities can collectively support the observed biological efficacy, including antimicrobial, anti-inflammatory, antidiabetic, and hepatoprotective effects reported in different *Terminalia* studies.

Research gaps

Although several species of the genus *Terminalia* have been extensively studied for their phytochemical composition, antioxidant potential, and biological activities, comparatively limited information is available for certain species, particularly *Terminalia elliptica* and *Terminalia pendula*. The available studies on these species are relatively few and have mainly focused on specific activities or plant parts. Therefore, further systematic investigation is required to comprehensively evaluate their phytochemical profiles, antioxidant potential, and biological efficacy.

CONCLUSION

The genus *Terminalia* represents a valuable source of bioactive phytochemicals with significant antioxidant and biological potential. The reviewed studies indicate that phenolic compounds, flavonoids, tannins, and other secondary metabolites contribute to the diverse biological activities reported in different *Terminalia* species. Antioxidant assays such as DPPH, ABTS, FRAP, and radical-scavenging assays have demonstrated antioxidant potential in several species. However, compared with extensively studied species such as *T. chebula*, *T. bellirica*, and *T. arjuna*, comparatively limited information is available for *T. elliptica* and *T. pendula*. Further systematic studies focusing on their phytochemical profiling, antioxidant mechanisms and biological efficacy may help provide a more comprehensive understanding of their therapeutic potential.

Conflict of interest

The authors declare no competing interests.

Data Availability Statement: Not applicable.

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