

FORMULATION AND EVALUATION OF AN ANTHELMINTIC SUSPENSION USING AQUEOUS EXTRACT OF *TERMINALIA CATAPPA* FRUIT PULP

Elakkiyamani G.*, Dinesh B., Indhuja A., Jeyapandi K., Jothiyo Franklin K. F.

PPG College of Pharmacy, Coimbatore.

Article Received: 27 August 2026 | Article Revised: 17 September 2026 | Article Accepted: 07 October 2026

*Corresponding Author: Elakkiyamani G.

Assistant Professor, PPG College of Pharmacy, Coimbatore, Tamil Nadu.

DOI: <https://doi.org/10.5281/zenodo.23415894>

How to cite this Article: Elakkiyamani G., Dinesh B., Indhuja A., Jeyapandi K., Jothiyo Franklin K. F. (2026) FORMULATION AND EVALUATION OF AN ANTHELMINTIC SUSPENSION USING AQUEOUS EXTRACT OF *TERMINALIA CATAPPA* FRUIT PULP. World Journal of Pharmaceutical Science and Research, 5(10), 553-565.



Copyright © 2026 Elakkiyamani G. | World Journal of Pharmaceutical Science and Research.

This work is licensed under creative Commons Attribution-NonCommercial 4.0 International license (CC BY-NC 4.0).

ABSTRACT

The present study aimed to formulate and evaluate an anthelmintic suspension using the aqueous extract of *Terminalia catappa* fruit pulp. The fruit pulp was extracted by the maceration technique using distilled water for 72 hours. Three suspension formulations, namely F1, F2 and F3, containing 4%, 8% and 12% w/v of the extract, respectively, were prepared using carboxymethyl cellulose as a suspending agent, Tween 80 as a wetting agent, sucrose as a sweetening agent, sodium benzoate and potassium sorbate as preservatives, citric acid as a pH-adjusting agent, and orange oil and amaranth as flavouring and colouring agents, respectively. The prepared formulations were evaluated for organoleptic properties, pH, viscosity, sedimentation volume, drug content, particle size, redispersibility, antimicrobial activity, stability and in-vitro anthelmintic activity. All three formulations exhibited a pink colour, sweet taste and liquid appearance. The pH values of F1, F2 and F3 were 4.27, 4.25 and 4.59, respectively, while their viscosity values were 1.069, 1.072 and 1.077 cP, respectively. The sedimentation volume increased with increasing extract concentration, with F3 showing the highest sediment volume of 0.9 mL. The drug content was found to be 14.27%, 24.71% and 33.61% for F1, F2 and F3, respectively. Among the formulations, F2 required the fewest inversions (6) for complete redispersion. The in-vitro anthelmintic activity was evaluated using adult *Pheretima posthuma* earthworms, with albendazole as the standard drug. All three formulations exhibited measurable paralysis and death responses. At a test volume of 2 mL, F1, F2 and F3 showed cumulative response times of 3.28, 2.98 and 2.82 minutes, respectively, compared with 3.50 minutes for the albendazole standard. F3 exhibited the shortest cumulative response time among the tested formulations, indicating the highest in-vitro anthelmintic activity under the experimental conditions. The study demonstrated the successful formulation of an oral suspension containing aqueous *Terminalia catappa* fruit pulp extract. Among the three formulations, F3 (12% w/v) exhibited the most pronounced in-vitro anthelmintic response. Further investigations are required to establish its safety, efficacy and suitability for therapeutic use.

KEYWORDS: *Terminalia catappa*, aqueous extract, herbal suspension, anthelmintic activity, maceration, *Pheretima posthuma*, albendazole.

INTRODUCTION

Helmintic Infection

Helmintic infections are among the most widespread parasitic diseases affecting humans and animals worldwide, particularly in tropical and subtropical regions where poor sanitation, inadequate hygiene, contaminated water supplies and poverty facilitate transmission.^[1] Helminths are parasitic worms classified into two major phyla: nematodes (roundworms) and platyhelminths (flatworms). Nematodes include intestinal or soil-transmitted worms and filarial worms that cause lymphatic filariasis and onchocerciasis. Platyhelminths include flukes (trematodes), such as schistosomes, and tapeworms (cestodes), such as the pork tapeworm that causes cysticercosis. These parasites infect various organs of the host, such as the gastrointestinal tract, blood vessels, lymphatic system, liver, lungs and other tissues, causing a broad spectrum of clinical manifestations ranging from mild discomfort to severe morbidity.

The most common helminth infections are ascariasis, trichuriasis and hookworm infections, followed by schistosomiasis and lymphatic filariasis (LF). In many poor rural areas of the tropics and subtropics, people are often chronically infected with multiple worm species simultaneously, a condition known as polyparasitism.^[2,3]

Helminths are parasitic worms that primarily live in the gastrointestinal (GI) tract of their hosts, where they obtain nutrients from the host, leading to various infections and diseases. These infections are particularly common in children and are associated with poor nutrition, anaemia, growth retardation and impaired cognitive development. Soil-transmitted helminthiasis and schistosomiasis are among the most significant helminth infections and are classified as neglected tropical diseases. In addition to their direct health effects, helminth infections can impair the immune system, increasing susceptibility to other infectious diseases such as malaria, tuberculosis and HIV/AIDS.^[4,5]

Gastrointestinal helminths are common parasites in humans and animals that cause anorexia, anaemia, diarrhoea and significant production losses. They belong to three main groups: nematodes (roundworms), trematodes and cestodes (flatworms). Among these, gastrointestinal nematodes such as *Haemonchus contortus*, *Bunostomum* spp. and *Trichostrongylus* spp. are particularly important because they negatively affect food security. These parasites are highly harmful to small ruminants, causing anaemia through blood feeding and impairing the animals' physiological, metabolic and immune functions.^[6]

Helminths generally do not multiply within the human host, except for *Strongyloides stercoralis*. This unique characteristic results in transmission patterns that differ from those of viruses, bacteria, fungi and protozoa. In helminth infections, disease severity is more closely related to the number of worms present (worm burden or intensity of infection) than to the mere presence of infection. For intestinal helminths, infection intensity is commonly measured by the number of eggs per gram (EPG) of faeces. Based on EPG values and their association with morbidity, the World Health Organization (WHO) classifies infections as light, moderate or heavy. For soil-transmitted helminths, WHO further categorises communities into high, medium or low transmission groups using both infection prevalence and the proportion of heavily infected individuals. This combined approach provides a more accurate assessment of disease burden and transmission risk.^[7,8]

Many helminth infections are chronic because the parasites can survive in the host for long periods. The immune response against these parasites often contributes significantly to disease development. In schistosomiasis, eggs produced by adult worms may become trapped in the liver, where they stimulate a strong immune response and the

formation of granulomas. These granulomas help protect liver tissue by isolating the eggs and reducing their toxic effects. However, over time, persistent granuloma formation can lead to fibrosis (scarring) of the liver, resulting in increased portal blood pressure and the development of portal hypertension. Severe complications, such as bleeding from enlarged veins (varices), can occur and are a major cause of death in schistosomiasis. Research has shown that immune factors, particularly the cytokine IL-13, play a key role in the development of fibrosis, while certain Th1 immune responses may help limit tissue damage. Thus, both the parasite and the host immune response contribute to the pathology of chronic helminth infections.^[9,10,11]

Anthelmintic Activity

Anthelmintics are drugs used to treat infections caused by parasitic worms (helminths). Helminths are classified into three major groups: nematodes (roundworms), trematodes (flukes) and cestodes (tapeworms), with trematodes and cestodes belonging to the phylum Platyhelminthes. Anthelmintic drugs work by either killing the parasites or expelling them from the body while causing minimal harm to the host. These drugs play a vital role in controlling helminth infections and reducing the health burden associated with parasitic diseases.^[12,13,14]

Helminth infections remain a significant global health problem, particularly in developing countries, where they contribute to malnutrition, anaemia, impaired growth and reduced productivity. Although anthelmintic drugs are also widely used in livestock, there is a continuing need to develop new and more effective anthelmintic therapies for humans to address the high disease burden and emerging drug resistance.^[15]

The control of helminth infections relies mainly on effective anthelmintic drugs. However, the widespread and inappropriate use of these drugs has led to the development of drug resistance, reducing their effectiveness in many regions. Consequently, there is an urgent need to discover, isolate and develop new anthelmintic agents with improved efficacy and novel mechanisms of action to effectively manage helminth infections and overcome resistance.^[16]

Anthelmintic resistance develops through several mechanisms that reduce the effectiveness of drugs against parasitic worms. These mechanisms include the upregulation of cellular efflux pumps, which remove drugs from parasite cells; increased drug metabolism, which inactivates the drug more rapidly; changes in drug receptor sites, reducing drug binding or its biological effect; and decreased expression or abundance of drug receptors, making the parasite less sensitive to treatment. The specific mechanisms responsible for resistance vary among different helminth species, making resistance management and the development of new anthelmintic drugs increasingly important.^[17]

Several plant-derived secondary metabolites exhibit significant anthelmintic activity through different mechanisms of action. Terpenes damage the intestinal tissues of parasites and inhibit egg hatching, as demonstrated by compounds such as terpinen-4-ol, borneol and β -elemene. Glycosides, particularly cardenolides, disrupt sodium and potassium ion transport in helminths, leading to parasite death. Saponins cause paralysis by inhibiting acetylcholinesterase and have shown activity against parasitic nematodes such as *Haemonchus contortus*. Flavonoids interfere with energy production in worms by blocking phosphorylation reactions, resulting in parasite death. Tannins exert their effects by reducing nutrient absorption and binding to the intestinal mucosa of helminths, causing autolysis. Alkaloids act by targeting acetylcholine receptors and suppressing glucose uptake, ultimately causing starvation and death of the parasites. These diverse mechanisms highlight the potential of plant secondary metabolites as promising sources for the development of new anthelmintic drugs.^[18]

The extensive use of anthelmintics for controlling helminth infections in livestock over the past five decades has resulted in the development of resistance to all major classes of anthelmintic drugs. Since the discovery and development of new anthelmintics are slow and expensive processes, it is essential to use the existing drugs carefully to minimise the impact of anthelmintic resistance (AR). Various management strategies, such as proper pasture management and the maintenance of refugia, help prevent parasite infections and reduce infection pressure, thereby decreasing the need for frequent anthelmintic treatments. ^[19]

Several important measures can slow the progression of AR. These include the proper and judicious use of anthelmintics, reducing dependence on deworming drugs, and preventing the introduction of resistant parasites onto farms by treating newly purchased animals and keeping them under quarantine before mixing them with the existing herd. Maintaining a population of anthelmintic-susceptible worms and regularly monitoring for anthelmintic resistance are also important components of sustainable parasite control. By integrating these management practices, the effectiveness of existing anthelmintic drugs can be preserved for a longer period. ^[20]

EXTRACTION OF *TERMINALIA CATAPPA* FRUIT PULP



Terminalia catappa fruit

The mature fruits of *Terminalia catappa* L. were collected and thoroughly washed with water to remove dust and other adhering impurities. The fruit pulp (rind) was separated carefully from the hard endocarp. The separated material was shade dried for approximately 5-6 days until it was completely dry. The dried fruit pulp was then reduced to a coarse powder using a suitable grinder and stored in an airtight container until extraction. Published work on *Terminalia catappa* fruit rind has used drying, powdering and solvent extraction as the preliminary steps in the preparation of the extract.

Maceration Extraction Technique

For the aqueous extraction, the required quantity of powdered *T. catappa* fruit pulp was accurately weighed and transferred into a clean, closed extraction vessel. Twenty grams of powdered fruit pulp was mixed with 250 mL of distilled water and allowed to undergo maceration at room temperature. The mixture was kept for 72 hours, with occasional stirring to improve contact between the powdered drug and the extracting solvent. Aqueous maceration of *T. catappa* material at room temperature has been reported in the literature; the quantities used here are a modification adopted for the present formulation rather than the exact quantities reported in the reference article.

After completion of the maceration period, the mixture was filtered first through muslin cloth to remove coarse plant particles and subsequently through suitable filter paper to obtain a clear filtrate. The aqueous filtrate was then concentrated carefully at a controlled, low temperature to reduce the water content and obtain a concentrated herbal extract. The concentrated extract was transferred into a clean, labelled, airtight container and stored under suitable conditions until further use in the herbal suspension formulation.



Aqueous extract of *Terminalia catappa* fruit pulp

FORMULATION OF *TERMINALIA CATAPPA* FRUIT PULP SUSPENSION

Three suspension formulations were prepared, differing only in the quantity of *Terminalia catappa* fruit pulp extract incorporated. In each case the extract was made up to a final volume of 50 mL, giving final concentrations of 4% w/v, 8% w/v and 12% w/v for F1, F2 and F3 respectively.

Preparation Procedure

CMC (1 g) was accurately weighed and triturated with a small quantity of purified water to form a smooth, uniform dispersion. The dispersion was allowed to hydrate properly to obtain a uniform suspending-agent base. Sucrose (20 g) was dissolved separately in a suitable quantity of purified water. Tween 80 (1 mL) was added to the vehicle and mixed thoroughly. The required quantity of *Terminalia catappa* fruit pulp extract was gradually incorporated into the vehicle with continuous trituration. Sodium benzoate (0.4 g) was dissolved separately in a small quantity of purified water and added to the formulation. Potassium sorbate (0.4 g) was similarly dissolved and incorporated into the formulation. Citric acid (0.4 g) was added and mixed thoroughly. Orange oil (1 drop) and amaranth (1 drop) were added and mixed uniformly. The prepared mixture was gradually incorporated into the hydrated CMC dispersion with continuous mixing. Purified water was added gradually to make the final volume up to 50 mL. The formulation was mixed thoroughly until a uniform suspension was obtained. The prepared suspension was transferred into a suitable, well-closed container. The same procedure was followed for F1, F2 and F3, using 2 g, 4 g and 6 g of *T. catappa* fruit pulp extract respectively, each made up to a final volume of 50 mL

Formulation of *Terminalia catappa* Fruit Pulp Suspension

INGREDIENTS	F1 (4% w/v)	F2 (8% w/v)	F3 (12% w/v)
<i>Terminalia catappa</i> fruit pulp extract	2 g	4 g	6 g
Carboxy methyl cellulose (CMC)	1 g	1 g	1 g
Tween 80	1 mL	1 mL	1 mL
Sodium benzoate	0.4 g	0.4 g	0.4 g
Sucrose	20 g	20 g	20 g
Citric acid	0.4 g	0.4 g	0.4 g
Potassium sorbate	0.4 g	0.4 g	0.4 g
Amaranth	1 drop	1 drop	1 drop
Orange oil	1 drop	1 drop	1 drop
Purified water (q.s.)	50 mL	50 mL	50 mL

EVALUATION TESTS FOR THE SUSPENSION

The prepared herbal suspension formulations (F1, F2 and F3) were evaluated for the physicochemical, pharmaceutical and microbiological parameters described below, in the same order in which the results are reported in the following chapter.

1. Appearance and Organoleptic Evaluation

Three suspension formulations of the aqueous extract of *Terminalia catappa* fruit pulp were prepared at 4% w/v (F1), 8% w/v (F2) and 12% w/v (F3) and evaluated as described in the previous chapter. The results obtained are presented below. Where a measurement has not yet been recorded in the laboratory, the corresponding cell has been left marked so that the value can be entered directly into this table.

Organoleptic Evaluation of the Formulated Suspensions

Organoleptic Evaluation

S.NO	PARAMETER	OBSERVATION
1	Nature	Liquid
2	Colour	Pink
3	Taste	Sweet

2. Determination of pH

The pH of the formulated *Terminalia catappa* fruit pulp extract suspension was determined using a calibrated digital pH meter.

Determination of pH

FORMULATION	CONCENTRATION (% w/v)	pH VALUE
F1	4	4.27
F2	8	4.25
F3	12	4.59

3. Determination of Viscosity

The viscosity of the formulated suspension was determined at room temperature using an Ostwald viscometer.

Determination of Viscosity

FORMULATION	CONCENTRATION (% w/v)	VISCOSITY (cP)
F1	4	1.069
F2	8	1.072
F3	12	1.077

4. Sedimentation Volume

The sedimentation volume was determined to assess the physical stability of the prepared suspension. The sedimentation volume is expressed as the ratio of the ultimate sediment volume (V_u) to the original volume of the suspension (V_o), using the formula $F = V_u/V_o$. The values obtained were compared among the F1, F2 and F3 formulations to evaluate their settling behaviour. 10 mL portion of each formulation was used for the test. Under the same test conditions, F3 showed the highest recorded sediment volume (0.9 mL) and F1 the lowest (0.1 mL), with F2 intermediate (0.5 mL). The recorded sediment volume therefore increased in the order $F1 < F2 < F3$.

Determination of Sedimentation Volume

FORMULATION	CONCENTRATION (% w/v)	VOLUME OF SUSPENSION TAKEN (mL)	SEDIMENT VOLUME (mL)
F1	4	10	0.1
F2	8	10	0.5
F3	12	10	0.9

5. Antimicrobial Screening

Microbial evaluation is important for an aqueous herbal suspension because the presence of water can support microbial growth. The test was performed to determine the microbiological quality of the formulation and to screen it for antimicrobial activity.



Figure 4: Zone of inhibition - *Bacillus* sp.



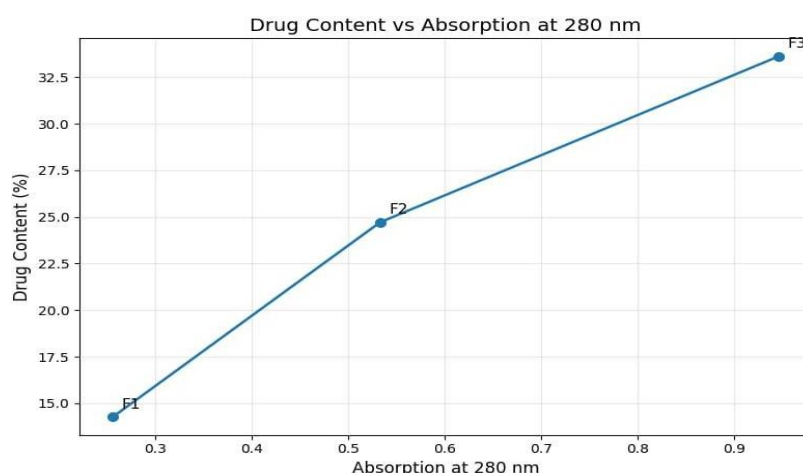
Figure 5: Zone of inhibition - *Escherichia coli*.

6. Drug Content

Extract content determination is performed to ensure that the formulated suspension contains a uniform and consistent amount of *Terminalia catappa* extract. For a herbal extract, estimation of a suitable marker compound, such as gallic acid, can provide better standardization than conventional drug-content testing. The suspension was shaken thoroughly to obtain a uniform dispersion, a measured quantity was transferred into a volumetric flask and extracted with a suitable solvent, and the mixture was sonicated and diluted to volume. The solution was filtered and the absorbance of the filtrate was measured using a UV-Visible spectrophotometer at the selected wavelength of the marker. The amount of marker present was calculated using the appropriate calibration curve, where percentage content = (estimated amount / theoretical amount) $\times$ 100.

The drug content of the formulation was determined spectrophotometrically at 280 nm and the concentration was calculated using the standard calibration curve.

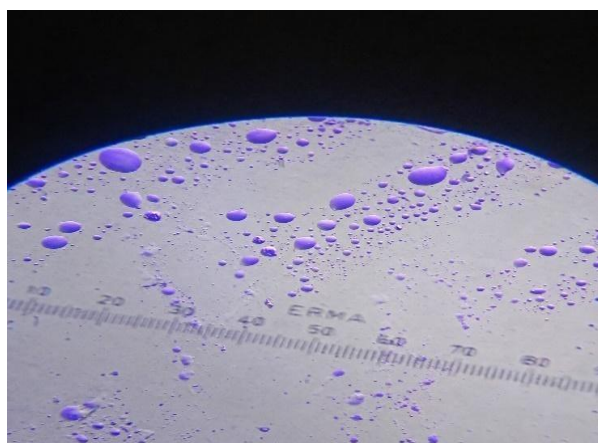
SAMPLE	Absorption at 280 nm	Drug amout found ($\mu\text{g/mL}$)	Drug content (%)
F1	0.256	17.12	14.27
F2	0.533	59.3	24.71
F3	0.946	121	33.61



7. Particle size determination

The particle size of the suspended particles is determined by observing the diluted suspension under a microscope and measuring the diameter of individual particles using a calibrated ocular micrometer.

The particle size of the formulated *Terminalia catappa* anthelmintic suspensions (F1, F2, and F3) was evaluated by measuring the size of individual particles and calculating the mean particle size. Ten particles were measured for each formulation.



FORMULATION	NO. OF PARTICLES	Arithmetic mean (μm)	Surface length mean (μm)	Volume surface mean (μm)
F1	124	12.4	14.2	16.8
F2	155	15.5	17.3	20.1
F3	226	22.6	24.5	28.4

8. Redispersibility Test

The formulated suspension was allowed to stand undisturbed until sedimentation occurred. Each formulation (F1, F2 and F3) was then gently inverted through 180° until a uniform dispersion was obtained. The number of inversions required for complete redispersion was recorded and the results were compared. The redispersibility of the *Terminalia catappa* suspension formulations was evaluated by the number of inversions required to obtain a uniform suspension after sedimentation. F1, F2, and F3 required 8, 6, and 9 inversions, respectively, for complete redispersion. F2 showed the best redispersibility, requiring the fewest inversions to achieve a uniform suspension.

9. Stability Study

Stability testing is performed to determine whether the formulated suspension maintains its physical, chemical and microbiological characteristics during storage. The optimised suspension was filled into its intended container, properly closed and stored under the selected stability condition; for a preliminary accelerated study the formulation may be stored at $40 \pm 2^\circ\text{C}$ / $75 \pm 5\%$ RH. Samples were withdrawn at predetermined intervals, such as 0, 1, 2 and 3 months, and evaluated for appearance, pH, viscosity, sedimentation volume, redispersibility, particle size.

The formulated *Terminalia catappa* fruit peel suspension was subjected to stability studies. No significant changes were observed in colour, odour, appearance, pH, viscosity, sedimentation volume, redispersibility, or drug content during the storage period. Thus, the formulation demonstrated good physical and chemical stability under the tested storage conditions.

10. In-vitro Anthelmintic Activity

In-vitro anthelmintic activity is the principal biological evaluation of the formulated suspension. Adult *Pheretima posthuma* earthworms are commonly used as an experimental model because of their anatomical and physiological resemblance to intestinal roundworms. The activity is evaluated by recording the time of paralysis and the time of death.

Procedure: adult *Pheretima posthuma* earthworms of approximately similar size were collected and washed thoroughly with water or normal saline to remove adhering soil and debris. The worms were divided into groups containing an equal number of worms. Albendazole was used as the standard drug and the vehicle was used as the control. The required volume of each test formulation was transferred into separate Petri dishes and the earthworms were introduced into the respective groups. The worms were then observed continuously.

Paralysis time (P): the time at which the worm showed no movement except after vigorous external stimulation was recorded.

Death time (D): the time at which the worm showed no movement even after vigorous external stimulation was recorded. The anthelmintic activity of the *Terminalia catappa* fruit pulp extract suspension was evaluated using adult earthworms (*Pheretima posthuma*). The paralysis time and death time were recorded for each formulation and the standard drug (Albendazole)

Table 11: In-vitro Anthelmintic Activity.

SAMPLE	PARALYSIS TIME (SEC)		DEATH TIME (MINS)	
	1ml	2ml	1ml	2ml
F1	49	44	3.25	2.55
F2	48	44	3.15	2.25
F3	48	43	3.03	2.1
Albendazole (standard)	1.05 min		2.45 min	

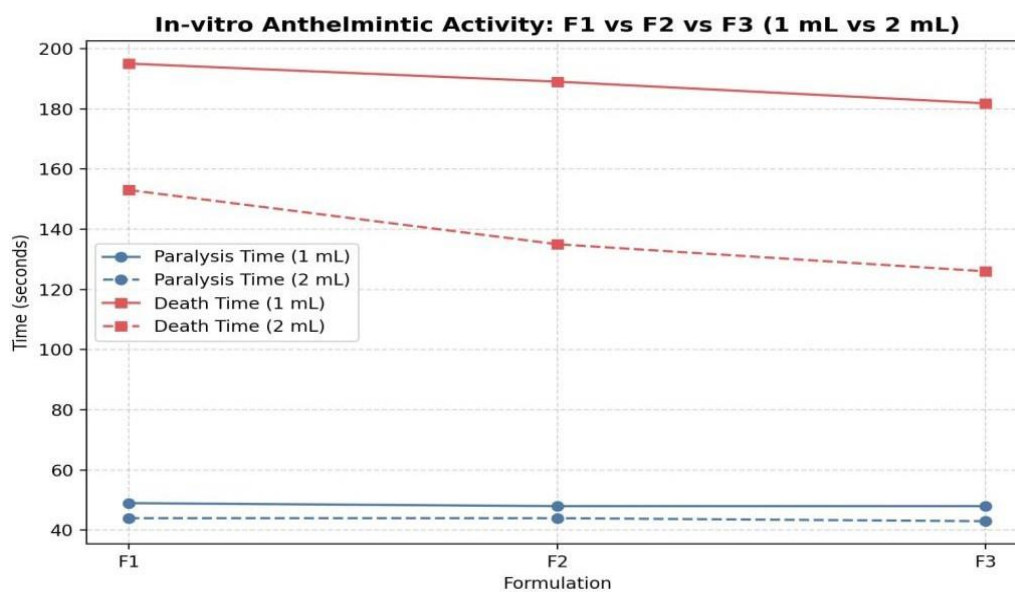
The in-vitro anthelmintic activity was evaluated against adult *Pheretima posthuma* earthworms by recording paralysis time and death time. The observations supplied for F1, F2 and F3 are presented for 1 mL and 2 mL test volumes, while Albendazole was used as the standard. The vehicle-control times were not supplied and are therefore not entered. The photographs below document the Albendazole standard and the sample earthworm used.



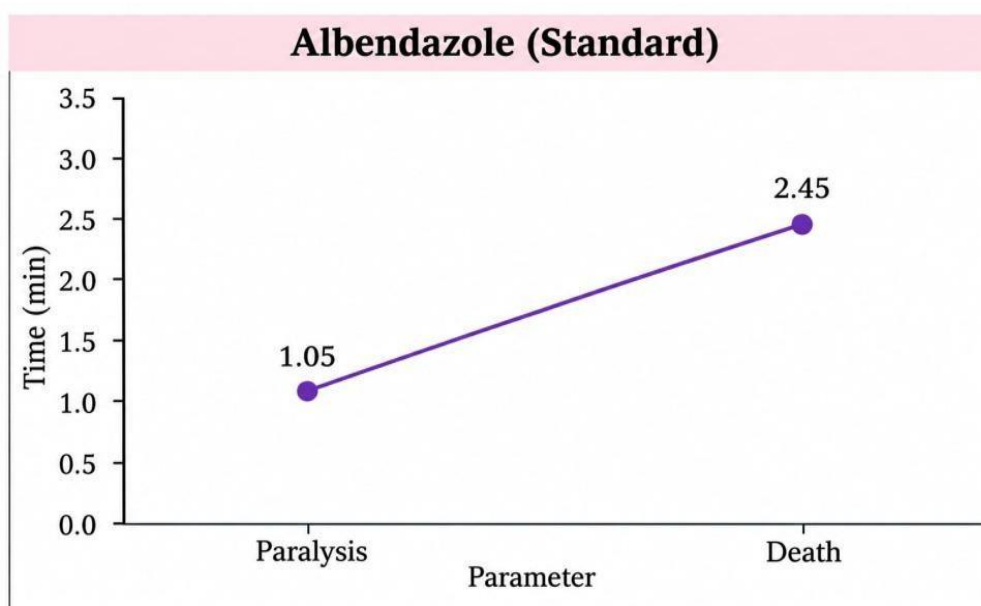
Albendazole standard used for the anthelmintic test.



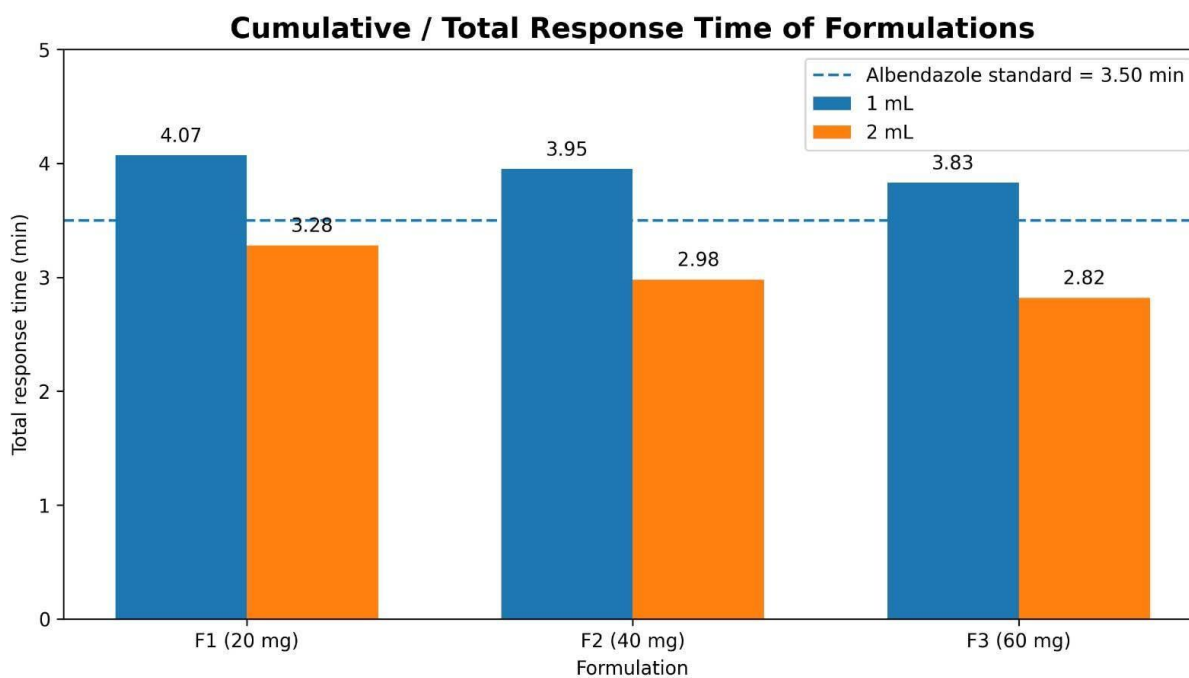
Earthworm sample used in invitro in-vitro anthelmintic test.



Paralysis and Death time of F1 & F2 & F3



Paralysis and death time of albendazole



Cumulative response time of formulation

CONCLUSION

In the present study, an aqueous extract of *Terminalia catappa* fruit pulp was successfully formulated into oral suspensions at concentrations of **4% w/v (F1), 8% w/v (F2) and 12% w/v (F3)** using carboxymethyl cellulose as the suspending agent along with suitable wetting, sweetening, preservative, colouring, flavouring and pH-adjusting agents.

The formulated suspensions exhibited acceptable **pink colour, sweet taste and liquid appearance**, indicating satisfactory organoleptic properties. The pH of the formulations ranged from **4.25 to 4.59**, indicating comparable acidic conditions among the formulations.

The sedimentation volume increased with extract concentration, with **F3 showing the highest sediment volume (0.9 mL)**, followed by F2 (0.5 mL) and F1 (0.1 mL). The drug-content values were **14.27%, 24.71% and 33.61% for F1, F2 and F3**, respectively, showing an increase corresponding to the extract concentration.

The **in-vitro anthelmintic study** demonstrated measurable paralysis and death responses for all formulations. Based on the cumulative response time shown in the study, the **2 mL test volume produced shorter total response times** than the 1 mL test volume.

The total response times for the 2 mL volume were **3.28 min (F1), 2.98 min (F2) and 2.82 min (F3)**, compared with **3.50 min for the albendazole standard**. Among the formulations, **F3 showed the shortest cumulative response time**, indicating a stronger in-vitro anthelmintic response under the specified experimental conditions.

Overall, the findings indicate that *Terminalia catappa* fruit pulp extract can be successfully incorporated into an oral suspension, and the **12% w/v formulation (F3) demonstrated the most pronounced in-vitro anthelmintic response among the formulations tested**. Further evaluation of stability, viscosity, antimicrobial activity and other quality parameters would help establish the formulation's overall pharmaceutical performance.

REFERENCES

1. Faust, E.C., Russell, P.F., and Jung, R.C., Craig and Faust's clinical parasitology. 8th edition. Philadelphia, Lea & Febiger, 1970; p. 251.
2. Hotez, P.J., et al. 2006. Incorporating a rapid impact package for neglected tropical diseases with programs for HIV/AIDS, tuberculosis, and malaria. *PLoS Med.* 3:e102.
3. Hotez, P.J., et al., Control of neglected tropical diseases. *N. Engl. J. Med.*, 2007; 357: 1018–1027.
4. Hotez PJ. Neglected parasitic infections and poverty in the United States. *PLoS Negl Trop Dis*, 2014; 8: e3012.
5. Brooker S, Kabatereine N, Gyapong J, et al. Rapid mapping of schistosomiasis and other neglected tropical diseases in the context of integrated control programmes in Africa. *Parasitol*, 2009; 136: 1707-18.
6. Suarez VH, Cristel SL, Buseti MR. Epidemiology and effects of gastrointestinal nematode infection on milk productions of dairy ewes. *Parasite*, 2009; 16(2): 141 7.
7. Anderson, R.M., Population dynamics of infectious diseases: theory and applications. Chapman and Hall. London, United Kingdom, 1982; 377.
8. Montresor, A., Crompton, D.W.T., Bundy, D.A.P., Hall, A., and Savioli, L., Guidelines for the evaluation of soil-transmitted helminthiasis and schistosomiasis at community level, 1998. http://whqlibdoc.who.int/hq/1998/WHO_CTD_SIP_98.1.pdf.
9. Cheever, A. W., K. F. Hoffmann, and T. A. Wynn. 2000. Immunopathology of schistosomiasis mansoni in mice and men. *Immunol. Today*, 21: 465–466.
10. Chiamonte, M. G., L. R. Schopf, T. Y. Neben, A. W. Cheever, D. D. Donaldson, and T. A. Wynn, IL-13 is a key regulatory cytokine for the cell-mediated pulmonary granuloma formation and IgE responses introduced by *Schistosoma mansoni* eggs. *J. Immunol*, 1999; 162: 920–930.
11. Dessein, A. J., D. Hillaire, N. E. Elwali, S. Marquet, Q. Mohamed-Ali, A. Mirghani, S. Henri, A. A. Abdelhameed, O. K. Saeed, M. M. Magzoub, and L. Abel, Severe hepatic fibrosis in *Schistosoma mansoni* infection is controlled by a major locus that is closely linked to the interferon-gamma receptor gene. *Am. J. Hum. Genet*, 1999; 65: 709–721.
12. Holden-Dye L, Walker RJ. Avermectin and avermectin derivatives are antagonists at the 4- aminobutyric acid (GABA) receptor on the somatic muscle cells of *Ascaris*; is this the site of anthelmintic action? *Parasitology*, 1990; 101(Pt 2): 265–271. [PubMed: 2175874]
13. Hotez PJ, Brindley PJ, Bethony JM, King CH, Pearce EJ, Jacobson J. Helminth infections: the great neglected tropical diseases. *J Clin Invest*, 2008; 118(4): 1311–1321. [PubMed: 18382743]
14. Martin RJ, Robertson AP, Bjorn H. Target sites of anthelmintics. *Parasitology*, 1997; 114(Suppl): S111–124. [PubMed: 9309773]
15. Doyle, S. R.; Cotton, J. A. *Trends Parasitol*, 2019; 35: 289–301.doi:10.1016/j.pt.2019.01.004
16. Preston S, Jiao Y, Baell JB, et al. Screening of the 'Open Scaffolds' collection from compounds Australia identifies a new chemical entity with anthelmintic activities against different developmental stages of the barber's pole worm and other parasitic nematodes. *Int J Parasitol*, 2017; 7: 286-94.
17. Sarai RS, Kopp SR, Coleman GT, Kotze AC. Drug-efflux and target-site gene expression patterns in *Haemonchus contortus* larvae able to survive increasing concentrations of levamisole in vitro. *Int J Parasitol Drugs Drug Resist*, 2014; 4:77–84. doi:10.1016/j.ijpddr.2014.02.001
18. Kaingu F, Kibor A, Waihenya R, et al. Efficacy of *Aloe secundiflora* crude extracts on *Ascaridia galli* in vitro.

Sustain Agric Res, 2013; 2: 49-53.

19. Sarai RS, Kopp SR, Coleman GT, Kotze AC. Drug-efflux and target-site gene expression patterns in *Haemonchus contortus* larvae able to survive increasing concentrations of levamisole in vitro. *Int J Parasitol Drugs Drug Resist*, 2014; 4: 77–84. doi:10.1016/j.ijpddr.2014.02.001
20. Teagasc A; 2010 <https://www.teagasc.ie/media/website/publications/2010/AnthelminticResistance.pdf>. Accessed May 4, 2017.