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Original Article

Ethnobotanical Insights: Phytochemical Richness, Nutritional Potential, and Bioactivity Evaluation of *Bambusa arundinacea* and *Bambusa nutans*

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Abstract

Bamboo species are widely utilized in traditional medicine, yet their pharmacological and nutritional potential remains insufficiently explored. This study specifically investigates the ethnobotanical uses, phytochemical composition, nutritional profile, and bioactivities of *Bambusa arundinacea* and *Bambusa nutans* from Odisha, India. Ethnobotanical surveys using structured interviews confirmed their application in treating gastrointestinal disorders, wound healing, and infectious diseases. Phytochemical screening revealed the presence of phenolics, flavonoids, tannins, alkaloids, and saponins, with *B. arundinacea* exhibiting comparatively higher phenolic and flavonoid contents. Nutritional analysis demonstrated appreciable levels of protein, crude fiber, carbohydrates, and essential minerals, highlighting their nutraceutical value. Bioactivity assays showed strong antioxidant activity (DPPH), significant antibacterial effects against *Salmonella typhi*, and pronounced anthelmintic activity, with *B. arundinacea* producing shorter paralysis and death times than *B. nutans*. The Brine Shrimp Lethality Assay further indicated notable cytotoxicity, suggesting the presence of pharmacologically active compounds. Overall, *B. arundinacea* displayed comparatively superior bioactivity and phytochemical richness, supporting traditional medicinal claims and establishing both species as promising sources of antioxidant, antimicrobial, and antiparasitic agents, thereby warranting further isolation and characterization of active constituents.

Keywords: *Anthelmintic Antioxidant; Bambusa arundinacea; Bambusa nutans; Brine Shrimp Lethality Assa; Ethnobotany; Nutraceuticals; Phytochemicals*

Introduction

Bamboo, a fast-growing perennial grass of the family Poaceae, plays a vital role in traditional medicine, nutrition, and rural livelihoods across Asia (Nazreen, 2022). In India, particularly in Odisha, bamboo species are valued not only for their structural and economic uses but also for their ethnomedicinal applications (Benjamin *et al.,* 2023). Communities traditionally use shoots, leaves, stems, and roots to treat gastrointestinal ailments, wounds, bone fractures, skin infections, and inflammatory disorders (Nazreen, 2022; Zubair *et al.,* 2013). Among these, *B. arundinacea* and *B. nutans* are widely utilized; however, their therapeutic properties remain largely anecdotal, with limited systematic scientific validation (Benjamin *et al.,* 2023; Giri Singh, 2013). The pharmacological potential of bamboo is linked to its diverse phytochemical constituents, such as phenolics, flavonoids, tannins, alkaloids, and saponins, which are associated with antioxidant, antimicrobial, and antiparasitic activities (Goswami *et al.,* 2024). Quantitative phytochemical assessments and bioactivity assays are essential for substantiating these traditional claims and identifying compounds of pharmaceutical or nutraceutical interest. Nutritionally, bamboo shoots are low in fat and calories while

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rich in dietary fiber, protein, and essential minerals, including potassium, calcium, and phosphorus, making them promising functional food ingredients (Kumar *et al*, 2017). Additionally, bioassays such as the DPPH assay for antioxidant activity, the Brine Shrimp Lethality Assay (BSLA) for cytotoxicity, antibacterial screening, and anthelmintic evaluation offer a comprehensive understanding of therapeutic potential (Ullah *et al.,* 2013). Although some studies have explored bamboo phytochemistry and individual bioactivities, integrated research encompassing ethnobotany, nutritional composition, phytochemical quantification, and multiple bioactivities of *B. arundinacea* and *B. nutans* remains limited (Tanaka *et al.,* 2014).

Material and Methods

Ethnobotanical Data Collection

Ethnobotanical data were collected between 2023 and 2025 through surveys conducted in the districts of Mayurbhanj, Keonjhar, and Koraput, Odisha, India, to record the medicinal applications of bamboo species among local tribal groups, including the Santhal, Munda, Ho, Khadia, Bathudi, Kolh, Bhuiyan, Juang, Paraja, Gadaba, Kondh, and Bonda communities. Information on the traditional medicinal uses of two bamboo species was obtained through random group discussions with community members. Prior to data collection, informed oral consent was obtained from all participants, and the study was conducted in accordance with recognized ethical standards (Kumar *et al.,* 2021; Jena *et al.,* 2025).

Collection of Plant Materials

The leaves and stems of *B. arundinaceae* and *B. nutans* were gathered in September 2021 from the districts of Mayurbhanj, Keonjhar, and Koraput in Odisha (Figure 1). At the Department of Botany, School of Applied Sciences, Centurion University of Technology and Management, Bhubaneswar, Odisha, the plant and its constituents were verified and identified. The collected plant material was used for further extraction in the study after drying and storage in sealed containers. Herbarium specimens of both species are deposited in the Herbarium unit of the Ambika Prasad Research Foundation, Odisha, India, and in the Centurion University of Technology and Management, Odisha, India (Jena *et al.,* 2025).

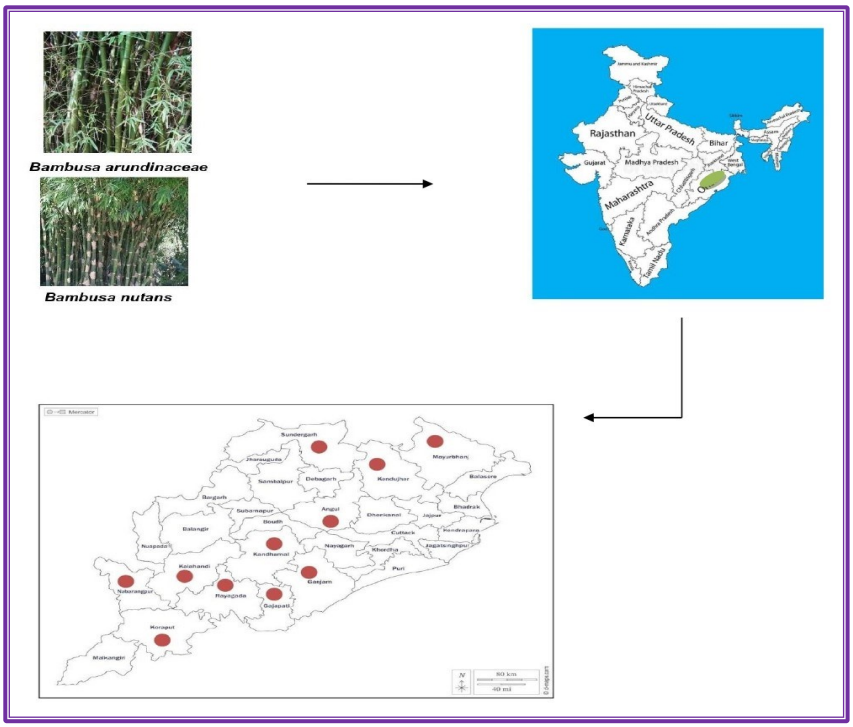

Figure 1: *Selected Bamboo Species for the Present Work and Their Collection Sites*

Bambusa arundinacea and *Bambusa nutans* are both widely distributed across the forested regions of Odisha, particularly within the Eastern Ghats and moist deciduous zones, though they differ in abundance, habitat preference, and distribution pattern. Both species are commonly reported from southern and southwestern districts such as Koraput, Rayagada, Nabarangpur, Kalahandi, Kandhamal, Gajapati, and Ganjam, and also occur in northern districts including Mayurbhanj, Keonjhar, and Sundargarh, as well as parts of Angul. However, *B. arundinacea* is more frequently associated with dense, natural forest ecosystems, especially in moist deciduous and semi-evergreen forests, where it grows in relatively undisturbed conditions and exhibits a more scattered yet ecologically dominant distribution. In contrast, *B. nutans* is comparatively more common along forest margins, valleys, and village-adjacent landscapes, reflecting its adaptability to semi-managed and accessible habitats. While both species prefer well-drained, fertile soils and humid environments up to about 1000 m elevation, *B. arundinacea* tends to show higher abundance in deeper forest zones of the Eastern Ghats, whereas *B. nutans* demonstrates a more localized but human-associated distribution. Overall, although their geographic ranges overlap significantly, they differ in ecological preference, with *B. arundinacea* being more forest-centric and *B. nutans* more adaptable to anthropogenic landscapes.

Preparation of Extracts

Plant samples collected during field surveys were thoroughly cleaned to eliminate dirt and other impurities. They were then dried at room temperature in a shaded environment to avoid direct sunlight exposure. After complete drying, the materials were pulverized into a coarse powder (Devi *et al.,* 2023; Jyotirmayee & Mahalik, 2022). For further analysis, aqueous, ethanol, and methanol extracts were obtained using the Soxhlet extraction method. The powdered samples were packed into a thimble and subjected to continuous extraction in a Soxhlet apparatus. The obtained extracts were collected, while the leftover residues were air-dried and preserved under refrigeration for subsequent experimental use (Kumar *et al.,* 2013).

Qualitative Phytochemical Analysis

Standard analytical methods were employed to examine the ethanol, methanol, and aqueous extracts of *B. arundinaceae* and *B. nutans*in order to determine the presence of major classes of secondary metabolites (Kumar *et al.*, 2012; Devi *et al.,* 2023; Jena *et al.,* 2024; Marndi*et al.,* 2024).

Test for Alkaloids

To about 1 ml of the plant extract, 3 to 4 drops of Dragendorff's reagent were added, and the mixture was heated in a water bath for a few minutes. The formation of a reddish-brown precipitate confirmed the presence of alkaloids.

Test for Flavonoids

To about 1 ml of the plant extract, 2 ml of dilute NaOH solution was added, followed by 3 to 4 drops of dilute HCl. The colour initially turned intense yellow with NaOH solution and later became colourless upon the addition of dilute HCl. This colour change confirmed the presence of flavonoids.

Test for Tannins

To about 1 ml of the plant extract, 3-5 drops of 10% lead acetate solution were added, and the formation of a white gelatinous precipitate confirmed the presence of tannin.

Test for Phenolic Compounds

To about 1 ml of the plant extract, 5 drops of 1% ferric chloride solution were added. The bluish-black colour confirmed the presence of phenolic compounds.

Test for Saponin

To about 1 ml of the plant extract, 1 ml of distilled water was added, and the mixture was shaken vigorously. The formation of persistent froth confirmed the presence of saponin.

Test for Terpenoids

To about 1 ml of the plant extract, 6 drops of chloroform were added, and the mixture was heated in a water bath for a few minutes. Then, 6 drops of concentrated H_2SO_4 were added. The formation of a reddish-brown interface confirmed the presence of terpenoids.

Quantitative Phytochemical Analysis

Established spectrophotometric and gravimetric techniques were used to quantitatively determine the main phytochemicals, including total phenolics, flavonoids, tannins, alkaloids, glycosides, and saponins. To ensure the reliability and reproducibility of the findings, each analysis was performed in triplicate. The total phenolic content (TPC) was determined using the Folin-Ciocalteu reagent method, with gallic acid as the standard. The results were expressed in milligrams of gallic acid equivalents (mg GAE) per gram of plant extract (Rana *et al.,* 2019; Zhang *et al.,* 2024) employed the aluminium chloride colourimetric method to measure total flavonoid content (TFC) using quercetin as the reference. Shirazi *et al.* (2014) defined the results as milligrams of quercetin equivalents (mg QE) per gram of extract. Using the Folin-Denis method, the tannin content was estimated. Tannin concentrations were determined and expressed as milligrams of tannic acid equivalents (mg TAE) per gram of extract as per Sadasivam and Manickam (2009) by employing Harborne's gravimetric method to ascertain the alkaloid content. Senguttuvan *et al.* (2014) quantified and reported the total alkaloid content as a percentage of the crude extract. The results were expressed as saponin content per gram of extract, and saponins were quantified using a standard gravimetric method (Obadoni & Ochuko, 2001).

Qualitative Nutrients Analysis

The qualitative nutritional composition of ethanol, methanol, and aqueous extracts of *Bambusa arundinacea* and *Bambusa nutans* was determined following standard biochemical assays for major nutrients.

Carbohydrates were detected using Molisch's test and Benedict's test as described by Trease and Evans (2002). In Molisch's test, 2 mL of extract was mixed with a few drops of α-naphthol solution, followed by the careful addition of concentrated sulfuric acid along the tube wall. Formation of a violet ring at the interface indicated the presence of carbohydrates. For Benedict's test, the extract was mixed with Benedict's reagent and heated in a boiling water bath; the appearance of a brick-red precipitate indicated the presence of reducing sugars.

Proteins were qualitatively tested using the Biuret test (Harborne, 1998). Two millilitres of extract were treated with 1 mL of 10% sodium hydroxide solution, followed by a few drops of 0.5% copper sulfate. The violet colouration confirmed the presence of proteins.

Fats/Lipids were determined by the Sudan III test. Two milliliters of extract were mixed with a few drops of Sudan III solution; the development of a red-stained oil layer confirmed lipid presence (Khouri *et al.*, 1989).

Crude Fibers were assessed using the method of Pearson (1976), involving digestion of the extract with dilute acid and alkali, followed by filtration. Retained fibrous residue indicated fiber content.

Vitamin Cwas detected using the 2,6-dichlorophenolindophenol (DCPIP) dye test as described by Ranganna (1986). Extracts were titrated with standard DCPIP solution; disappearance of the pink colour indicated vitamin C.

Quantitative Nutrients Analysis

Total Carbohydrates Estimation

For carbohydrate estimation, 0.1 mL of sample (from 10 mg/mL stock, diluted to standard range) was mixed with 0.5 mL of 5 % phenol, followed by rapid addition of 2.5 mL concentrated H_2SO_4 in an ice bath. After vortexing for 10 s, the mixture was incubated for 20 min at room temperature and 30 min

at 30 °C. Absorbance was measured at 490 nm, and carbohydrate content was calculated from a glucose standard curve as mg glucose equivalents per g of extract (Dubois *et al.,* 1956).

Total Protein Estimation

Protein content was determined by pipetting 0.1 mL of the sample into test tubes, adding 5 mL of alkaline copper reagent, and incubating for 10 min at room temperature. Subsequently, 0.5 mL of Folin–Ciocalteu reagent was added, and the mixture was incubated for 30 min. Absorbance was recorded at 750 nm, and protein content was calculated from a bovine serum albumin (BSA) standard curve, expressed as mg BSA equivalents per g extract (Lowry *et al.,* 1951).

Total Lipid Estimation

Lipid content was estimated by extracting 1 g of sample with chloroform–methanol (2:1, v/v) using the Soxhlet method. The solvent was evaporated to dryness, and the lipid residue was weighed. Results were expressed as mg lipid per g extract (Bligh & Dyer, 1959).

Total Crude Fiber Estimation

Crude fiber was estimated by boiling 1 g of the sample in 200 mL of 1.25 % H_2SO_4 for 30 min, filtering, and washing with distilled water. The residue was then boiled in 200 mL of 1.25 % NaOH for 30 min, filtered, washed, dried at 105°C, weighed, ashed at 550°C, and reweighed. Fiber content was expressed as % dry weight (Pearson, 1976).

Total Vitamin C Estimation

Vitamin C content was determined by titrating the sample filtrate against 2,6-dichlorophenolindophenol dye until a pink endpoint was reached. The results were calculated from an L-ascorbic acid standard curve and expressed as mg ascorbic acid per g extract (Ranganna, 1986).

Hatching of Brine Shrimp (Artemia salina) Nauplii

The process of hatching brine shrimp (*Artemia salina*) nauplii involved continually aerating the eggs in a beaker containing a salty solution, which was created by dissolving 38 grammes of sea salt in 1 L of distilled water (Prakash*et al.,* 2008). The beaker was exposed to a light source for the entire day and maintained between 25 and 28°C. For the experiment, active nauplii were collected 48 hours later using a Pasteur pipette (Abdelhameed *et al.,* 2020).

Test Solution Preparation

10 mg of each crude extract was dissolved in 1 mL of dimethyl sulfoxide (DMSO) to create stock solutions. By serially diluting this stock with saline solution, various concentrations (25, 50, 75, and 100 µg/mL) were prepared. Saline solution containing 1% DMSO was used to create a control group (Bajwa *et al.,* 2020).

Lethality Assay for Brine Shrimp Larvae

10 nauplii were placed in each test tube with 1 mL of the prepared test solution. Three separate tests were conducted for each concentration. The test tubes were incubated for 24 hours at room temperature (25-28°C) under constant illumination. Following incubation, the % mortality was computed by counting the number of surviving nauplii in each well (Gagliano *et al.,* 2022).

Data Analysis

Using probit analysis, the median lethal concentration (LC_{50}) was calculated to assess the plant extracts' lethality. Plotting the extract concentration logarithm versus the *Artemia salina* nauplii mortality percentage yielded the LC_{50} value. Extracts were deemed bioactive and possibly cytotoxic if their LC_{50} values were less than 1000 µg/mL (Kimura *et al.,* 2022).

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Estimation of Antioxidant Activity

The antioxidant capacity of the plant extracts was determined using two assays: DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging and metal chelating assays, following established protocols. The DPPH assay was performed based on the methods described by Cao *et al.* (1997), Gouda *et al.* (2013), and Kumar *et al.* (2017), with results expressed as EC_{50} values, the concentration of extract needed to inhibit 50% of DPPH radicals. For the DPPH assay, 5.0 mL of the extract solution (100 µg/mL) or the standard antioxidant solution was combined with 1.0 mLof a 0.001% DPPH solution in ethanol**.** The DPPH reagent was freshly prepared for each experiment and stored in the dark at 4 ± 2°C to prevent degradation. The mixture was incubated in the dark at 30 ± 2°C **for** 20–30 minutes to allow complete interaction between the antioxidant compounds and the DPPH radicals. After incubation, the reduction in DPPH radical concentration, indicating antioxidant activity, was measured spectrophotometrically at 517 nm. A lower absorbance value corresponded to higher radical scavenging activity. Each sample was analysed in triplicate to ensure precision and reliability of the results (Choi *et al.,* 2022).

Anthelmintic Activity

The anthelmintic activity of ethanol, methanol, and aqueous extracts of *B. arundinacea* and *B. nutans* was evaluated using adult earthworms (*Eisenia fetida*, 7-10 cm). Shade-dried plant material was powdered and extracted separately with ethanol, methanol, and water. The dried extracts were dissolved in 1% DMSO (ethanol and methanol extracts) to prepare three concentrations (10, 20, and 30 mg/mL). Earthworms were divided into test groups for each plant-extract-concentration combination, along with a positive control (Albendazole 10 mg/mL). Each worm was placed individually in a Petri dish containing 10 mL of the respective solution. The time of paralysis (TP)and time of death (TD) were recorded in minutes. Paralysis was noted as the absence of movement except on vigorous shaking, and death was confirmed when worms showed no response to stimulation and became flaccid in warm water (~50°C). All experiments were performed in triplicate, and results were expressed as Mean ± SE. Statistical analysis was carried out using one-way ANOVA followed by LSD post hoc test at $p< 0.05$ (Ajaiyeoba *et al.,* 2001).

IC_{50} Calculation

Adult *E. Fetida* earthworms were used to test the plant extract's anthelmintic properties. The extract was evaluated at several concentrations (e.g., 1.0, 2.0, and 3.0 mg/mL). Following a predetermined exposure period, the % mortality at each concentration was determined (Ajaiyeoba *et al.,* 2001). Using the following formula, two concentrations directly above and below the 50% effect level were linearly interpolated to calculate the IC_{50} value (the concentration causing 50% death):

$$IC_{50} = C_1 + \frac{(50 - E_1) \times (C_2 - C_1)}{E_2 - E_1}$$

C_1 = Lower concentration (just below 50% effect)
C_2 = Higher concentration (just above 50% effect)
E_1 = % Effect (e.g., mortality) at C_1
E_2 = % Effect at C_2

Antibacterial Activity

Bacterial strains of *Salmonella typhi* (MTCC-1252) and *Streptococcus mutans* (MTCC-497) were procured from the Microbial Type Culture Collection and Gene Bank, Institute of Microbial Technology, Chandigarh. Test samples were prepared by dissolving plant extracts in DMSO, methanol, or distilled water to obtain concentrations of 50, 100, and 200 µg/mL. Essential materials included agar powder, Petri plates, sterile distilled water, an autoclave, stirring rods, an alcohol lamp, micropipettes, sterile agar spreaders, sterile inoculating loops, and nutrient broth. For media preparation, agar powder was weighed and mixed with sterile distilled water at a ratio of 1.5–2.5%

(w/v). The mixture was stirred until fully dissolved and sterilised in an autoclave at 121°C for 15–20 minutes. After sterilisation, the molten agar was cooled to a temperature that prevented premature solidification and poured into sterile Petri plates to form an even layer. Once solidified at room temperature, the plates were inoculated with *S. typhi & S. mutans* using sterile inoculating loops. Wells were bored into the agar using a sterile cork borer, and 1 mL of plant extracts or the standard antibiotic (ampicillin) at concentrations of 25, 50, and 100 µg/mL was added to each well. Plates were incubated, and the zones of inhibition were measured in millimetres. The size of the inhibition zone reflected the antibacterial efficacy of the test sample, with larger zones indicating higher susceptibility (Mansour-Ghanaei *et al.,* 2022).

Results

Ethnobotanical Survey

An extensive survey was conducted across selected districts of Odisha to document traditional knowledge regarding the utilization of *Bambusa nutans* and *Bambusa arundinacea*. The data presented in Table 1 are based on firsthand information collected through personal field visits and direct interviews with local villagers, tribal elders, traditional healers (Vaidyas), and artisans.

Table 1: *Ethnobotanical Uses of B. Arundinaceaand B. Nutans*

Parameter	***B. nutans***	***B. arundinacea***
Local Names	Muli, Katua bans	Kantia bans, Thorny bamboo
Distribution in Odisha	Mayurbhanj, Keonjhar, Koraput, Kandhamal	Kalahandi, Bargarh, Ganjam, Angul, Sundargarh
Parts Used	Young shoots, leaves, roots, culms	Young shoots, leaves, roots, culms, tabasheer
Culinary Uses	Boil young shoots as a vegetable; ferment shoots in chutney	Pickled or fermented shoots; curry preparation
Medicinal Uses	Leaf decoction for cough, cold, fever; root paste for joint pain	Tabasheer for asthma, urinary disorders; leaf decoction for digestive ailments
Cultural Uses	Used in festivals, sacred grove fencing, and ritual items	Boundary fencing, windbreaks, and sacred site demarcation
Handicrafts & Construction	Baskets, mats, fishing traps, and agricultural tools	Scaffolding, bridges, heavy-duty construction, fencing
Harvest Season for Shoots	June–August (monsoon)	June–August (monsoon)
Notable Features	Straight culms, smooth surface, flexible	Thorny culms, high tensile strength

During the survey, *B. nutans* was locally known as MuliandKatua bans, while B. arundinacea was commonly referred to as Kantia bans or Thorny bamboo**.** The geographical distribution of *B. nutans* was mainly concentrated in Mayurbhanj, Keonjhar, Koraput, and Kandhamal districts, whereas *B. arundinacea* was predominantly reported from Kalahandi, Bargarh, Ganjam, Angul, and Sundargarh districts. Both bamboo species were found to be multipurpose. In *B. nutans*, the young shoots, leaves, roots, and culms were commonly utilized, while in *B. arundinacea*, tabasheer (a siliceous concretion obtained from the culms) was additionally valued. Culinary practices revealed that the shoots of *B. nutans* were usually boiled and consumed as vegetables or fermented to make chutneys, whereas those of *B. Arundinacea* were mainly pickled or cooked into curries. Medicinal applications constituted an important component of traditional knowledge. A decoction prepared from the leaves of *B. nutans* was used for treating cough, cold, and fever, while the root paste was applied for relief from joint pain. In the case of *B. arundinacea*, tabasheer was reported to be used for the treatment of asthma and urinary disorders, and leaf decoctions were used for managing digestive ailments. Cultural associations were also evident. *B. nutans* was frequently used for festival decorations, ritual items, and fencing of sacred groves. In contrast, *B. arundinacea* was primarily utilized for boundary fencing, windbreaks, and demarcation of sacred sites. Economically, *B. nutans* supported the production of handicrafts such as baskets, mats, fishing traps, and agricultural implements, whereas *B.*

arundinacea was preferred for construction purposes, including scaffolding, bridges, and heavy-duty fencing due to its high tensile strength and thorny culms.

Both species were mainly harvested for edible shoots during the monsoon season (June–August). Morphologically, *B. nutans* was characterised by straight, smooth, and flexible culms, while *B. arundinacea* was distinguished by its thorny culms and superior mechanical strength.

Qualitative Phytochemical Analysis

The qualitative phytochemical screening of *Bambusa arundinacea* and *Bambusa nutans* confirmed the presence of alkaloids, flavonoids, phenols, tannins, saponins, and terpenoids in aqueous, ethanol, and methanol extracts (Table 2), with variation in their relative abundance. In *B. arundinacea*, methanol extracts showed high (+++) levels of alkaloids and phenols, while ethanol extracts were rich (+++) in flavonoids and terpenoids; aqueous extracts exhibited mostly moderate (+/++) phytochemical presence, with comparatively higher saponins (++). A similar trend was observed in *B. nutans*: methanol extracts were rich (+++) in flavonoids and phenols; ethanol extracts contained higher levels of terpenoids; and aqueous extracts showed moderate (+/++) levels of most constituents, with relatively abundant saponins (++).

Table 2: *Qualitative Phytochemical Analysis of Aqueous, Ethanol, And Methanol Extracts of B. Arundinacea and B. Nutans*

Qualitative Screening of phytochemicals	***B. arundinacea Ethanol***	***B. arundinacea Methanol***	***B. arundinacea Aqueous***	***B. nutans Ethanol***	***B. nutans Methanol***	***B. nutans Aqueous***
Alkaloid	++	+++	++	+++	++	+
Flavonoid	+++	++	++	++	+++	++
Phenolic Compound	++	+++	++	+++	++	++
Tannin	++	++	+	++	++	+
Saponin	+	+	++	+	+	++
Terpenoid	+++	++	+	++	++	+

Quantitative Phytochemical Analysis

This study confirmed the presence and relative abundance of major bioactive compounds in both *Bambusa arundinacea* and *Bambusa nutans* across aqueous, ethanol, and methanol extracts (Table 3; Figure 2).

Table 3: *Quantitative Phytochemical Estimation of Aqueous, Ethanol, And Methanol Extracts of B. Arundinacea & B. Nutans*

Qualitative Screening of phytochemicals	***B. arundinacea* Ethanol (mg/g ± 3SD)**	***B. arundinacea* Methanol (mg/g ± SD)**	***B. arundinacea* Aqueous (mg/g ± SD)**	***B. nutans Ethanol* (mg/g ± SD)**	***B. nutans* Methanol (mg/g ± SD)**	***B. nutans* Aqueous (mg/g ± SD)**
Alkaloid	12.42 ± 0.36	14.88 ± 0.41	10.55 ± 0.29	13.65 ± 0.33	15.10 ± 0.38	11.02 ± 0.27
Flavonoid	42.35 ± 0.85	48.62 ± 0.73	31.15 ± 0.54	45.78 ± 0.69	50.11 ± 0.81	33.05 ± 0.57
Phenolic Compound	28.74 ± 0.64	31.55 ± 0.59	21.10 ± 0.48	30.66 ± 0.53	34.12 ± 0.67	22.88 ± 0.42
Tannin	14.15 ± 0.41	16.20 ± 0.39	10.55 ± 0.25	15.09 ± 0.37	17.55 ± 0.41	11.22 ± 0.28
Saponin	8.45 ± 0.23	7.88 ± 0.21	9.56 ± 0.27	8.12 ± 0.22	7.65 ± 0.19	9.02 ± 0.25
Terpenoid	5.62 ± 0.15	4.95 ± 0.12	3.11 ± 0.08	5.18 ± 0.14	4.72 ± 0.11	2.98 ± 0.09

The concentrations of phytochemicals varied significantly with solvent type and species. Methanol extracts recorded the highest levels of phenolics, flavonoids, tannins, and alkaloids in both species. In *B. nutans*, methanol extract showed the maximum phenolic content (50.11 ± 0.81 mg/g) and flavonoid content (34.12 ± 0.67 mg/g), marginally higher than those in *B. arundinacea*. Alkaloid content was also highest in methanol extracts, with *B. nutans* (15.10 ± 0.38 mg/g) slightly exceeding *B. arundinacea* (14.88 ± 0.41 mg/g). Ethanol extracts were comparatively more efficient in extracting terpenoids, with *B. arundinacea* registering the highest terpenoid content (5.62 ± 0.15 mg/g). In contrast, saponins were predominantly extracted with aqueous solvents, with higher values observed

in *B. arundinacea* (9.56 ± 0.27 mg/g) and *B. nutans* (9.02 ± 0.25 mg/g). Overall, *B. nutans* exhibited comparatively higher phenolic and flavonoid contents, whereas *B. arundinacea* showed greater terpenoid and saponin concentrations.

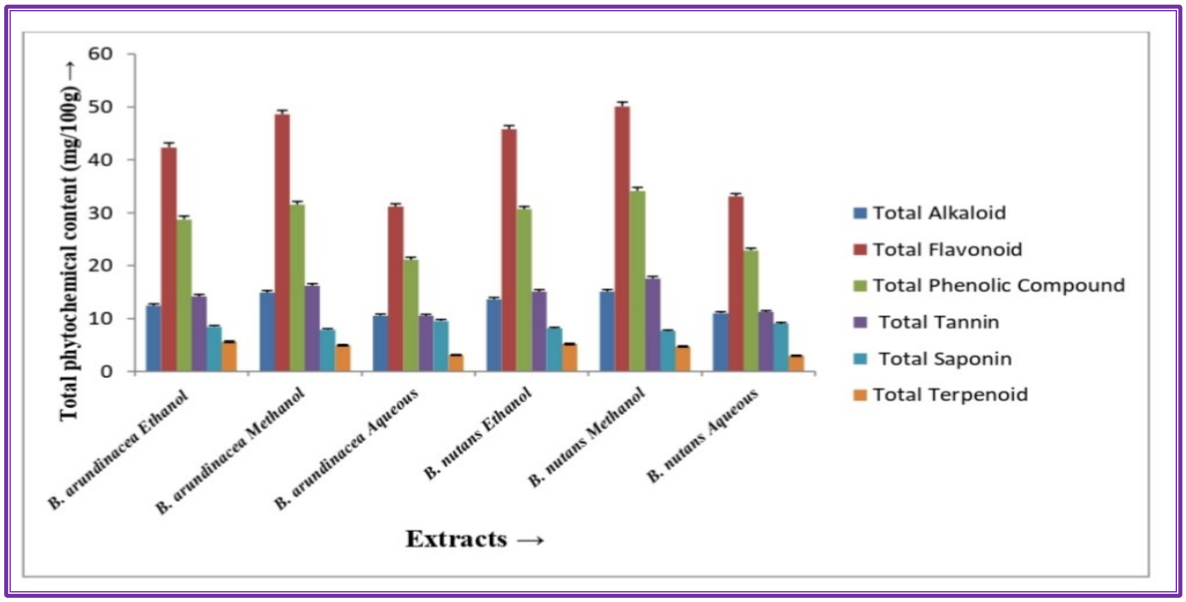

***Figure 2**: Quantitative Phytochemical Analysis of Ethanol, Methanol & Aqueous Extracts of B. Arundinacea and B. Nutans*

Qualitative Nutrients Analysis

The qualitative nutritional analysis (Table 4) indicated that both *Bambusa arundinacea* and *B. nutans* contain a wide range of essential nutrients across all three solvent extracts (aqueous, ethanol, and methanol). Carbohydrates were highly present (+++) in the aqueous extracts of both species, while ethanol and methanol extracts showed moderate presence (++). Protein content remained consistently moderate (++) in all extracts, irrespective of solvent type. Fats/lipids were detected at low levels (+) in aqueous and ethanol extracts but showed a moderate presence (++) in methanolic extracts. Crude fiber was moderately present (++) in aqueous and ethanol extracts, whereas methanol extracts exhibited lower levels (+). Vitamin C was observed at low to moderate levels, with aqueous extracts showing a comparatively higher presence (++). Overall, the nutrient profile varied with extraction solvent, with aqueous extracts generally yielding higher carbohydrate, crude fiber, and vitamin C content.

***Table 4:** Qualitative Nutrient Analysis of Aqueous, Ethanol, and Methanol Extracts of B. Arundinacea & B. Nutans*

Nutrient Parameter	***B. arundinacea* Ethanol**	***B. arundinacea* Methanol**	***B. arundinacea* Aqueous**	***B. nutans* Ethanol**	***B. nutans* Methanol**	***B. nutans* Aqueous**
Carbohydrates	++	++	+++	++	++	+++
Proteins	++	++	++	++	++	++
Lipids	+	++	+	+	++	+
Crude fibers	++	+	++	++	+	++
Vitamin C	+	+	+	+	+	++

Quantitative Nutrients Analysis

The quantitative nutrient analysis showed that *Bambusa arundinacea* and *B. nutans* contained considerable amounts of carbohydrates, proteins, lipids, fiber, and vitamin C in all three solvent extracts (Table 5; Figure 3). Nutrient levels varied significantly with the extraction solvent, with ethanol extracts consistently yielding the highest concentrations, followed by methanol and aqueous extracts.

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Carbohydrate content was maximum in ethanol extracts (25.6 mg g^{-1} in *B. arundinacea* and 24.1 mg g^{-1} in *B. nutans*), and similar solvent-dependent trends were observed for protein, lipid, and fiber contents. Despite being water-soluble, vitamin C was also higher in ethanol extracts. Overall, *B. arundinacea* showed slightly higher nutritional values than *B. nutans*, and LSD analysis confirmed that most differences among solvents and species were statistically significant ($p < 0.05$).

Table 5: *Quantitative Nutrient Evaluation (Mean ± SD) of Ethanol, Methanol, and Aqueous Extracts of Bambusa arundinacea and Bambusa nutans with LSD Grouping*

Nutrient Parameter	***B. arundinacea*** Ethanol	***B. arundinacea*** Methanol	***B. arundinacea*** Aqueous	***B. nutans*** Ethanol	***B. nutans*** Methanol	***B. nutans*** Aqueous
Carbohydrates	25.6 ± 0.45 a	22.4 ± 0.38 b	18.9 ± 0.31 c	24.1 ± 0.41 a	21.8 ± 0.36 b	18.5 ± 0.29 c
Proteins	6.42 ± 0.15 a	5.93 ± 0.12 ab	5.31 ± 0.10b	6.11 ± 0.14 a	5.82 ± 0.11 ab	5.27 ± 0.09 b
Lipids	2.31 ± 0.07 a	2.21 ± 0.06 ab	2.05 ± 0.05 b	2.28 ± 0.07 a	2.18 ± 0.06 ab	2.03 ± 0.05 b
Crude fibers	12.8 ± 0.24 a	11.9 ± 0.22 ab	11.1 ± 0.20 b	12.5 ± 0.23 a	11.8 ± 0.21 ab	11.0 ± 0.19 b
Vitamin C	12.8 ± 0.24 a	14.6 ± 0.29 ab	13.9 ± 0.27 b	15.1± 0.30 a	14.5 ± 0.28 ab	13.8 ± 0.26 b

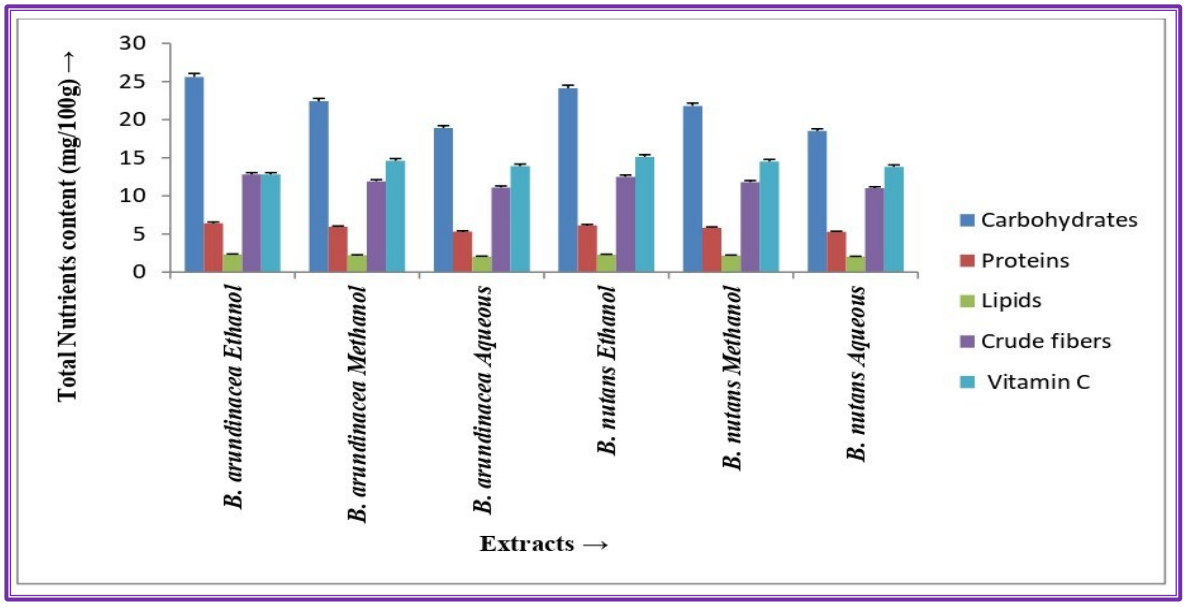


Figure 3*: Quantitative Nutrient Analysis of Ethanol, Methanol & Aqueous Extracts of B. arundinacea and B. nutans*

Brine Shrimp (Larvae) Lethality Assay (BSLA)

The brine shrimp lethality assay (BSLA) was employed to assess the cytotoxic activity of ethanolic, methanolic, and aqueous extracts of *Bambusa arundinacea* and *Bambusa nutans* at concentrations ranging from 25 to 100 µg/mL. The mortality of brine shrimp larvae increased progressively with increasing extract concentration, indicating a clear dose-dependent response (Table 6; Figure 4). Among the tested solvents, ethanolic extracts exhibited the highest cytotoxicity, with LC_{50} values of 72.0 µg/mL for *B. arundinacea* and 70.8 µg/mL for *B. nutans*. Methanolic extracts showed moderate toxicity, recording LC_{50} values of 75.2 µg/mL and 73.6 µg/mL, respectively. In contrast, aqueous extracts showed lower cytotoxicity, with LC_{50} values of 87.5 µg/mL (*B. arundinacea*) and 85.5 µg/mL (*B. nutans*). Overall, *B. nutans* extracts showed slightly greater cytotoxic potential than *B. arundinacea* across all solvent systems.

Table 6: *Result of Toxicity Assessment of Ethanol, Methanol & Aqueous Extracts of B. arundinacea and B. nutans LSD Grouping*

Plant Species	Extract Type	Concentration (µg/mL)	% Mortality ± SE	LC_{50} (µg/mL)	LSD Grouping
B. arundinacea	Ethanol	25	21± 1	72.0	A
		50	39 ± 2		A
		75	56 ± 2		A
		100	72 ± 2		A
	Methanol	25	19 ± 1	75.2	B
		50	37 ± 1		B
		75	53 ± 2		B
		100	70 ± 2		B
	Aqueous	25	12 ± 1	87.5	C
		50	29 ± 1		C
		75	45 ± 2		C
		100	60 ± 2		C
B. nutans	Ethanol	25	22 ± 1	70.8	A
		50	40 ± 2		A
		75	58 ± 2		A
		100	75 ± 2		A
	Methanol	25	20 ± 1	73.6	B
		50	38 ± 1		B
		75	55 ± 2		B
		100	71 ± 2		B
	Aqueous	25	14 ± 1	85.5	C
		50	30 ± 1		C
		75	47 ± 2		C
		100	63 ± 2		C
Control (1% DMSO in saline solution)	-	0%	0%		

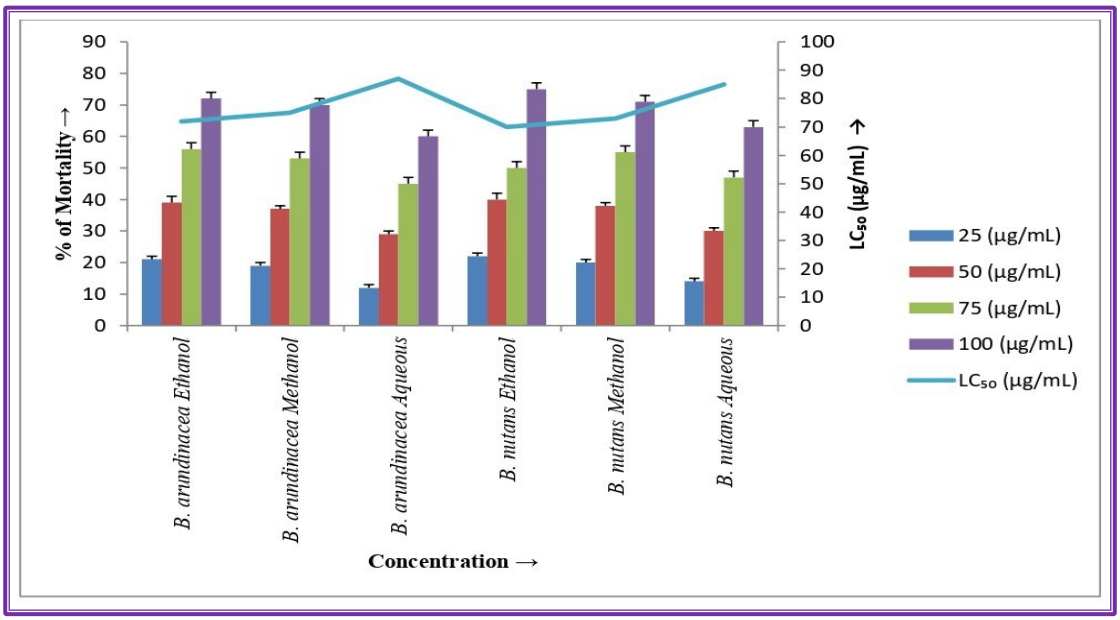


Figure 4*: Mortality response of Artemia salina nauplii on Ethanol, Methanol, and Aqueous Extracts of B. arundinacea and B. nutans*

Antioxidant Activity Assay

The antioxidant activity of *B. arundinacea* and *B. nutans* was assessed using the DPPH free radical scavenging assay. All extracts (ethanolic, methanolic, and aqueous) exhibited a concentration-dependent increase in antioxidant activity over the tested range of 0.1–1.0 mg/mL (Table 7; Figure 5).

Among the solvents, ethanolic extracts showed the highest radical scavenging activity, followed by methanolic and aqueous extracts. At a1.0 mg/mL concentration, the ethanolic extract of *B. arundinacea*recorded the highest inhibition (82.45%), closely followed by *B. nutans* (80.27%). Methanolic extracts exhibited moderate activity, while aqueous extracts showed comparatively lower scavenging potential. The standard antioxidant, vitamin C, exhibited the maximum scavenging activity (88.63%) at the same concentration. The EC_{50} values further confirmed this trend. Vitamin C showed the lowest EC_{50} value (9.84 µg/mL), indicating the highest antioxidant potency. Among the plant extracts, ethanolic extracts showed lower EC_{50} values (14.52–15.38 µg/mL) than methanolic (18.74–20.15 µg/mL) and aqueous extracts (28.63–30.12 µg/mL), demonstrating superior antioxidant activity.

Table 7: *Antioxidant Activity (% Inhibition And EC_{50} Values) of Ethanol, Methanol, And Aqueous Extracts of B. Arundinacea and B. Nutans Compared with Vitamin C (Standard) Using DPPH Assay with LSD Grouping*

Plant species	Extract type	% of Inhibition at 0.1 (mg/ml) (Mean ± SE)	% of Inhibition at 0.5 (mg/ml) (Mean ± SE)	% of Inhibition at 1 (mg/ml) (Mean ± SE)	EC_{50} (µg/mL)	LSD grouping (EC_{50})
Vitamin C (Standard*)		46.38 ± 0.92	72.15 ± 1.16	88.63 ± 1.42	9.84	a
B. arundinacea	Ethanol	42.15 ± 0.84	67.48 ± 1.12	82.45 ± 1.21	14.52	b
	Methanol	38.26 ± 0.79	61.52 ± 1.07	78.62 ± 1.08	18.74	c
	Aqueous	25.41 ± 0.66	48.32 ± 0.94	65.81 ± 0.97	28.63	e
B. nutans	Ethanol	40.72 ± 0.81	64.25 ± 1.09	80.27 ± 1.15	15.38	B
	Methanol	36.18 ± 0.72	58.37 ± 1.03	75.14 ± 1.05	20.15	D
	Aqueous	23.85 ± 0.61	45.29 ± 0.91	62.94 ± 0.85	30.12	F

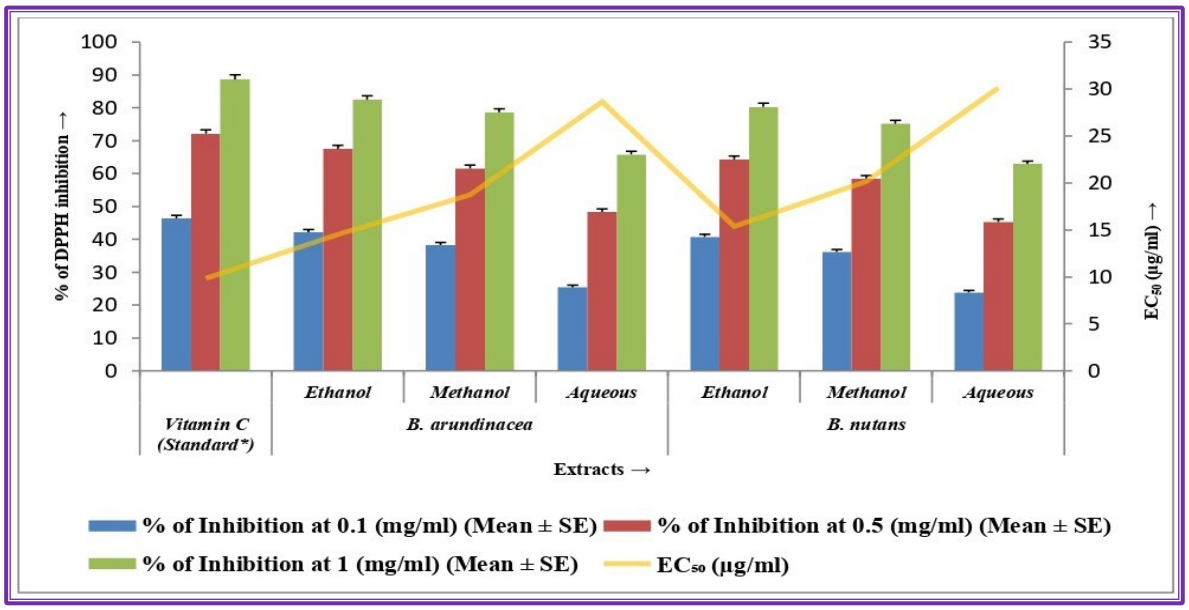


Figure 5: *Antioxidant Activity (% Inhibition and EC_{50} Values) of Ethanol, Methanol, and Aqueous Extracts of B.arundinacea and B. nutans Compared with Vitamin C (Standard) Using DPPH Assay*

Anthelmintic Activity Assay

The anthelmintic activity assay demonstrated that all tested extracts of *Bambusa arundinacea* and *B. nutans* possessed significant anthelmintic effects ($p< 0.05$). A clear dose-dependent reduction in paralysis and death times was observed with increasing extract concentrations (Table 8; Figure 6).

Among the solvents, ethanolic extracts showed the highest activity, followed by methanolic extracts, while aqueous extracts were comparatively less effective. At 30 mg/mL, the ethanolic extract of *B. nutans* exhibited the strongest activity, inducing paralysis and death at 20.3 and 41.5 minutes, respectively. This was closely followed by the ethanolic extract of *B. arundinacea*, which caused paralysis at 21.5 minutes and death at 42.7 minutes. The LC_{50} values further supported this trend, with *B. nutans* ethanolic extract showing the lowest LC_{50} (17.2 mg/mL), indicating the highest potency among the plant extracts tested. However, the standard drug Albendazole remained significantly more potent, with a lower LC_{50} value (7.5 mg/mL) and the highest statistical significance (p = 0.001).

Table 8: *AnthelminticActivity (% of Paralysis & % Of Mortality And LC_{50} Values) of Ethanol, Methanol, And Aqueous Extracts of* B. Arundinacea *and* B. Nutans *Compared with Albendazole (Standard) Using Eisiniafetida with LSD Grouping*

Plant species	Extract type	Concentration (mg/mL)	Time of Paralysis [Mean (min) ± SE]	Time of Death [Mean (min) ± SE]	LC_{50} (mg/ml)	LSD grouping	*P*-value
B. arundinacea	Ethanol	10	45.2 ± 1.1	78.5 ± 1.3	18.6	A	0.032
		20	32.8 ± 0.9	61.4 ± 1.0		B	0.021
		30	21.5 ± 0.7	42.7 ± 0.8		C	0.009
	Methanol	10	47.1 ± 1.2	81.2 ± 1.4	19.8	A	0.036
		20	34.0 ± 0.8	63.0 ± 0.9		B	0.024
		30	22.7 ± 0.6	44.2 ±0.7		C	0.011
	Aqueous	10	53.5 ± 1.4	90.1 ± 1.5	25.4	A	0.041
		20	40.8 ± 1.0	70.5 ± 1.1		B	0.028
		30	28.4 ± 0.9	52.8 ± 1.0		C	0.014
B. nutans	Ethanol	10	44.0 ± 1.0	76.2 ± 1.2	17.2	A	0.030
		20	31.5 ± 0.8	59.8 ± 1.0		B	0.018
		30	20.3 ± 0.6	41.5 ± 0.7		C	0.007
	Methanol	10	46.0 ± 1.1	79.0 ± 1.3	18.4	A	0.033
		20	33.2 ± 0.9	62.1 ± 1.0		B	0.020
		30	21.2 ± 0.7	43.0 ± 0.8		C	0.010
	Aqueous	10	51.8 ± 1.3	88.5 ± 1.4	23.7	A	0.039
		20	39.5 ± 1.0	68.9 ± 1.1		B	0.025
		30	27.0 ± 0.8	51.0 ± 0.9		C	0.012
Albendazole (Standard*)		10	12.5 ± 0.4	28.3 ± 0.5	7.5	A	0.001

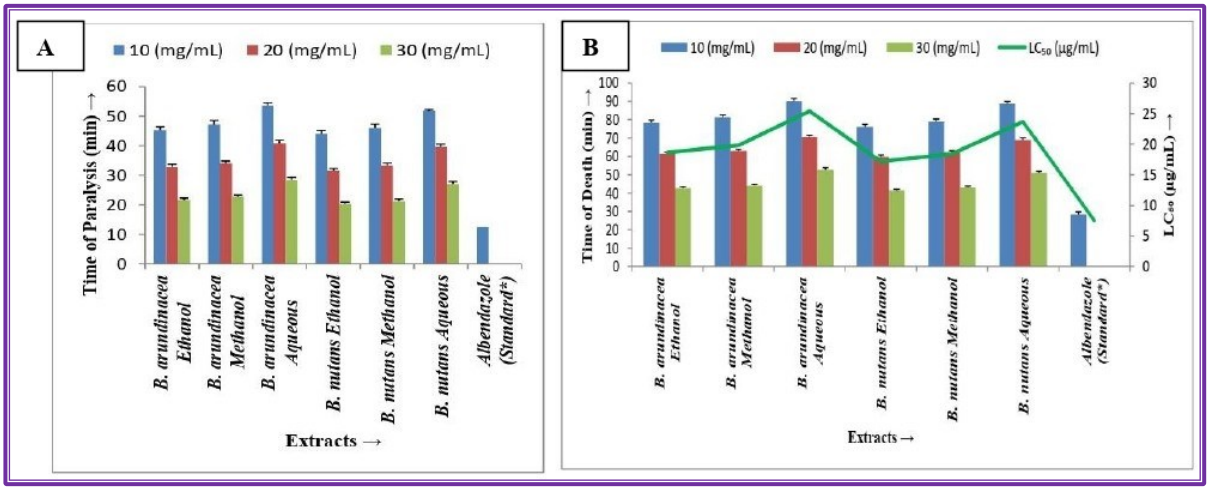
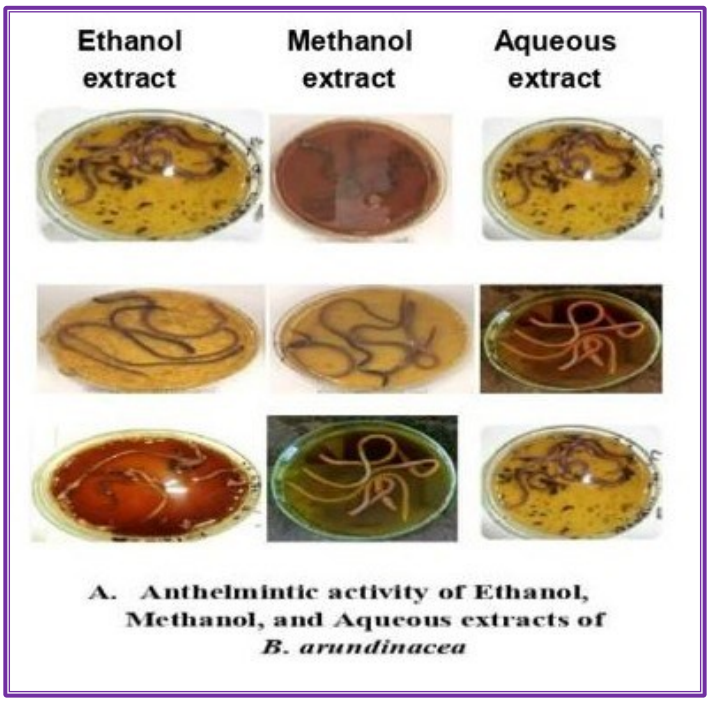
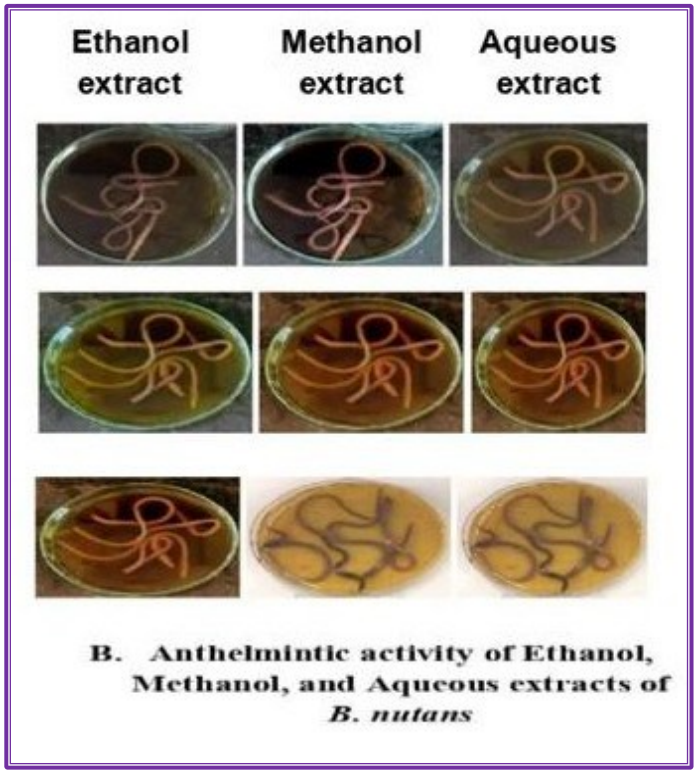


Figure 6: *Anthelmintic Activity % of Paralysis (A)& % of Mortality And LC_{50} Values (B) of Ethanol, Methanol, and Aqueous Extracts of B. arundinacea and B. nutans Compared with Albendazole (Standard)*



A. Anthelmintic activity of Ethanol, Methanol, and Aqueous extracts of *B. arundinacea*



B. Anthelmintic activity of Ethanol, Methanol, and Aqueous extracts of *B. nutans*

Figure 7: *Anthelmintic Activity of Ethanol, Methanol, and Aqueous Extracts of B. arundinacea and B. nutans (A-B)*

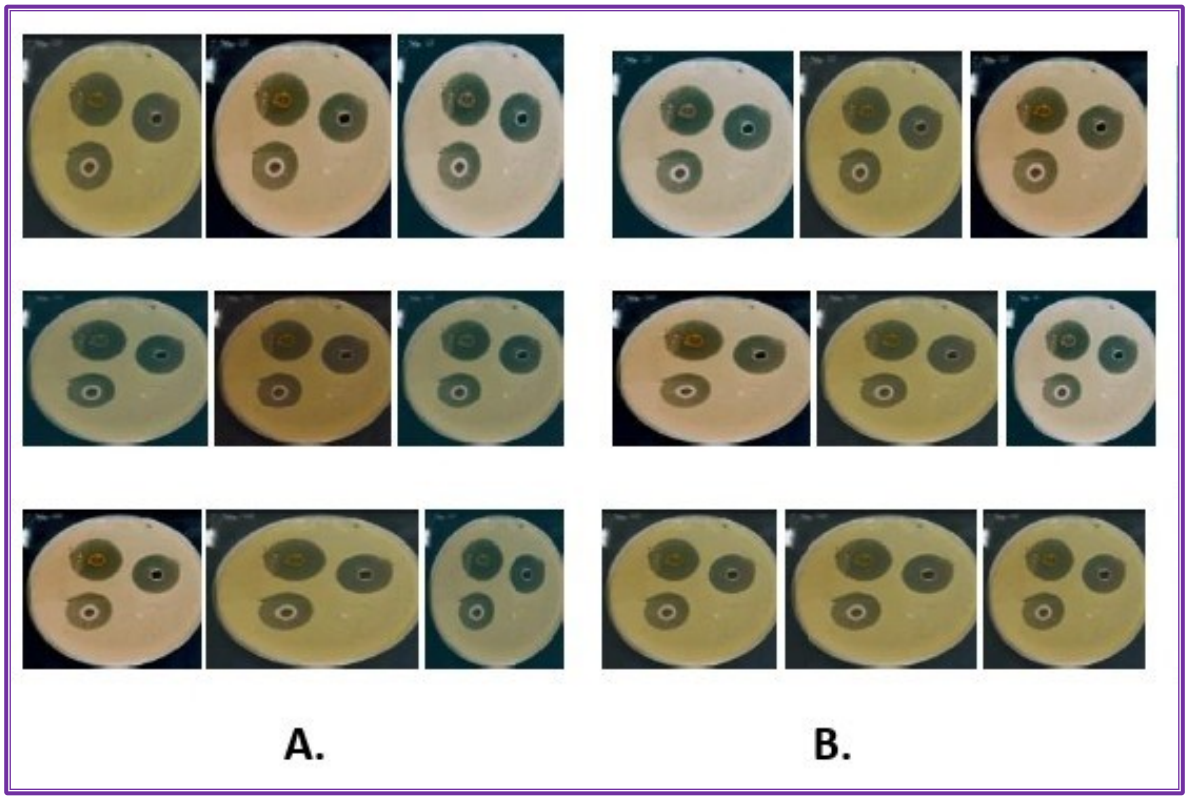
Antibacterial Activity

The antibacterial assay demonstrated that all solvent extracts (aqueous, methanolic, and ethanolic) of *Bambusa arundinacea* and *B. nutans* exhibited inhibitory activity against *Salmonella typhi* and *Streptococcus mutans*. A clear concentration-dependent response was observed, with zones of inhibition increasing from 10, 25 to 50 and 100 µg/mL (Table 9; Figure 9). Among the extracts, ethanolic extracts showed the highest antibacterial activity, followed by methanolic and aqueous

extracts. at 100 µg/mL, the ethanolic extract of *B. arundinacea* produced the maximum inhibition zones (22.4 ± 1.2 mm against *S. typhi* and 18.9 ± 0.9 mm against *S. mutans*). *B. nutans* followed a similar trend, though with comparatively lower inhibition values across all concentrations. The standard antibiotic ampicillin (10 µg/disc) recorded the largest zones of inhibition against both test organisms (26.5 ± 1.0 mm for *S. typhi* and 23.2 ± 0.9 mm for *S. mutans*), exceeding those of all plant extracts.

Table 9: *Antibacterial Activity of B. Arundinacea & B. Nutans against S. Typhi & S. Mutans Showing Zone of Inhibition with LSD Grouping*

Plant Species	Extract Type	Concentration (µg/Ml)	*S. typhi* Zone of Inhibition (Mm ± Se)	Lsd Grouping	*S. mutans* Zone of Inhibition (Mm ± Se)	Lsd Grouping
B. arundinacea	Ethanol	25	15.2 ± 0.8	a	12.5 ± 0.6	a
		50	18.7 ± 1.0	b	15.8 ± 0.7	b
		100	22.4 ± 1.2	c	18.9 ± 0.9	c
	Methanol	25	14.8 ± 0.7	a	11.9 ± 0.5	a
		50	17.5 ± 0.9	b	14.3 ± 0.6	b
		100	21.0 ± 1.1	c	17.2 ± 0.8	c
	Aqueous	25	12.3 ± 0.6	a	10.5 ± 0.5	a
		50	15.0 ± 0.8	b	13.0 ± 0.6	b
		100	18.1 ± 0.9	c	15.2 ± 0.7	c
B. nutans	Ethanol	25	14.5 ± 0.7	a	11.8 ± 0.5	a
		50	17.9 ± 0.9	b	14.7 ± 0.7	b
		100	21.6± 1.1	c	18.1 ± 0.8	c
	Methanol	25	13.9 ± 0.6	a	11.2 ± 0.5	a
		50	16.8 ± 0.9	b	14.0 ± 0.6	b
		100	20.5 ± 1.0	c	17.1± 0.8	c
	Aqueous	25	11.8 ± 0.5	a	9.8 ± 0.4	a
		50	14.5 ± 0.7	b	12.5± 0.6	b
		100	17.9 ± 0.9	c	15.0 ± 0.7	c
Positive control (Ampicillin*)		10	26.5± 1.0	d	23.2± 0.9	d



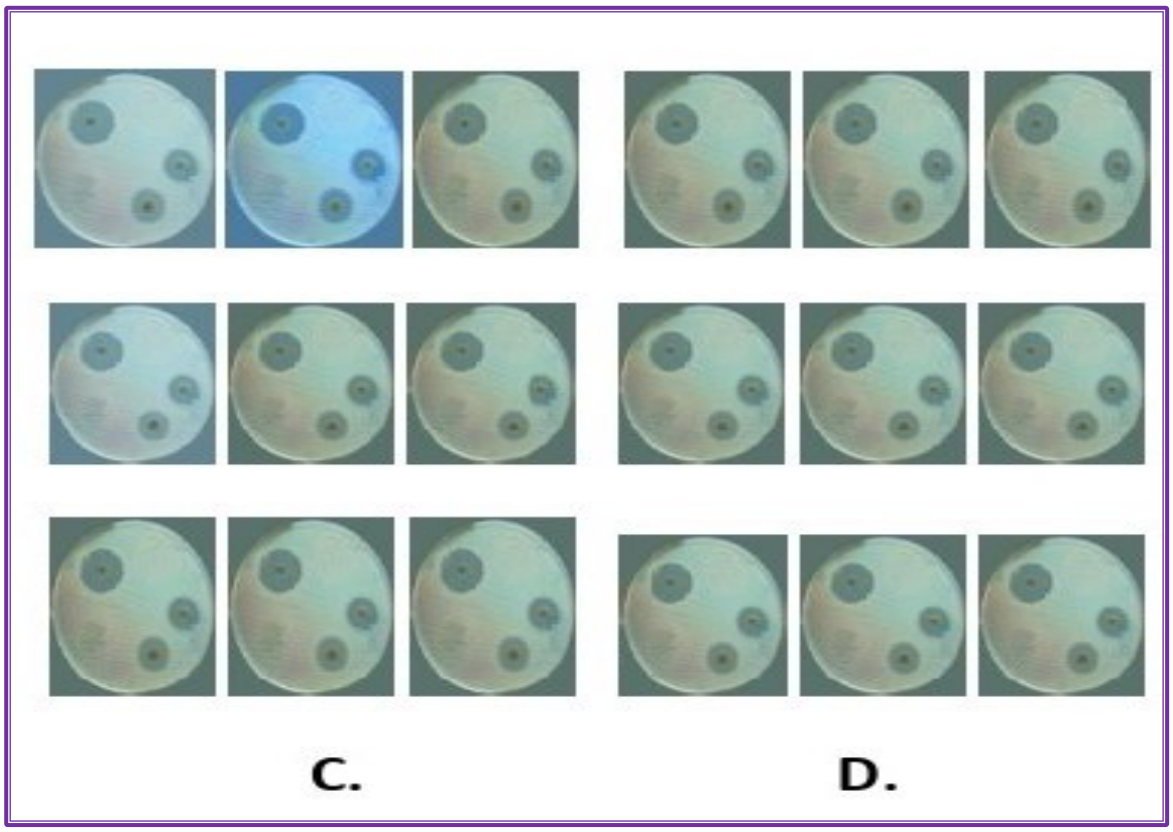
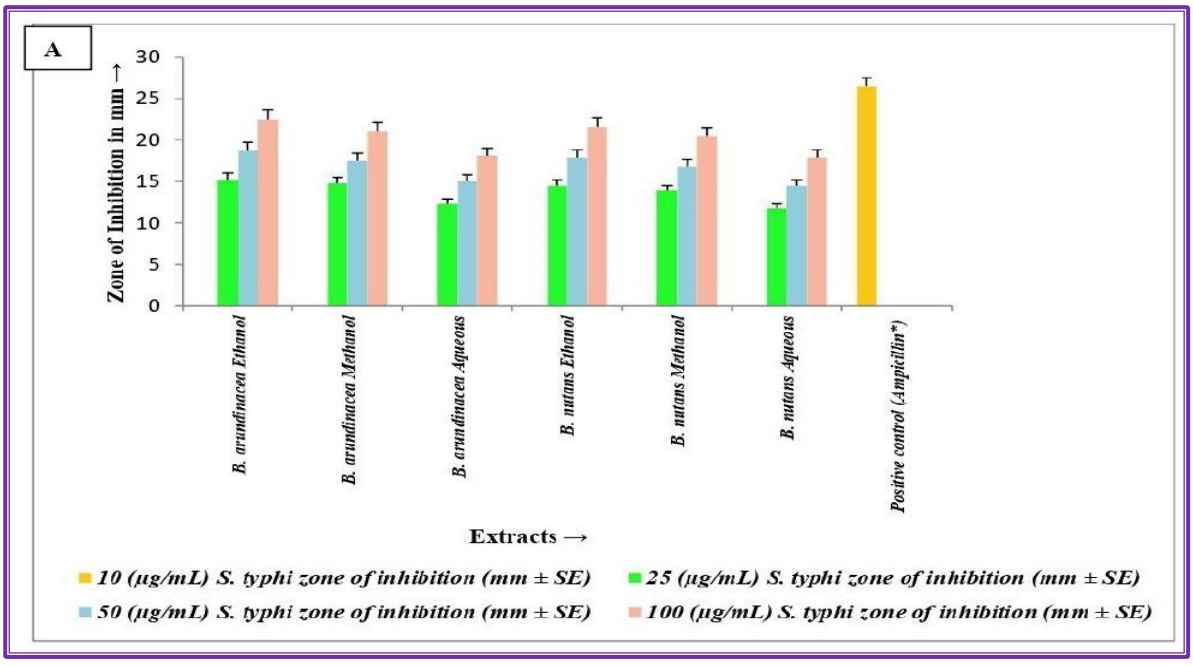


Figure 8: (A-D): *Antibacterial Activity of B. arundinacea & B. nutans against S. typhi & S. mutans showing Zone of Inhibition*



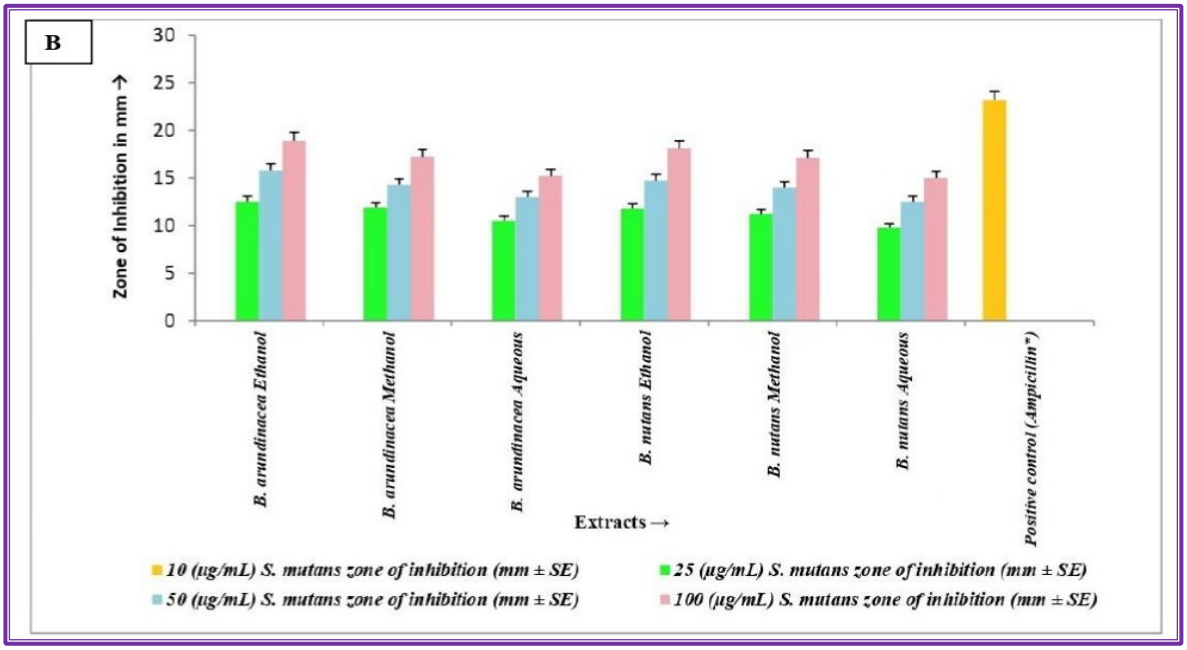


Figure 9: (A-B): *Antibacterial Activity of B. arundinacea & B. nutans against S. typhi & S. mutans showing Zone of Inhibition.*

Discussion

Ethnobotanical Survey

The findings of the present ethnobotanical survey on *B. nutans* and *B. arundinacea* largely corroborate earlier reports from Odisha. Similar culinary and medicinal uses of *B. nutans* have been documented by Benjamin *et al.* (2023), while Aisha *et al.* (2019) reported the medicinal importance of tabasheer from *B. arundinacea* in the treatment of asthma and urinary disorders, findings that align closely with the present observations. However, certain variations in utilisation patterns were also recorded. In the current survey, *B. nutans* was found to have stronger cultural and ritual significance. Notably, the preparation of fermented chutneys from *B. nutans* shoots appears to be a location-specific practice, particularly prevalent in Mayurbhanj and Keonjhar districts, and has been sparsely reported in earlier literature. Overall, comparative analysis underscores the significant ethnobotanical value of *B. nutans* and *B. arundinacea* in Odisha. While many traditional uses align with previous studies, the present field survey captures nuanced, region-specific practices that enrich the existing documentation of bamboo-based traditional knowledge and highlight its continued relevance to rural livelihoods and cultural heritage.

Qualitative Phytochemical Analysis

The qualitative phytochemical profile of *B. arundinacea* and *B. nutans* confirms that both species are rich in diverse secondary metabolites, supporting their traditional ethnobotanical use. The consistent presence of alkaloids, flavonoids, phenols, tannins, saponins, and terpenoids across solvents reflects the broad chemical diversity of bamboo. Higher levels of alkaloids and phenols in methanolic extracts indicate methanol's efficiency in extracting polar bioactive compounds, whereas ethanol effectively recovered flavonoids and terpenoids. Aqueous extracts contained comparatively lower levels of most phytochemicals, except saponins, which were more abundant due to their hydrophilic nature. Overall, variations in phytochemical abundance across solvents highlight the importance of the extraction medium, and the rich phytochemical composition of both species warrants further quantitative and bioactivity-based investigations. The present phytochemical findings are in agreement with earlier and recent studies, particularly those focused on phytochemical composition and extraction efficiency. Similar bioactive constituents such as phenols, flavonoids, tannins, and alkaloids in bamboo species

have been reported by Bishnu *et al.* (2023), who highlighted the broad pharmacological potential of bamboo. Studies by Kumar *et al.* (2021) on *Bambusa arundinacea* confirmed that methanolic extracts yield higher concentrations of phenolic compounds, supporting the present observation of solvent efficiency. Furthermore, Chitiva, *et al.* (2024) reported the presence of diverse secondary metabolites contributing to antioxidant and antimicrobial activities in bamboo species. Recent work by Azzahra *et al;* (2025) also demonstrated that solvent polarity plays a crucial role in phytochemical extraction, with methanol and ethanol being more effective than aqueous solvents. Collectively, these studies validate the present results, confirming both the rich phytochemical profile of *Bambusa arundinacea* and *Bambusa nutans* and the importance of solvent selection in phytochemical investigations.

Quantitative Phytochemical Analysis

The quantitative analysis supported the qualitative findings and demonstrated clear solvent-dependent extraction efficiency. Methanol proved most effective for extracting phenolics, flavonoids, tannins, and alkaloids, with *B. nutans* showing comparatively higher phenolic and flavonoid contents, indicating stronger antioxidant potential. Ethanol favoured terpenoid extraction, particularly in *B. arundinacea*, while aqueous extracts yielded higher saponin levels, reflecting their hydrophilic nature and traditional water-based usage. Overall, *B. nutans* appears more suitable for antioxidant applications, whereas *B. arundinacea* may be more valuable for antimicrobial or bioactive formulations, highlighting the importance of solvent choice for targeted phytochemical extraction.

Qualitative Nutrients Analysis

The observed variation in nutrient composition among different solvent extracts of *Bambusa arundinacea* and *Bambusa nutans* reflects the solvent-dependent efficiency of nutrient extraction, consistent with recent studies. Aqueous extracts exhibited the highest carbohydrate content, due to the hydrophilic nature of carbohydrates, which facilitates solubilisation in polar media. Protein content was relatively uniform across water, ethanol, and methanol extracts, similar to findings by Sebastian *et a*l;(2024), indicating that bamboo proteins are relatively stable and less influenced by solvent polarity. Methanolic extracts showed higher fat and lipid recovery, aligning with as methanol's intermediate polarity enhances solubilisation of lipid-associated compounds. Crude fiber levels were higher in aqueous and ethanol extracts, consistent with likely due to partial extraction of soluble fiber components, whereas methanol exhibited reduced affinity for fibrous material (Ponphaiboon *et al;* 2023) Slightly higher vitamin C content in aqueous extracts corroborates reports by Avilés-Betanzos *et al;* (2022), reflecting the water solubility of this vitamin. Collectively, these findings indicate that aqueous solvents are more suitable for extracting carbohydrate- and vitamin-rich fractions, while methanol is more effective for lipid-associated nutrients, underscoring the importance of solvent selection in the nutritional evaluation of bamboo species, as also highlighted in broader phytochemical studies of *Bambusa vulgaris* and *Dendrocalamus asper* (Fitri *et al.,* 2020).

Quantitative Nutrients Analysis

The variation in nutrient content among solvent extracts underscores the crucial role of solvent polarity in extraction efficiency. Ethanol proved most effective in extracting carbohydrates, proteins, lipids, fibre, and vitamin C, likely due to its ability to solubilise both hydrophilic and lipophilic compounds (Ghaffar & Perveen, 2024). Enhanced recovery of carbohydrates and fibre may result from better cell wall disruption, while higher protein and lipid contents reflect ethanol's efficiency in solubilising structural and membrane-associated components. Despite being water-soluble, vitamin C showed higher retention in ethanol extracts, possibly due to reduced oxidative degradation during extraction. Species-wise, *B. arundinacea* exhibited slightly higher nutritional values than *B. nutans*, indicating inherent differences in nutrient composition. The statistically significant differences confirmed by LSD analysis validate these findings. Overall, the results support ethanol as the most suitable solvent for obtaining nutritionally rich extracts from bamboo species, in agreement with earlier reports (Singhal *et al.,* 2021).

Brine Shrimp (Larvae) Lethality Assay (BSLA)

The BSLA is widely recognised as a rapid and reliable preliminary bioassay for screening the cytotoxic potential of plant extracts and for predicting possible antitumor and pesticidal activities (Nhamussua *et al.,* 2026). The observed solvent-dependent variation in LC_{50} values highlights the critical role of the extraction solvent in recovering bioactive compounds from bamboo species. The superior cytotoxicity of ethanolic extracts may be attributed to ethanol's ability to efficiently solubilise a wide range of bioactive secondary metabolites, including phenolics, flavonoids, and terpenoids, which are often associated with cytotoxic and antioxidant activities (Krishnaraju *et al.,* 2005; Chanda &Nagani, 2010). The comparatively lower activity of aqueous extracts suggests limited extraction of these compounds in polar water-based systems. The slightly higher cytotoxic potential observed in *B. nutans* compared to *B. arundinacea* indicates species-specific differences in phytochemical composition, a trend consistent with earlier reports on medicinal plants exhibiting variable toxicity profiles across species (Patel & Mehta, 2021). Notably, the LC_{50} values of the ethanolic extracts of both bamboo species are below 100 µg/mL, categorizing them as highly toxic according to Padmaja *et al.* (2002), and indicating stronger bioactivity than several commonly studied medicinal plants such as *Euphorbia hirta* and *Annona squamosa*. Overall, these findings substantiate the ethnomedicinal significance of *Bambusa* species and identify ethanol as the most effective solvent for extracting cytotoxic constituents. The pronounced bioactivity observed in BSLA supports further bioassay-guided fractionation and characterisation of active metabolites to explore their potential pharmacological and therapeutic applications.

Antioxidant Activity Assay

Both *B. arundinacea* and *B. nutans* exhibited significant antioxidant activity, as evidenced by their concentration-dependent DPPH radical scavenging activity, and this pattern aligns with recent findings on bamboo species and other plant extracts. The superior performance of ethanolic extracts, reflected in lower $\mathbf{EC_{50}}$ values, agrees with studies showing that ethanol efficiently extracts phenolics and flavonoids the key antioxidant constituents due to its optimal polarity for these phytochemicals (e.g., recent work by Kumar *et al.,* 2021. Methanolic extracts showed moderate activity, consistent with reports indicating that methanol can extract a broad range of polyphenols but often with lower affinity for some flavonoid subclasses compared to ethanol (Babbar *et al*, 2012). Aqueous extracts were the least effective, reflecting the limited solubility of many antioxidant compounds in water, a trend also observed in antioxidant evaluations of bamboo shoots and leaves (Zhang *et al.,* 2024). Slightly higher activity in *B. arundinacea* suggests interspecific variation in phytochemical profiles, a phenomenon documented in comparative antioxidant studies of different bamboo taxa (Macwan *et al;* 2010). The strong activity of vitamin C as a positive control validated the assay, echoing similar methodological confirmations in recent antioxidant research (Padayatty, 2003). Collectively, these findings confirm that solvent polarity strongly influences antioxidant efficiency and highlight ethanolic bamboo extracts as promising natural antioxidant sources, extending the conclusions of earlier reports such as Nirmala *et al.* (2014) with updated comparative evidence from contemporary studies.

Anthelmintic Activity Assay

The present results confirm the significant anthelmintic potential of Bambusa arundinacea and B. nutans, supporting their traditional ethnomedicinal use. Ethanolic and methanolic extracts were more effective than aqueous extracts, indicating that moderately polar solvents better extract bioactive compounds such as tannins, flavonoids, and polyphenols, consistent with recent studies showing solvent polarity strongly influences the yield and efficacy of plant-derived anthelmintic metabolites (Ali *et al.*, 2012). The strong activity of B. nutans ethanolic extract, reflected by shorter paralysis and death times and lower LC_{50} values, suggests a higher concentration or more effective composition of active phytoconstituents, in agreement with recent reports that tannin- and flavonoid-rich extracts enhance nematocidal activity by disrupting parasite metabolism and neuromuscular function (Nahar *et al.*, 2025). Although albendazole exhibited superior efficacy, the dose-dependent activity of bamboo extracts highlights their potential as natural anthelmintic agents, echoing global interest in plant-based

alternatives amid rising resistance to conventional drugs (Muda *et al.*, 2021). Overall, these findings validate traditional claims and recent literature, identifying B. nutans ethanolic extract as a promising candidate for further bioactivity-guided isolation of novel plant-derived anthelmintic compounds.

Antibacterial Activity

The antibacterial activity of *Bambusa arundinacea* and *B. nutans* observed in this study confirms their broad-spectrum potential against both enteric and oral pathogens, demonstrating dose-dependent increases in inhibition that are consistent with recent investigations into plant-derived antimicrobials. As with other phytotherapeutic studies, ethanolic and methanolic extracts were more effective than aqueous extracts, underscoring the influence of solvent polarity on extracting phenolics, flavonoids, tannins, and alkaloids—bioactive classes increasingly recognized for their antimicrobial efficacy (Zubair *et al.,* 2013). In our results, *B. arundinacea* exhibited stronger antibacterial activity than *B. nutans*, aligning with contemporary evidence highlighting its potent antimicrobial properties in vitro (S *et al.,* 2024). The activity against *Streptococcus mutans* and *Salmonella typhi* parallels recent reports on bamboo species and allied grasses demonstrating inhibitory effects against oral and enteric pathogens (S *et al.,* 2024; Owolabi & Lajide*,* 2015). Although the standard antibiotic ampicillin produced larger zones of inhibition, the ethanolic extract of *B. arundinacea* at 100 µg/mL approached the effect of the reference drug, suggesting considerable antimicrobial potential that resonates with efforts to identify plant-based alternatives amid rising antibiotic resistance (Tayung*et al.,* 2011). Differences between studies may stem from variability in plant part used, extraction procedures, strain susceptibility, and assay conditions, as noted in recent comparative analyses of herbal extracts (Sun *et al.,* 2025). Overall, these findings support and extend current literature, justifying further isolation and characterization of active compounds from bamboo species for potential development as natural antimicrobial agents.

Limitations

The study is limited to selected districts of Odisha, potentially missing region-specific traditional uses of *Bambusa arundinacea* and *Bambusa nutans*, and only aqueous, ethanolic, and methanolic extracts were analyzed, possibly overlooking other bioactive compounds. Preliminary bioassays including Brine Shrimp Lethality, antioxidant, anthelmintic, and antibacterial tests lack mechanistic and in vivo validation, while crude extract analyses may mask individual metabolite contributions. Seasonal, developmental, and environmental variations could further affect reproducibility, and antimicrobial screening against limited pathogens may underestimate potential.

Future Scope

Future research should expand ethnobotanical surveys, isolate and characterize active compounds through bioassay-guided approaches, and validate activities in vivo. Advanced extraction methods, broader microbial screening, and assessment of seasonal or developmental influences will optimize the utilization of bamboo species for nutraceutical, pharmaceutical, and natural antimicrobial or anthelmintic applications.

Conclusion

This study underscores the ethnobotanical, nutritional, and pharmacological significance of *Bambusa nutans* and *Bambusa arundinacea* in Odisha. *B. nutans* holds higher cultural and medicinal value, while *B. arundinacea* serves ecological and utilitarian roles. Methanolic and ethanolic extracts revealed rich bioactive profiles, exhibiting strong antioxidant, antibacterial, anthelmintic, and cytotoxic activities. *B. nutans* showed superior antioxidant and anthelmintic potential, whereas *B. arundinacea* was more effective against bacteria. These findings validate traditional uses and support further isolation of active metabolites for therapeutic and nutraceutical development.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this research.

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