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Ethnopharmacological evaluation of *Dendrocalamus strictus* (Roxb.) Nees

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Abstract

Dendrocalamus strictus is an economically and ecologically important bamboo species widely distributed in the Indian subcontinent. The present study was undertaken to document the morphology, habitat and phytochemical properties of *D. strictus*, with particular emphasis on the qualitative screening and quantitative estimation of its secondary metabolites. Field observations were carried out to document its morphological characteristics and habitat, followed by phytochemical analysis of the plant material using standard analytical methods. Qualitative screening revealed the presence of primary metabolites including protein, carbohydrate, starch and several bioactive constituents including tannin, saponin, flavonoids, terpenoids and reducing sugar. Quantitative analysis demonstrated the occurrence of 17.94 mg / 100 ml tannin, 6.13% saponin, 1.72 mg / 100 ml phenolic compounds and 0.40 mg / ml. The antioxidant activity using DPPH assay evaluated demonstrated considerable antioxidant potential with inhibition percentage increased from 48.92% to 51.71% for ethanol extract and 39.28% to 50.71% for aqueous extract of *D. strictus* in the increasing concentration. The presence of these metabolites suggests that *D. strictus* may possess significant biological and therapeutic potential. In addition to its traditional uses in construction, handicrafts, household materials and other livelihood activities, the species has potential for further exploration as a source of valuable bioactive compounds. The findings reveal the multifaceted importance of *D. strictus* and provide a basis for future investigations on nutraceutical and pharmacological and toxicity. Sustainable utilization and conservation of this valuable bamboo resource are recommended for maintaining its ecological and socioeconomic benefits.

Keywords: Bamboo, morphology, habitat, phytochemical screening, secondary metabolites

Introduction

Dendrocalamus strictus is one of the most ecologically and economically important bamboo species of India. It is a perennial, clump-forming bamboo characterized by a sympodial growth habit and a pachymorph rhizome system. The culms are erect, cylindrical, smooth and generally unarmed, typically attaining a height of approximately 8-16 m. The species has a wide ecological amplitude and occurs predominantly in dry deciduous forests, open forest areas, dry hills, plains, ravines, forest margins and degraded landscapes. *D. strictus* is capable of growing under relatively dry conditions and is distributed from near sea level to approximately 1,200 m elevation. It generally prefers well-drained soils, particularly sandy-loam and other coarse-textured soils and can tolerate a relatively broad range of soil conditions. The species is widely distributed throughout India, including Odisha, Madhya Pradesh, Uttar Pradesh, Himachal Pradesh, parts of the Western Ghats and Northeast India (Sreedevi *et al.*, 2026; Nongdam and Tikendra, 2014) ^[29, 21]. The ethnobotanical importance of *D. strictus* is closely associated with the multifunctional utilization of its young shoots, leaves, culms and other plant parts. Young bamboo shoots are traditionally consumed as vegetables in several parts of India and constitute an important seasonal food resource for rural and indigenous communities. Bamboo shoots are commonly harvested at an early developmental stage and subjected to processing such as boiling, soaking, cooking or fermentation before consumption. The consumption of bamboo shoots is particularly important in traditional food systems because they provide dietary fibre, protein, carbohydrates, minerals and several bioactive compounds (Nongdam and Tikendra, 2014; Karthik and Jayashankar, 2023; Maya *et al.*, 2024) ^[21, 14, 20]. Different parts of *D. strictus*

have also been associated with traditional medicinal practices. Leaves and other plant materials have traditionally been used for various ailments, including cough, cold, fever and wounds, while siliceous material obtained from bamboo has been incorporated into traditional medicinal preparations. Research have found that *D. strictus* indigenous communities have utilized different plant parts according to locally developed ethnomedicinal knowledge (Sreedevi *et al.*, 2026) ^[29]. Karthik and Jayashankar (2023) ^[14] evaluated the nutritional and qualitative phytochemical composition of edible bamboo shoots collected from different parts of Karnataka and reported variation in moisture, carbohydrate, protein, crude fibre and ash among bamboo species. Their findings indicated that edible bamboo shoots can contribute to dietary diversification and

may serve as nutritionally valuable vegetables. Bamboo shoots are particularly important as sources of fibre and plant-based nutrients, and their low-fat nature further enhances their potential as a functional food. (Karthik & Jayashankar, 2023) ^[14]. In addition to its food and therapeutic values, it is also a fodder plant for Asian Elephant, an endangered animal (Dhamdhare *et al.*, 2026) ^[8]. Considering its importance in food and therapeutic importance, the present study aimed to document the morphological characteristics and habitat of *D. strictus*, assess the qualitative profile of primary and secondary metabolites, quantify the major secondary metabolites, and evaluate the antioxidant potential of the plant extracts using the DPPH radical-scavenging assay.



Fig 1: Leaves of *Dendrocalamus strictus*



Fig 2: Culm nodes of *D. strictus*



Fig 3: Habitat of *D. strictus* at Boudh district, Odisha

Methodology

During a floristic survey conducted along the Mahanadi River in Boudh District, Odisha, the authors recorded *Dendrocalamus strictus* in its natural habitat (Figure 1, 2 and 3). Detailed observations of the habitat and plant morphology were documented, and photographs of the habit and diagnostic plant parts were taken during field visits. The species was identified using standard regional floras, herbarium specimens, and authenticated online botanical databases (Gunjal *et al.*, 2025; Sharma *et al.*, 2024) ^[10, 26]. Fresh leaves were collected from naturally growing plants and processed for phytochemical profiling and evaluation of antioxidant activity.

Qualitative phytochemical analysis

The leaf extracts of *D. strictus* were subjected to qualitative screening for primary and secondary metabolites using standard phytochemical procedures. For protein detection, 1 mL of extract was treated with 2-5 drops of Millon's reagent and heated in a water bath for 30 min. Development of pink coloration was considered indicative of protein. Carbohydrates were assessed by adding Fehling's solutions A and B to 1 mL of extract followed by heating; the formation of an orange to red precipitate indicated a positive reaction. Starch was detected by acid hydrolysis of the extract followed by neutralization and treatment with Benedict's reagent, with a red-orange colour indicating its presence. Sucrose was tested using iodine solution, while lipids were detected by staining with Sudan III, with pink-coloured droplets indicating a positive reaction. Amino acids were examined using ninhydrin reagent; the development of purple-coloured Rhuemann's purple confirmed their presence.

Secondary metabolites were screened using specific colour and precipitation reactions. Tannins were detected by treating the extract with 10% lead acetate, where formation of a gelatinous precipitate indicated a positive result. Saponins were evaluated by vigorous shaking of the extract with distilled water, with persistent frothing confirming their presence. Flavonoids were detected by treatment with

2% sodium hydroxide followed by dilute hydrochloric acid; the development of an intense yellow colour that subsequently disappeared upon acidification indicated a positive reaction. For terpenoids, the extract was treated with chloroform and concentrated sulphuric acid, and a reddish-brown interface was considered positive. Phenolic compounds were tested using 5% ferric chloride, with dark bluish-black coloration indicating their presence. Reducing sugars were identified using Fehling's solutions A and B, followed by heating, with a red-orange precipitate indicating a positive reaction. Steroids were detected by treatment with chloroform and concentrated sulphuric acid, while alkaloids were screened using Dragendorff's reagent, with formation of a reddish-brown precipitate indicating a positive reaction.

Quantitative estimation of secondary metabolites

Estimation of phenolic compound content

For total phenol estimation, 0.5 g of plant material was extracted with 60% methanol using a mortar and pestle. The homogenate was centrifuged at 5000 rpm for 20 min, and the extraction procedure was repeated. Suitable aliquots of the extract were diluted to 1 mL with 60% methanol and treated with 0.1 N HCl followed by a sodium nitrite-molybdate reagent. After appropriate incubation, the mixture was diluted with distilled water and treated with 1 N NaOH. Absorbance was measured at 515 nm, and the phenolic content was determined from a gallic acid standard calibration curve (Swain and Hills, 1959).

Estimation of tannin content

For tannin estimation, a tannic acid standard solution was prepared and different concentrations were reacted with Folin reagent and 20% sodium carbonate. Following incubation under dark conditions, absorbance was measured at 720 nm to construct the standard calibration curve. For sample extraction, 5 mg of plant material was boiled in distilled water for 30 min and centrifuged at 2000 rpm for 20 min. The supernatant was collected, appropriately diluted and treated with Folin reagent and 20% sodium carbonate. After incubation, absorbance was recorded at 720 nm, and

tannin content was calculated using the tannic acid standard curve (Sadasivam and Manickam, 2009) ^[25].

Estimation of saponin content

For total saponin estimation, 5 gms of powdered plant material were extracted with 20% aqueous ethanol and stirred for 30 min, followed by heating at 45°C for 4 h. The extract was filtered and the residue was re-extracted with 25% aqueous ethanol. The combined extracts were concentrated and partitioned successively with diethyl ether and *n*-butanol. The *n*-butanol fraction was washed with 5% aqueous sodium chloride and evaporated to dryness. The residue was oven-dried at 40°C to constant weight, and the percentage of saponin was calculated (Swain and Hills, 1959).

Saponin (%) = (Weight of dried saponin fraction / Weight of initial sample) × 100

Estimation of flavonoid content

Total flavonoid content was determined using the aluminium chloride colorimetric method of Chang *et al.* (2002) ^[5]. 100 µL of plant extract was mixed with 100 µL of 5% sodium nitrite and allowed to react for 5 min. Subsequently, 150 µL of aluminium chloride was added and incubated for 6 min, followed by the addition of 200 µL of 1 M sodium hydroxide. The final volume was adjusted to 3 mL with distilled water and incubated for 15 min at room temperature in the dark. Absorbance was measured at 510 nm. Quercetin was used as the reference standard, and flavonoid content was calculated from the corresponding calibration curve (Chang *et al.*, 2002; Shirazi *et al.*, 2014; Raina & Misra, 2023) ^[5, 27, 23].

Quantitative antioxidant activity

Leaf extracts were prepared by the maceration method following Abubakar and Haque (2020) ^[1]. 1 gm of dried and powdered leaves was macerated separately with 10 mL of the respective solvents in tightly closed containers for 48 h with intermittent stirring. The mixtures were subsequently strained, pressed and filtered. The resulting filtrates were concentrated in a hot-air oven to obtain crude extracts, which were reconstituted in 1% dimethyl sulfoxide (DMSO) to prepare the working solutions. A 0.1 mM DPPH solution was prepared. 3.94 mg of 2,2-diphenyl-1-picrylhydrazyl (DPPH) was dissolved in 100 mL methanol to obtain the stock solution. Subsequently, 3 mL of the stock solution was diluted to 50 mL with methanol to prepare the working solution. The DPPH solution was protected from light by wrapping the container in aluminium foil. The antioxidant activity of the aqueous, ethanol and *n*-hexane leaf extracts was evaluated using the DPPH radical-scavenging assay. Different concentrations of each extract were prepared and mixed with an equal volume of 0.1 mM DPPH solution.

Appropriate sample blanks containing the respective extract and solvent without DPPH were included for background correction, while methanol was used as the control blank. The reaction mixtures were incubated in the dark at room temperature for 10 min, and absorbance was measured at 517 nm using a UV spectrophotometer. Quercetin was used as the reference antioxidant. Radical-scavenging activity was expressed as percentage inhibition and calculated using the following equation (Baliyan *et al.*, 2022; Majhi *et al.*, 2026) ^[3, 17]:

$$\text{DPPH inhibition (\%)} = [(A_0 - A_1) / A_0] \times 100$$

where A_0 represents the absorbance of the control and A_1 represents the absorbance of the sample. A graph of percentage inhibition against extract concentration was plotted to evaluate the concentration-dependent antioxidant activity.

Results and Discussion

Morphology

D. strictus is a perennial, clump-forming bamboo characterized by usually small central cavity. The culms are generally erect, cylindrical, smooth and non-thorny and usually attain a height of approximately 6-16 m, although considerable variation occurs depending on geographical and environmental conditions. Lower culm sheaths oblong 7.5-30 cm, top rounded or waved, not or only slightly auricled. Young culms are generally bluish-green and gradually become greenish-yellow or yellowish with maturity. The internodes are usually relatively short, while the nodes are prominent. One characteristic feature of *D. strictus* is the variable nature of its culm cavity. The culm sheaths are well developed and the leaves are linear to lanceolate with parallel venation and distinct midribs. The inflorescence consists of fasciculate pseudospikelets, and flowering may occur sporadically or synchronously over large areas. Considerable morphological variation has been documented within the species, reflecting its adaptation to diverse ecological conditions (Sreedevi *et al.*, 2026) ^[29].

Qualitative phytochemical analysis of primary metabolites

The qualitative phytochemical screening of *Dendrocalamus strictus* leaves revealed various distribution of primary metabolites among the solvent extracts. Proteins and carbohydrates were detected in both aqueous and ethanol extracts. Starch was detected only in the aqueous extract, while sucrose, lipids and amino acids were not detected in any of the three extracts. The occurrence of proteins and carbohydrates predominantly in the aqueous and ethanol extracts may be attributed to their relatively polar nature and greater solubility in polar solvents (Figure 4). The absence of detectable lipids in the tested extracts may reflect either their low abundance in the leaves or the sensitivity and specificity of the qualitative tests employed.

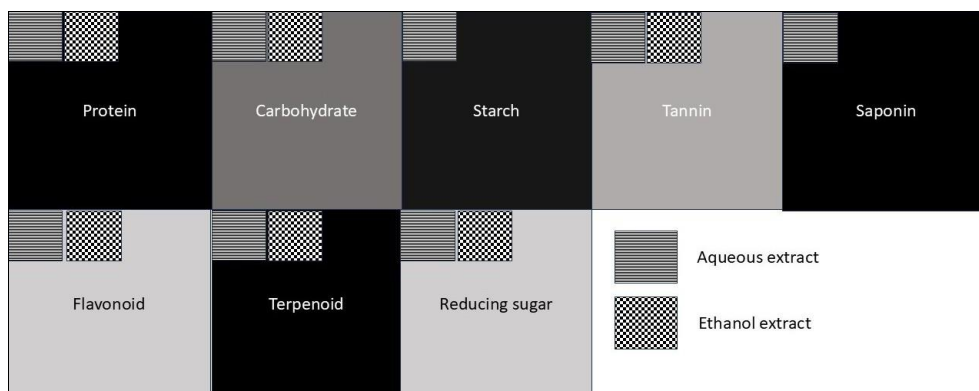


Fig 4: Illustration representing detection of primary and secondary metabolites in aqueous and ethanol extract of *D. strictus*

Qualitative phytochemical analysis of secondary metabolites

The screening of secondary metabolites demonstrated a more pronounced response in the aqueous and ethanol extracts. Tannins, flavonoids, terpenoids and reducing sugars were detected in both aqueous and ethanol extracts, whereas saponins were detected only in the aqueous extract. Terpenoids were also detected in both extracts. The detection of saponins exclusively in the aqueous extract may be associated with their generally polar and water-soluble nature. Reducing sugars were present in both aqueous and ethanol extracts, consistent with the positive carbohydrate reaction (Figure 4). The present findings are broadly consistent with earlier phytochemical investigations of *D. strictus* leaves, which have reported the presence of several classes of bioactive constituents, including tannins, flavonoids, glycosides and other secondary metabolites (Wangawar *et al.*, 2017) [31]. Such phytochemical diversity may contribute to the traditional and pharmacological importance attributed to the species.

Quantitative phytochemical composition

Quantitative analysis further confirmed the presence of several important secondary metabolites in *D. strictus* leaves. Tannin was the predominant quantified constituent, with a concentration of 17.94 mg/100 mL, followed by saponin at 6.13%, phenol at 1.72 mg/100 mL, and

flavonoids at 0.40 mg/mL. The comparatively higher tannin content suggests that tannins constitute an important component of the phytochemical profile of the leaves. Tannins are polyphenolic compounds known for their astringent properties and their potential antioxidant and antimicrobial activities. Phenolic compounds and flavonoids were quantitatively detected despite the negative qualitative result for the broad "phenolic group". This apparent discrepancy may arise from differences in assay sensitivity, extraction conditions or the specificity of the qualitative and quantitative methods used. Therefore, the quantitative data provide additional evidence that *D. strictus* leaves contain measurable concentrations of phenolic and flavonoid constituents. Differences in reported phytochemical concentrations among studies may be expected because phytochemical accumulation is influenced by geographical origin, environmental conditions, plant age, season, extraction solvent and analytical methodology (Wangawar *et al.*, 2017; Sreedevi *et al.*, 2026) [31, 29].

DPPH radical-scavenging activity

The antioxidant potential of *D. strictus* leaves was evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging assay, and all three extracts demonstrated measurable antioxidant activity. A better DPPH inhibition was observed for the aqueous while the ethanol extract also showed a gradual increase across the tested concentration range.

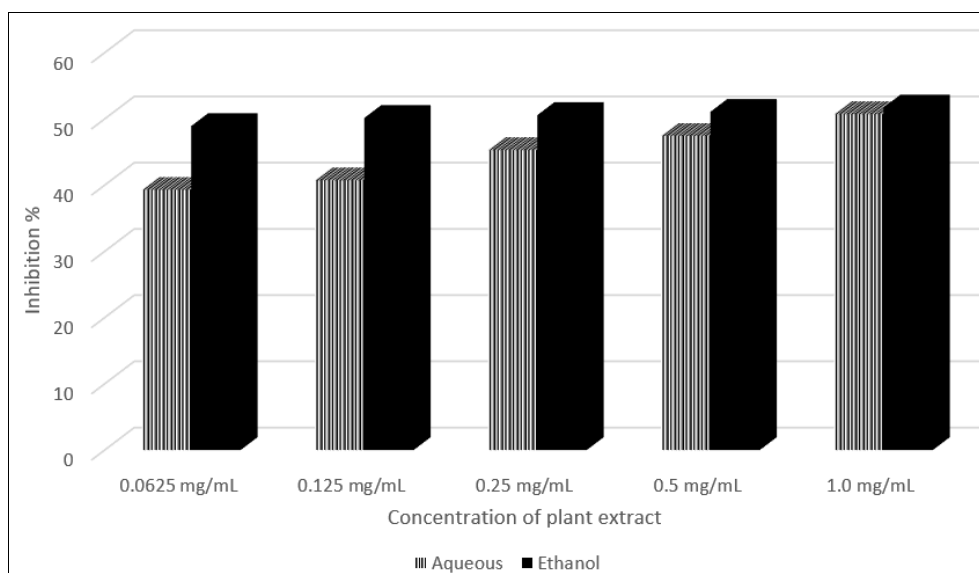


Fig 5: DPPH radical-scavenging assay of *D.* leaves extracts

In the aqueous extract, inhibition increased from 39.28% at 0.0625 mg/ml to 50.71% at 1.0 mg/ml. Similarly, the ethanol extract showed an increase from 48.92% to 51.71%. The present findings indicate that increasing extract concentration generally enhanced the ability of the leaf extracts to reduce the DPPH radical (Figure 5).

Among the three extracts, the ethanol extract showed the highest activity, with inhibition increasing from 48.92% to 51.71%, whereas the aqueous extract showed comparatively lower activity, ranging from 39.28% to 50.71%. The comparatively stronger activity of the ethanol extract may be associated with its ability to extract a broad spectrum of flavonoids, tannins and terpenoid constituents, which were detected qualitatively in the present study. Phenolic compounds and flavonoids are widely recognized for their capacity to donate hydrogen atoms or electrons to free radicals, thereby contributing to radical-scavenging activity. The measurable antioxidant activity of the aqueous extract is also consistent with the presence of tannins, flavonoids and saponins. Previous studies on *D. strictus* have reported phytochemical constituents and biological activities in different plant parts, supporting the possibility that its secondary metabolites contribute to antioxidant and other functional properties (Wangawar *et al.*, 2017; Sreedevi *et al.*, 2026) ^[31, 29]. The phytochemical composition of *D. strictus* is diverse and varies according to the plant part, developmental stage, geographical origin and extraction solvent. Studies on bamboo shoots and leaves have reported several classes of secondary metabolites, including phenolics, flavonoids, tannins, alkaloids, saponins, glycosides, steroids and phytosterols. Karthik and Jayashankar (2023) ^[14] reported the occurrence of different phytochemical groups in edible bamboo shoots collected from Karnataka, with phenolic compounds and flavonoids contributing substantially to their functional-food potential. Similarly, Acharya *et al.* (2024) ^[2] documented variation in alkaloids, flavonoids, saponins and other phytochemical constituents among bamboo species sampled from the Niyamgiri Hill Range. The leaves of *D. strictus* have also been investigated for their phytochemical and antimicrobial properties. Wangawar *et al.* (2017) ^[31] reported several phytochemical groups in leaf extracts, including flavonoids, steroids, glycosides and tannins. The occurrence of phenolic and flavonoid compounds is particularly relevant because these classes of metabolites are frequently associated with antioxidant properties. Singha *et al.* (2024) ^[28] investigated the physicochemical properties of *D. strictus* and *Bambusa bambos* seeds and identified bamboo seeds as a potentially valuable functional-food resource. Bamboo seeds contain carbohydrates, protein and fibre together with phenolic and flavonoid compounds. Their nutritional characteristics suggest that they may have potential as alternative grain-like food resources, particularly during bamboo flowering events when large quantities of seeds can become available. Kapoor *et al.* (2026) ^[12] further emphasized the potential of bamboo seeds in relation to nutrition, phytochemistry, germination, storage and biotechnological applications.

Conclusion

The present study on *D. strictus* shows considerable morphological, ecological and phytochemical significance. The species is a versatile bamboo with important applications in rural livelihoods, construction, handicrafts, food, traditional medicine and environmental management.

The qualitative phytochemical investigation indicated the presence of several biologically important primary and secondary metabolites, while the quantitative analysis demonstrated appreciable levels of compounds such as tannins, phenols, flavonoids and saponins. These phytoconstituents suggest that *D. strictus* possesses promising nutraceutical, pharmacological and antioxidant potential. The study therefore emphasizes the importance of further research on its bioactive compounds, antioxidant mechanisms, antimicrobial properties and traditional uses. Sustainable harvesting, propagation and conservation of *D. strictus* should also be encouraged to ensure its long-term ecological and socioeconomic value.

Conflict of Interest

Authors declare that there is no conflict of interest.

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