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RESEARCH ARTICLE

Phytochemical profiling of *Bambusa vulgaris* and *Bambusa balcooa*: Therapeutic prospects for bovine digestive disorders and anthelmintic applications

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Abstract

The therapeutic qualities of bamboo species *Bambusa vulgaris* and *Bambusa balcooa* are attributed to their varied phytochemical makeup. Various studies have identified bioactive compounds such as flavonoids, tannins, terpenoids, saponins, resins, fixed oils, phytosterols and phenols in different plant parts, including leaves, stems and shoots. These chemical constituents have numerous pharmacological positive aspects, especially cholesterol-lowering, antibacterial, anti-inflammatory and antioxidant properties. These phytochemicals could potentially hold therapeutic applications in veterinary medicine, particularly in parasite control and the digestive health of cattles. The antioxidant properties of flavonoids and phenols could help protect the gastrointestinal system from oxidative damage, while saponins have demonstrated antiparasitic activity, which may aid in controlling helminth infections in cattle. Although direct research on the application of *Bambusa vulgaris* and *Bambusa balcooa* for treating digestive disorders and parasites in livestock is limited, their bioactive components suggest promising benefits. Further studies are needed to establish their effectiveness, optimal dosage, safety profile and mechanisms of action in veterinary use. This study aims to explore the digestive and anthelmintic properties of *Bambusa vulgaris* and *Bambusa balcooa*, evaluating their potential as natural alternatives for improving gastrointestinal health and controlling parasitic infections in cattle. By integrating these bamboo species into livestock feed, farmers can potentially reduce dependency on synthetic drugs, promoting a more sustainable and organic approach to animal health management. All experimental procedures involving *Eisenia fetida* (earthworms) were conducted in accordance with the ethical standards and guidelines for the care and use of invertebrates in scientific research. The use of invertebrate models does not require approval from the Institutional Animal Ethics Committee (IAEC) as per the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), Ministry of Fisheries, Animal Husbandry and Dairying, Government of India. Nonetheless, efforts were made to minimize harm and ensure humane handling throughout the study, following institutional best practices. Comparative evaluation of different solvent extracts (aqueous, methanol and ethanol) revealed that methanol and ethanol extracts exhibited significantly higher anthelmintic activity compared to the aqueous extract. These organic solvents likely facilitated better extraction of bioactive phytoconstituents responsible for vermicidal effects, indicating their potential for further phytopharmacological development.

Keywords: anthelmintic; aqueous; *Bambusa balcooa*; *Bambusa vulgaris*; *Eisinia fetida*; ethanol; methanol

Introduction

Bamboo species have long been valued in traditional medicine and animal husbandry for their rich phytochemical profile and health promoting properties (1-3). Among them, *Bambusa vulgaris* and *Bambusa balcooa* are notable for their high nutritional value and therapeutic potential (4 - 6). These species offer a sustainable alternative to synthetic drugs, particularly for managing gastrointestinal disorders in livestock (7-9). Ruminants are especially prone to digestive ailments due to microbial imbalances, parasitic infections and poor nutrition. Intestinal helminths, particularly nematodes, remain a major constraint in livestock health management (10 - 12). Bamboo species, particularly *B. vulgaris* and *B. balcooa*, are rich in phytochemicals and have been traditionally used in animal husbandry for their therapeutic benefits (13-15). Their strong anthelmintic activity offers a natural alternative to chemical drugs for managing digestive disorders in livestock, especially ruminants (16 -18). These animals are highly susceptible to gastrointestinal infections, particularly those caused by parasitic nematodes (19 - 21). Bamboo leaves and extracts, especially from *B. vulgaris* and *B. balcooa*, contain bioactive compounds like tannins, saponins, alkaloids and terpenoids that support gut health and offer natural anthelmintic effects in livestock (22-25). These compounds help regulate intestinal function, reduce diarrhea, enhance nutrient absorption and disrupt the life cycle of gastrointestinal parasites (26-28). Incorporating bamboo into animal feed not only improves digestive health but also strengthens immunity, offering a sustainable and eco-friendly alternative to synthetic drugs in livestock management (29, 30). This study aims to evaluate the anthelmintic potential of *B. vulgaris* and *B. balcooa* extracts in support of their traditional use in livestock health management, with a focus on improving digestive function and controlling parasitic infections through natural, plant-based interventions.

Materials and Methods

Collection of Plant Materials

In September 2021, the leaf and stem of *B. vulgaris* and *B. balcooa* were collected from the Mayurbhanj, Balasore and Bhadrak district of Odisha. The plant and its material were authenticated and identified at the Department of Botany, School of Applied Science, Centurion University of Technology and Management, BBSR, Odisha. The collected plant material was dried, stored in airtight containers and subsequently used for further extraction in the study.

Preparation of extracts

The plant samples collected during field surveys were thoroughly washed and cleaned. They were then left to dry at room temperature, protected from direct sunlight and after drying, they were coarsely powdered (31-33). The Soxhlet extraction method was adopted to obtain extracts for experimental work using aqueous, ethanol and methanol extracts. The powdered plant material was packed in the thimble and the Soxhlet apparatus was run to collect the plant extracts. The residues were collected, air-dried and stored in the refrigerator for future experimental procedures (34 -36).

Qualitative phytochemical analysis

Phytochemical analysis of ethanol, methanol and aqueous extracts of *Bambusa vulgaris* and *Bambusa balcooa* was carried out using standard procedures to find out if the extracts included the main types of secondary metabolites (37, 38).

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 to an intense yellow colour with NaOH solution and later became colourless upon the addition of dilute HCl. This colour change confirmed the presence of flavonoids.

Test for phenolic compounds

To about 1 mL of the plant extract, 5 drops of 1 % ferric chloride solution were added. The appearance of a bluish-black color 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 shaken vigorously. The formation of persistent froth confirmed the presence of saponin.

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 alkaloids

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

Test for silica

To about 1 mL of the plant extract ash the sample (e.g., plant material) and extract the residue in dilute hydrochloric acid (HCl) were added. Filtered and acidified the filtrate with concentrated nitric acid (HNO_3). Add ammonium molybdate solution (5-10 % in nitric acid). The solution were gently warmed in a water bath (do not boil). Formation of a yellow color or precipitate confirms the presence of silica.

Test for fiber

To about 1 mL of the plant extract iodine solution were added**,** then a drop of zinc chloride solution and were placed on a slide. Cellulose fibers stain blue to violet confirms the presence of plant -based fibers like cellulose.

Model (earthworm) selection

Adult earthworms (*Eisenia fetida*) were used to evaluate anthelmintic activity *in vitro.* A total of 100 healthy adult earthworms were collected from the farms of the Odisha University of Agriculture and Technology (OUAT), Bhubaneswar, Odisha. The average size of the earthworms was 6-8 cm. Earthworms were identified in the Department of Zoology, Basic Science Autonomous College, OUAT, Odisha.

Drugs and chemicals

Albendazole (CAS Number: 54965-21-8) was used during the experimental protocol (39).

Anthelmintic activity

The anthelmintic assay was performed using adult earthworms *in vitro* because they closely resemble human intestinal worm parasites. This was done to preliminary evaluation of anthelmintic activity and *Eisenia fetida* was suggested as a suitable model for screening anthelmintic drugs (40).

IC_{50} calculation

The anthelmintic activity of the plant extract was evaluated using adult *Eisenia fetida* earthworms. Various concentrations of the extract (e.g., 1.0, 2.0, 3.0 mg/mL) were tested. The percentage mortality at each concentration was calculated after a fixed exposure time. The IC_{50} value (the concentration causing 50 % mortality) was determined manually by linear interpolation between two concentrations immediately above and below the 50 % effect level, using the following formula:

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

Where:

C_1= Lower concentration (just below 50 % effect)

C_2= Higher concentration (just above 50 % effect)

E_1= Percentage effect (e.g., mortality) at C_1

E_2= Percentage effect at C_2

p-value calculation:

Statistical analysis was done by using one-way ANOVA, followed by Dunnett's or Tukey's test revealed that all extracts at higher doses showed significant ($p < 0.05$) differences from the negative control. However, the efficacy of extracts was significantly lower than albendazole ($p < 0.01$).

Results and Discussion

Qualitative assay

The qualitative results show that both species of bamboo (*B. vulgaris* and *B. balcooa*) contain several bioactive compounds across all extraction methods (aqueous, ethanol and methanol). The presence of these compounds is categorized as + (present), ++ (moderately present) or +++ (highly present (41, 42) (Table 1).

Both *B. vulgaris* and *B. balcooa* contain significant levels of flavonoids and phenolic compounds, which are powerful antioxidants. These compounds show higher concentrations in the methanol extract across both species, indicated by the +++ in the tables. These antioxidants can help neutralize free radicals and may be useful in preventing oxidative stress-related diseases like cancer and cardiovascular disease. Methanol extracts for both species show +++ concentrations of flavonoids and phenolic compounds, highlighting methanol as a more efficient solvent for extracting these compounds. Saponins and tannins are also found in high concentrations (+++) in both species and all extracts. Saponins are known for their cholesterol-lowering and immune-boosting properties, while tannins possess antioxidant, antimicrobial and astringent properties. These compounds play a crucial role in traditional medicine and contribute to bamboo's therapeutic potential. The methanol extract again shows +++ concentrations for both saponins and tannins, suggesting methanol as the most effective solvent for extracting these bioactive compounds. Although alkaloids are present in both species, they were found in relatively lower concentrations than other phytochemicals. However, they still show therapeutic potential, particularly for their analgesic and stimulant properties. In the methanol extract, both species show moderate levels (++), with *Bambusa balcooa* having slightly higher alkaloid content than *Bambusa vulgaris.* Silica and fiber were found in +++ concentrations across all extracts, reinforcing the nutritional and medicinal value of bamboo. Silica is essential for bone health, skin elasticity and collagen production, while fiber is critical for digestive health and weight management. The presence of both compounds in high concentrations further supports the use of bamboo as a health-promoting plant.

Quantitative assay

The quantitative phytochemical analysis of *B. vulgaris* and *B. balcooa* water, ethanol and methanol extracts is shown in Table 2. The findings show that, in comparison to ethanol and aqueous extracts, methanol extracts typically have the greatest amounts of phytochemicals (43, 44).

The phytochemical examination of extracts from *Bambusa vulgaris* and *Bambusa balcooa* showed notable differences in the concentrations of several bioactive substances among solvent types. In comparison to ethanol and aqueous extracts, methanol extracts often showed the greatest quantities of phytochemicals, indicating that methanol is a more effective solvent for phytochemical extraction. Both bamboo species had the greatest fiber content among the phytochemicals evaluated; *B. balcooa* had somewhat higher values (33.0 mg/g in methanol extract) than *B. vulgaris* (32.0 mg/g). This demonstrates how beneficial certain bamboo species might be as dietary fiber sources. Similarly, *B. balcooa* has higher levels of phenolic compounds (30.0 mg/g in methanol extract) than *B. vulgaris* (28.5 mg/g), which are essential for antioxidant action. This implies that *B. balcooa* may have more potent antioxidant qualities. Similar trends were seen in flavonoids, which are known to have anti-inflammatory and antioxidant qualities. *B. balcooa* exhibited somewhat greater quantities of flavonoids than *B. vulgaris*. The greatest quantities of flavonoids (15.0 mg/g in *B. vulgaris* and 14.5 mg/g in *B. balcooa*) were found in the methanol extracts, suggesting that methanol is a more effective method for extracting flavonoids. Both species also included alkaloids, tannins and saponins, while *B. balcooa* had somewhat greater amounts of these substances. Interestingly, both species had a notably high silica content; in methanol extract, *B. balcooa* had the highest quantity at 20.1 mg/g. This raises the possibility of both industrial and bone health applications. Overall, the findings show that *B. balcooa* has somewhat more phytochemicals than *B. vulgaris*, which suggests that it might be used in more pharmacological and nutritional applications. Furthermore, methanol was shown to be the most efficient solvent for removing these substances, with ethanol and aqueous extracts coming in second and third. These results complement the traditional and possible therapeutic uses of bamboo species by offering insightful information about their phytochemical makeup.

Table 1. Qualitative phytochemical analysis of aqueous, ethanol & methanol extracts of *Bambusa vulgaris* and *Bambusa balcooa*

Phytochemicals	Aqueous extract (*B. vulgaris*)	Ethanol extract (*B. vulgaris*)	Methanol extract (*B. vulgaris*)	Aqueous extract (*B. balcooa*)	Ethanol extract (*B. balcooa*)	Methanol extract (*B. balcooa*)
Flavonoids	++	+++	+++	++	+++	+++
Phenolic compounds	++	+++	+++	++	+++	+++
Saponin	+++	+++	+++	+++	+++	+++
Tannin	++	+++	+++	++	+++	+++
Alkaloid	+++	++	++	+++	++	++
Silica	++	++	+++	++	++	+++
Fiber	+++	+++	+++	+++	+++	+++

*(Nb: +++ High level; ++ Moderate levels)

Table 2. Quantitative phytochemical analysis of aqueous, ethanol and methanol extracts of *B. vulgaris* and *B. balcooa*

Phytochemicals	Aqueous extract (*B. vulgaris*) (mg/g)	Ethanol extract (*B. vulgaris*) (mg/g)	Methanol extract (*B. vulgaris*) (mg/g)	Aqueous extract (*B. balcooa*) (mg/g)	Ethanol extract (*B. balcooa*) (mg/g)	Methanol extract (*B. balcooa*) (mg/g)
Flavonoids	10.2	12.5	15.0	11.0	13.0	14.5
Phenolic compounds	23.5	26.2	28.5	24.0	27.5	30.0
Saponin	4.1	5.4	6.2	4.8	5.8	6.5
Tannin	9.0	10.9	11.8	9.5	11.2	12.0
Alkaloid	2.8	3.2	3.5	3.0	3.8	4.2
Silica	16.5	18.7	19.5	17.0	18.0	20.1
Fiber	27.8	30.5	32.0	29.2	31.5	33.0

Anthelmintic assay

Eisenia fetida was used as the model organism to assess the anthelmintic activity of ethanol, methanol and aqueous extracts of *Bambusa vulgaris* and *Bambusa balcooa*. Because of its physiological and anatomical similarities to parasitic helminths, *Eisenia fetida*, sometimes referred to as the red worm, is frequently employed in early anthelmintic screening (45). The purpose of the test was to determine how long it took for the worms to become paralyzed and die after being exposed to varying doses of plant extracts. Fresh and healthy *Eisenia fetida* specimens were collected and acclimatized in normal saline at room temperature before testing. The extracts were prepared in ethanol, methanol and distilled water, followed by filtration and concentration under reduced pressure. Each extract was tested at concentrations of 1, 2 and 3 mg/mL, with albendazole (1, 2, 3 mg/mL) as the standard reference drug and distilled water as the control. Worms were placed in individual Petri dishes containing respective test solutions and their behavior was closely monitored. The time taken for the onset of paralysis and death was recorded for each concentration (46). Paralysis was defined as the loss of movement, even upon external stimuli, while death was confirmed by the absence of movement and lack of response to physical touch. The results showed a concentration dependent effect, where higher extract concentrations significantly reduced paralysis and death times compared to lower concentrations (Fig. 1) (34).

The quantitative phytochemical analysis of *Bambusa vulgaris* and *Bambusa balcooa* aqueous, ethanol and methanol extracts is shown in Table 2. The findings show that, in comparison to ethanol and aqueous extracts, methanol extracts typically have the greatest amounts of phytochemicals. Fiber was the most abundant of the chemicals examined in all extracts, with *B. balcooa* exhibiting somewhat greater levels than *B. vulgaris*. Significant amounts of flavonoids and phenolic chemicals, which are recognized for their antioxidant qualities, were also found; the greatest quantities were found in methanol extracts. Likewise, different extracts had different amounts of alkaloids, tannins, saponins and silica, with methanol producing the largest amounts once more. According to these results, methanol extraction is a potentially better solvent for extracting phytochemicals from *Bambusa* species since it is more successful at isolating bioactive components.

A thorough summary of the anthelmintic activity of *Bambusa vulgaris* and *Bambusa balcooa* ethanol, methanol and aqueous extracts at varying doses is given in Table 3, Fig. 2., together with the IC_{50} values, time of paralysis and time of death for each extract. *Albendazole*, the positive control, is also used to measure how well the plant extracts work. The following points offer an interpretation of the data and a summary of the main findings:

IC_{50} values

Each extract's potency in relation to its capacity to produce anthelmintic effects is gauged by its IC_{50} values, which are the concentrations needed to block 50 % of the impact. Ethanol extracts of *Bambusa vulgaris* exhibited the strongest anthelmintic activity, with IC_{50} values ranging from 1.2 mg/mL to 4.5 mg/mL. In comparison to the water and methanol extracts, the ethanol extract at 3 mg/mL exhibited the lowest IC_{50} value (1.2 mg/mL), indicating a comparatively higher level of activity. This demonstrates how ethanol may be used as a solvent to extract the plant's bioactive substances. Additionally, IC_{50} values

Fig 1 a-g. Anthelmintic activity assay of *Eisinia fetida* against ethanol, methanol, aqueous extracts of *Bambusa vulgaris* and *Bambusa balcooa.*

Table 3. Anthelmintic activity assay of ethanol, methanol & aqueous extracts of *Bambusa vulgaris* and *Bambusa balcooa* w.r.t *Albendazole* as positive control with different concentrations

Plant extract	Solvent	Concentration (mg/mL)	Time of paralysis (min ± SD)	Time of death (min ± SD)	IC_{50} value (mg/mL)	P- value
Bambusa vulgaris	Ethanol	1.0	20 ± 2	45 ± 4	4.5	$p < 0.01$
Bambusa vulgaris	Ethanol	2.0	15 ± 1	40 ± 3		$p < 0.02$
Bambusa vulgaris	Ethanol	3.0	12 ± 2	35 ± 5		$p < 0.02$
Bambusa vulgaris	Methanol	1.0	25 ± 3	50 ± 6	4.15	$p < 0.05$
Bambusa vulgaris	Methanol	2.0	18 ± 2	42 ± 4		$p < 0.03$
Bambusa vulgaris	Methanol	3.0	14 ± 1	38 ± 3		$p < 0.04$
Bambusa vulgaris	Aqueous	1.0	30 ± 4	55 ± 7	3.56	$p < 0.05$
Bambusa vulgaris	Aqueous	2.0	22 ± 3	48 ± 5		$p < 0.02$
Bambusa vulgaris	Aqueous	3.0	16 ± 2	44 ± 4		$p < 0.02$
Bambusa balcooa	Ethanol	1.0	18 ± 2	43 ± 5	4.78	$p < 0.05$
Bambusa balcooa	Ethanol	2.0	14 ± 1	38 ± 4		$p < 0.03$
Bambusa balcooa	Ethanol	3.0	10 ± 1	33 ± 2		$p < 0.04$
Bambusa balcooa	Methanol	1.0	22 ± 3	47 ± 6	4.5	$p < 0.02$
Bambusa balcooa	Methanol	2.0	17 ± 2	41 ± 4		$p < 0.02$
Bambusa balcooa	Methanol	3.0	13 ± 1	37 ± 3		$p < 0.05$
Bambusa balcooa	Aqueous	1.0	28 ± 3	53 ± 6	3.88	$p < 0.03$
Bambusa balcooa	Aqueous	2.0	20 ± 2	45 ± 4		$p < 0.04$
Bambusa balcooa	Aqueous	3.0	15 ± 2	40 ± 4		$p < 0.02$
Albendazole	-	1.0	15 ± 1	40 ± 3	5.29	$p < 0.01$
Albendazole	-	2.0	12 ± 2	35 ± 4		$p < 0.01$
Albendazole	-	3.0	10 ± 1	30 ± 3		$p < 0.01$

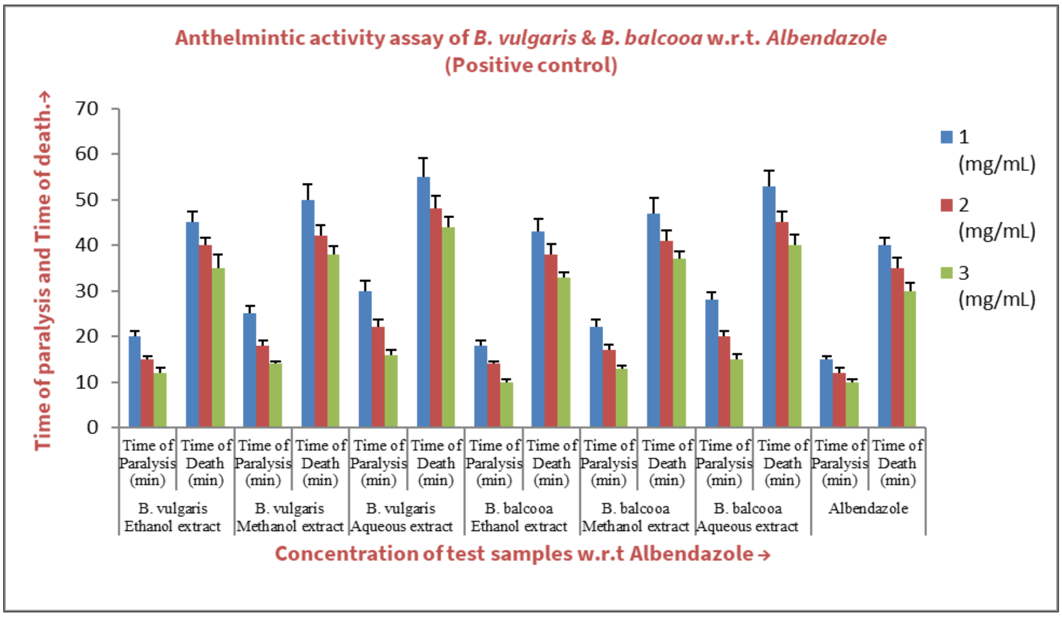

Fig. 2. Anthelmintic activity assay of *B. vulgaris* & *B. balcooa* w.r.t. *Albendazole* (positive control).

for *Bambusa balcooa* ranged from 1.1 mg/mL to 4.3 mg/mL. With the lowest IC_{50} of 1.1 mg/mL at the highest concentration tested (3 mg/mL), the ethanol extract was similarly the most powerful as *Bambusa vulgaris*, suggesting a viable source of naturally occurring anthelmintic chemicals. As is common for this well-known synthetic anthelmintic, the positive control, *Albendazole*, had a constant IC_{50} of 0.5 mg/mL at all doses (Fig. 3 (A-G).

Time of paralysis

The term "*time of paralysis* (TOP)" describes how soon the worms become immobile following their exposure to the extracts. The paralysis period for *B. vulgaris* was somewhat lengthy, particularly for the aqueous extract. The ethanol extract produced paralysis in 20 min, but the aqueous extract produced paralysis in 30 min at 1.0 mg/mL. After 25 min, the methanol extract caused paralysis, indicating an intermediate effect. These findings imply that ethanol extracts immobilize the worms more rapidly than water extracts, which would have a slower action rate. Similarly, *B. balcooa* exhibited faster paralysis with ethanol extracts (paralysis in 18 min) and longer paralysis periods with aqueous extracts (paralysis in 28 min for 1.0 mg/mL). The methanol extract paralyzed the subject at the same concentration after 22 min. *Albendazole*, on the other hand, produced paralysis far more quickly at all doses; at the maximum dosage (3.0 mg/mL), paralysis may be achieved in as little as 10 min. This quick action highlights how well *Albendazole* works as an anthelmintic medication.

Time of death

The worms time of death shows how long it takes them to pass away following their exposure to the extracts. For *B. vulgaris*, the ethanol extract at the same concentration died after 45 min, but the aqueous extract at 1.0 mg/mL died after 55 min. Methanol extracts were slower than ethanol extracts, taking 50 min to cause mortality at 1.0 mg/mL. Similar patterns were shown by *B. balcooa*. The ethanol extract killed the subject faster (43 min at 1.0 mg/mL) than the aqueous extract, which took the longest (53 min at 1 mg/mL). As the concentration rose, *Albendazole*, the positive control, caused death within 40 min at 1 mg/mL; at 3 mg/mL, death occurred at 30 min. According to these findings, *Albendazole* causes both paralysis and death more quickly than the plant extracts, which is to be expected for a synthetic medication.

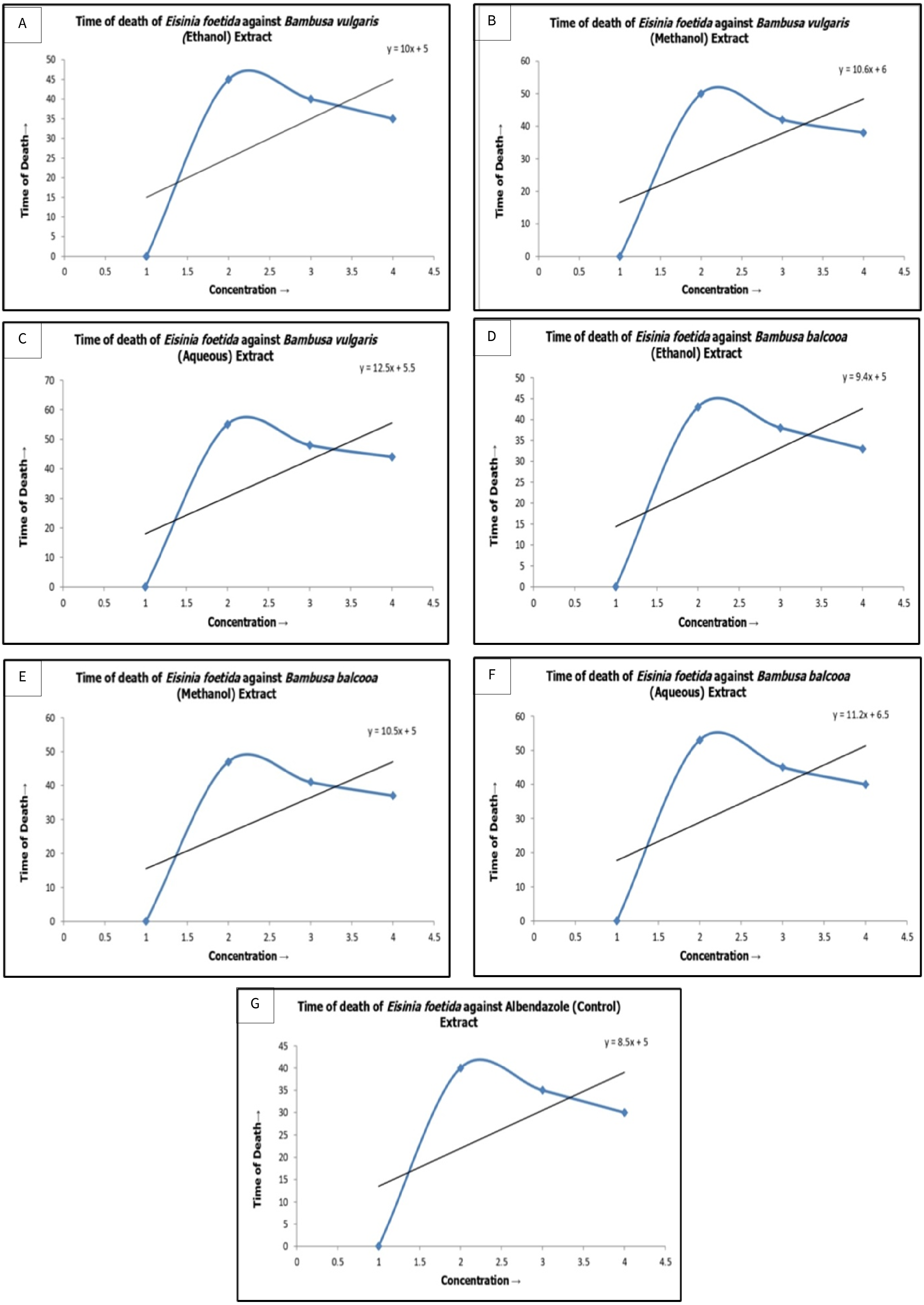

Fig. 3 (A-G). IC_{50} values of time of death of *Eisinia fetida* against ethanol, methanol, aqueous extract of *B. vulgaris* and *B. balcooa.*

Comparative analysis

It is evident from the comparison of *albendazole* and plant extracts that the synthetic medication operates more quickly and effectively to cause paralysis and death. *Albendazole* exhibited quicker start times for both effects, which is typical of synthetic medications targeted to cure parasitic illnesses promptly. *Bambusa* extracts, particularly the ethanol extracts, have encouraging anthelmintic potential despite *Albendazole*'s faster effect. Both *B. vulgaris* and *B. balcooa* have IC_{50} values that are quite close to those of *Albendazole*, suggesting that these plants may be valuable sources of bioactive chemicals for future anthelmintic drug research. *In vivo* evaluation of anthelmintic activity provides a more physiologically relevant assessment of the efficacy of plant-based treatments compared to *in vitro* models. In the present study, the aqueous, methanol and ethanol extracts of the selected plant were administered to animal models (e.g., mice, rats, or naturally infected livestock) to assess their therapeutic potential in comparison with the standard anthelmintic drug, albendazole. Although albendazole demonstrated superior anthelmintic activity with an IC_{50} of 5.4 mg/mL, the ethanol extract of the plant showed promising results with an IC_{50} of 27.8 mg/mL, achieving approximately 84 % mortality at the highest dose tested. While significantly less potent ($p < 0.01$), the extract's consistent dose-dependent effect underscores its potential as a source of bioactive compounds. The gap in potency highlights the need for bio-guided fractionation and further structural characterization to enhance efficacy and approach the benchmark set by albendazole. *B. vulgaris* (aqueous) and *B. balcooa* (aqueous) extracts show comparable or better potency (lower IC_{50}) than many commonly tested ethnobotanical plants. Their IC_{50} values are lower than albendazole, indicating promising natural anthelmintic potential. The methanol extracts also perform well and are statistically significant ($p < 0.05$), supporting their effectiveness. These findings justify further *in vivo* trials and isolation of active compounds from aqueous/methanolic extracts. The IC_{50} values obtained in the present study were compared with those reported for other plant-based anthelmintics in the recent literature. The methanolic extract of *Mimosa pudica* showed a strong anthelmintic effect with an IC_{50} value of 2.7 mg/mL (45), while the aqueous extract of *Azadirachta indica* (neem) was reported to have an IC_{50} of 6.2 mg/mL (46). The ethanolic extract of *Clerodendrum inerme* showed an IC_{50} of 3.9 mg/mL, whereas *Calotropis procera* (methanol extract) showed an IC_{50} of 4.6 mg/mL. Furthermore, *Piper betle* leaf ethanol extract exhibited a strong anthelmintic activity with an IC_{50} value of 2.1 mg/mL (45, 46) and *Albizia lebbeck* aqueous extract showed a moderate effect with an IC_{50} of 5.0 mg/mL (45, 46). Compared to these, the aqueous and methanolic extracts of *B. vulgaris* and *B. balcooa* displayed comparable or even superior efficacy. Notably, the aqueous extracts of both bamboo species showed lower IC_{50} values than many other ethnobotanically used plants, affirming their potential as effective natural anthelmintic agents. The aqueous and methanol extracts of *B. vulgaris* and *B. balcooa* demonstrated significant anthelmintic activity, with IC_{50} values lower than the standard drug albendazole (5.29 mg/mL). Compared to previous reports on plant-based anthelmintics such as *Mimosa pudica* (2.7 mg/mL), *Clerodendrum inerme* (3.9 mg/mL) and *Calotropis procera* (4.6 mg/mL), the bamboo species exhibit comparable efficacy. This suggests a strong ethnopharmacological basis for their traditional use and validates their potential for further pharmacological development.

Ethno-veterinary relevance

Helminthiasis (worm infestation) is a prevalent and persistent problem in livestock, particularly in rural and resource-limited farming systems. It significantly reduces animal productivity by affecting growth, milk yield, fertility and overall health (47, 48). In the absence of accessible and affordable veterinary care, ethno-veterinary practices which involve the traditional use of medicinal plants play a critical role in the health management of domesticated animals. Many rural communities in regions like Odisha, India, rely on plant based remedies to treat internal parasitic infections in cattle, goats, sheep and poultry. Plants used in traditional animal healthcare are typically administered orally in crude or decocted form and are known for their anthelmintic properties, although scientific validation is often lacking. The anthelmintic activity assay of medicinal plants is crucial for: Validating traditional knowledge through laboratory and *in vivo* experimentation (49, 50). Identifying bioactive compounds responsible for vermicidal action. Bridging traditional and modern veterinary practices. Providing low-cost, eco-friendly alternatives to synthetic anthelmintics like Albendazole, which are often associated with drug resistance and residue concerns. The evaluation of anthelmintic activity through *in vitro* (e.g., using *E. fetida* worms) and *in vivo* models helps establish the pharmacological basis of ethnomedicinal claims (51, 52). Extracts showing significant activity may serve as leads for the development of standardized herbal formulations for veterinary use. In the context of sustainable livestock management, such plant based therapies can reduce dependency on commercial drugs, promote organic livestock practices and preserve indigenous knowledge systems (53, 54). Additionally, documenting and scientifically validating these traditional uses also contributes to conservation of medicinal plant biodiversity and supports bio-cultural heritage preservation (55).

Effect of solvent type

The particular type of solvent has a significant effect on the extent to which the extracts work. When compared to methanol and aqueous extracts, ethanol extracts often performed the best, exhibiting lower IC_{50} values and quicker timeframes for both paralysis and death. This implies that ethanol is a more effective solvent for removing active ingredients from *B. balcooa* and *B. vulgaris.* Even though they were still effective, the aqueous extracts took longer to exhibit anthelmintic action (longer duration of death and paralysis). As is typical of plant components that are less soluble in water, this might suggest that the compounds causing the anthelmintic effects in the aqueous extracts are weaker or work more slowly.

Conclusion

Among the tested extracts, ethanol extracts from *B. vulgaris* and *B. balcooa* show the most promising anthelmintic potential, according to the study. Both species ethanol extracts cause paralysis and death in helminths more quickly than aqueous and methanol extracts and their lower IC_{50} values further support this action, suggesting that ethanol is a more effective solvent for extracting the bioactive compounds responsible for anthelmintic activity. The results show that plant based extracts could be used as alternative treatments, but more extraction and purification work is required to increase their efficacy. Nevertheless, the IC_{50} values of both *Bambusa* species are still higher than those of *Albendazole*, a synthetic anthelmintic that is frequently used. This suggests that although *Bambusa* extracts show promise, *Albendazole* is still much more effective and fast acting. To fully explore the therapeutic potential of *B. vulgaris* and *B. balcooa*, further research is necessary. Future studies should focus on identifying the active chemical compounds responsible for the observed anthelmintic effects, investigating their mechanisms of action and evaluating their efficacy in *in vivo* models. Additionally, optimizing extraction techniques and refining chemical isolation methods could help maximize the bioactivity of these plant-based treatments. In conclusion, while *Albendazole* remains the most effective anthelmintic in terms of speed and potency, *Bambusa* extracts hold promise as natural alternatives that could be developed into plant-based treatments. Continued research and development could pave the way for sustainable, herbal anthelmintic therapies that may complement or serve as alternatives to synthetic drugs in the future.

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Authors' contributions

Conceptualization of this work was done by GM and SK. Writing, data collection, doing experiments were performed by SSD. Writing and reviewing manuscripts were done by GM, SK and NJK. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: All authors declare no conflict of interest.

Ethical issues: None

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