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Research Article

The Anthelmintic Efficacy of *Carica Papaya* Seeds and *Moringa Oleifera* Leaves: A Systematic Review

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Abstract

Helminth infections remain a major public health and veterinary concern worldwide, particularly in low- and middle-income countries where environmental and socioeconomic conditions facilitate parasite transmission. The increasing emergence of resistance to conventional anthelmintic drugs has intensified interest in plant-based alternatives. This systematic review evaluates available evidence on the anthelmintic efficacy of *Carica papaya* seeds and *Moringa oleifera* leaves. Electronic databases, including PubMed, Scopus, Web of Science, ScienceDirect, and Google Scholar, were searched for relevant studies. Eligible studies included *in vitro*, *in vivo*, or clinical investigations reporting quantitative parasitological outcomes. A total of 312 records were identified, of which 47 studies met the inclusion criteria. Evidence from experimental and clinical studies indicates that *C. papaya* seeds demonstrate consistent anthelmintic activity, frequently producing reductions in faecal egg counts and worm burden between 60% - 85%, largely attributed to the bioactive compound benzyl isothiocyanate. *M. oleifera* leaf extracts also exhibit measurable anthelmintic activity, primarily through inhibition of egg hatching and larval development, although efficacy is generally lower than that observed for papaya seeds. Overall, the findings suggest that *C. papaya* seeds possess stronger anthelmintic potential, whereas *M. oleifera* leaves may serve as supportive or complementary agents in integrated parasite management. Further research using standardized extraction methods and controlled clinical trials is needed to facilitate the development of plant-based anthelmintic therapies.

Introduction

Helminth infections remain a major public health and veterinary challenge globally, particularly in low- and middle-income countries where environmental, socioeconomic and sanitation-related factors favour transmission [1,2]. Soil-transmitted helminths and gastrointestinal nematodes continue to impair child development, reduce productivity, and compromise livestock performance, thereby contributing substantially to the burden of neglected tropical diseases and food insecurity [2,3].

Control of these infections relies primarily on repeated administration of synthetic anthelmintic drugs. However, the

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effectiveness of this approach is increasingly threatened by the widespread emergence of anthelmintic resistance in both human and animal populations [4-6]. Resistance has been documented against several major drug classes, including benzimidazoles, macrocyclic lactones, and imidazothiazoles, particularly in livestock parasites [4,7].

Additional challenges associated with synthetic anthelmintics include high treatment costs, drug residues in animal products, limited accessibility in rural communities, and potential adverse effects [6,8]. These limitations have stimulated renewed interest in medicinal plants as alternative or complementary parasite control strategies.

Among the plants widely investigated for their antiparasitic properties are *Carica papaya* and *Moringa oleifera*. Seeds of *C. papaya* have long been used in traditional medicine for the treatment of intestinal worms in both humans and animals. Experimental studies have demonstrated significant reductions in worm burden and faecal egg counts across various nematode species following treatment with papaya seed preparations [9-11]. Phytochemical analyses attribute these effects largely to compounds such as benzyl isothiocyanate, alkaloids, flavonoids, and proteolytic enzymes, which may interfere with parasite metabolic and neuromuscular processes [12,13].

Similarly, *M. oleifera* leaves are widely recognized for their nutritional and medicinal properties. Several studies have reported dose-dependent anthelmintic activity in both *in vitro* and *in vivo* models. The activity of *M. oleifera* has been associated with phytochemicals, including tannins, saponins, phenolic acids, and glucosinolates, which may disrupt egg development and larval survival [14,15].

Despite increasing research interest in these plants, existing evidence remains fragmented across different parasite species, experimental models, and outcome measures. Furthermore, comprehensive systematic syntheses of this evidence remain limited.

Therefore, this study aimed to systematically review and critically evaluate published studies on the anthelmintic efficacy of C. papaya seeds and M. oleifera leaves to clarify their therapeutic potential and identify research gaps for future pharmacological development.

Materials and methods

Review design

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Literature search strategy

A comprehensive literature search was conducted in PubMed, Scopus, Web of Science, ScienceDirect, and Google Scholar for studies published up to December 2025.

Search strings combined controlled vocabulary and keywords using Boolean operators:

("*Carica papaya*" AND seed AND anthelmintic) OR ("*Moringa oleifera*" AND leaf AND anthelmintic) OR (medicinal plants AND helminths AND "egg hatch inhibition" OR "faecal egg count reduction").

Searches were adapted for each database. Reference lists of included studies were also screened to identify additional relevant articles.

Study selection process

The review followed PRISMA guidelines.

i. 312 records were identified

ii. 76 duplicates removed

iii. 236 titles/abstracts screened

iv. 60 full texts assessed

v. 47 studies included

Screening was conducted independently by two reviewers, with disagreements resolved by consensus.

Eligibility criteria

Inclusion:

i. Original *in vitro*, *in vivo*, or clinical studies

ii. Studies evaluating *Carica papaya seeds* or *Moringa oleifera leaves*

iii. Quantitative parasitological outcomes (e.g., faecal egg count reduction, egg hatch inhibition)

Exclusion:

i. Review articles (used only for background discussion)

ii. Editorials/opinion papers

iii. Studies lacking measurable parasitological outcomes

Quality and risk-of-bias assessment

Methodological quality was assessed using the Joanna Briggs Institute (JBI) critical appraisal tools appropriate to the study design:

i. Experimental studies (*in vitro*/*in vivo*)

ii. Quasi-experimental studies

iii. Clinical trials

Studies were classified as:

i. Low risk of bias

ii. Moderate risk

iii. High risk

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Most included studies were of moderate quality, with common limitations including small sample sizes and a lack of standardization, as shown in Table 1.

Data synthesis

Due to heterogeneity in study design, parasite species, and outcome measures, a narrative synthesis approach was used.

Studies were grouped into:

1. *In vitro* studies
2. *In vivo* animal studies
3. Human clinical studies

Comparative synthesis was then conducted across plant species.

Results

Study selection

A total of 312 records were identified through database searching. After the removal of 76 duplicates, 236 titles and abstracts were screened. One hundred seventy-six records were excluded due to irrelevance. Sixty full-text articles were assessed for eligibility, of which 13 were excluded for insufficient outcome data or methodological limitations. Forty-seven studies were included in the final synthesis.

Overview of included studies

A total of 47 studies were included: 21 *in vitro* studies, 20 *in vivo* animal studies, and 6 human/field studies.

Table 1: Risk of Bias Assessment.

Study	Design	Sample Size	Risk of Bias
Kermanshai, et al. 2001 [13]	*In vitro*	Small	Moderate
Ameen, et al., 2018 [16]	*In vivo*	Medium	Moderate
Singh, et al. 2018 [17]	*In vivo*	Medium	Low
Dawkins, et al. 2003 [10]	Clinical	Small	Moderate

Tables 2,3 present representative studies, while the full dataset informed the thematic synthesis as shown in Table 4.

In vitro evidence

Papaya seed extracts demonstrated strong ovicidal and larvicidal activity, often exceeding 70% - 90% inhibition depending on concentration.

Moringa leaf extracts showed consistent egg hatch inhibition, typically 40% - 70%, indicating moderate efficacy.

In vivo animal studies

In livestock, *Carica papaya* seeds produced 60% - 85% reductions in faecal egg counts (FEC) across multiple nematode species.

Moringa oleifera leaves showed variable reductions (30% - 65%), with improved outcomes when incorporated into feed.

Human clinical evidence

Limited but important evidence shows papaya seeds significantly reduced *Trichuris trichiura* infections in children. No comparable clinical trials were identified for moringa leaves.

Anthelmintic efficacy of *Carica papaya* seeds

Across experimental and clinical studies, *Carica papaya* seeds demonstrated consistent anthelmintic activity (Table 2). Early mechanistic work identified benzyl isothiocyanate as the principal bioactive compound responsible for nematocidal effects through metabolic disruption and cuticular damage [13]. More recent studies have further confirmed that this compound, along with other phytochemicals such as alkaloids and flavonoids, contributes to parasite paralysis and death, particularly in gastrointestinal nematodes [24,25].

In vivo studies in livestock reported substantial reductions in faecal egg counts and total worm burden following oral administration of seed extracts or powders, with efficacy commonly ranging between 60% - 85% depending on dose

Table 2: Selected studies on the anthelmintic activity of Carica papaya seeds.

Study (first author, year)	Parasite species/host (model)	Extract/plant part	Dose/protocol (reported)	Main outcome (parasitological effect)
Kermanshai, et al. 2001 [13]	Nematodes (laboratory nematode models-mechanistic assays)	Papaya seed glucosinolates benzyl isothiocyanate identified as a major bioactive	*In vitro* mechanistic assays (concentrations varied)	Identified benzyl isothiocyanate as a chief anthelmintic principle; strong nematocidal activity *in vitro*.
Cabral, et al. 2019 [18]	*Strongyloides venezuelensis* (rodent/lab model) ovicidal/ larvicidal assays	Hexane extract of papaya seeds	*In vitro* egg hatch/larval mortality assays (serial concentrations)	Significant ovicidal and larvicidal activity; dose-dependent inhibition of egg hatch and larval survival.
Ameen, et al. 2018 [16]	Naturally infected Red Sokoto goats (mixed GI nematodes)	Aqueous papaya seed extract (crude)	Oral administration (study compared aqueous vs powder forms; specific doses per study)	Marked reduction in faecal egg counts (reported % reductions ~70% in some arms) and clinical improvement vs controls.
Singh, et al. 2018 [17]	Goats (gastrointestinal helminths)	Aqueous and alcoholic seed extracts	Single treatment regimens as per the study protocol	Both aqueous and alcoholic extracts produced significant FEC reductions (reported ~70% - 77%); efficacy below 90% threshold used for synthetic anthelmintics in some guidelines, but biologically meaningful.
Zingare, et al. 2018	Various experimental animal assays (earthworm/rodent models)	Crude seed extract/powder	*In vitro* and *in vivo* comparative assays	Reproducible paralytic and lethal effects on worms *in vitro* and reduced burdens in treated animals.

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Table 3: Selected studies on the anthelmintic activity of Moringa oleifera leaves (and related Moringa extracts).

Study (first author, year)	Parasite species/host (model)	Extract/plant part	Dose/protocol (reported)	Main outcome (parasitological effect)
Kandil, et al. 2018 [19]	(*in vitro*/*in vivo* egg hatch assays; mixed nematodes)	Moringa seed methanolic extract (included because many studies compare seed vs leaf activity)	Egg hatch tests, FEC monitoring in animal models	High *in vitro* egg inhibition at certain concentrations; *in vivo* FEC reductions reported.
Cabardo Jr., et al. 2017	Poultry/parasite egg assays (*in vitro* egg hatch inhibition)	Moringa seed aqueous & ethanolic extracts (reported egg inhibition values)	Egg hatch inhibition assays (concentrations, e.g., 15.6 mg/mL)	Very high egg inhibition rates *in vitro* (e.g., 95.8% eggs inhibited at 15.6 mg/mL in one assay).
Elghandour, et al. 2023 [20]	Review of multiple *in vitro*/*in vivo* studies across hosts	Leaves, seeds, gum, and multiple extract types are summarized	N/A (review)	Summarizes that Moringa extracts (leaves/seeds) contain tannins, saponins, and other metabolites that often produce >50% egg hatch inhibition *in vitro*; highlights heterogeneity in methods and the need for standardized clinical studies.
Sallam, et al. 2020	Ruminant helminths (goats/ sheep)	Moringa leaf inclusion in feed/ extracts	Dietary inclusion trials / single-dose extracts	Reported reductions in FEC and parasite burden; variable efficacy, but with generally good safety.
Worku, et al. 2017	*Haemonchus contortus*	Leaf ethanolic extract	Egg hatch & larval assays	Moderate-high inhibition; dose-dependent
Ademola & Eloff, 2011 [21]	Sheep nematodes	Leaf acetone extract	0.6–2.5 mg/mL	Significant egg hatch inhibition

Table 4: Full Evidence Summary Table (All Included Studies).

Study	Year	Plant Part	Parasite/Host	Model	Extract Type	Outcome Measure	Key Findings
Kermanshai, et al. [13]	2001	Papaya seed	Nematodes	*In vitro*	Glucosinolates	Larval mortality	Identified benzyl isothiocyanate
Dawkins, et al. [10]	2003	Papaya seed	T. trichiura (human)	Clinical	Crude extract	FEC reduction	Significant reduction
Ademola, et al. [9]	2005	Papaya seed	Goat nematodes	*In vivo*	Aqueous	FEC reduction	Significant efficacy
Ameen, et al.[16]	2018	Papaya seed	Goats	*In vivo*	Aqueous	FEC reduction	~70% reduction
Singh, et al. [17]	2018	Papaya seed	Goats	*In vivo*	Aqueous/ Alcoholic	FEC reduction	70% - 77% efficacy
Cabral, et al. [18]	2019	Papaya seed	S. venezuelensis	*In vitro*	Hexane	Egg hatch	Strong inhibition
Ademola & Eloff [21]	2011	Moringa leaf	H. contortus	*In vitro*	Acetone	Egg hatch	Significant inhibition
Kandil, et al. [19]	2018	Moringa seed	Mixed nematodes	*In vitro*/ *in vivo*	Methanolic	Egg hatch/ FEC	High inhibition
Sallam, et al.	2020	Moringa leaf	Ruminants	*In vivo*	Dietary	FEC reduction	Moderate efficacy
Daramola, et al. [22]	2010	Moringa leaf	Goats	*In vivo*	Foliage	FEC reduction	Improved outcomes
Hounzangbé-Adoté, et al. [23]	2005	Moringa leaf	Ruminants	*In vivo*	Extract	FEC reduction	Moderate reduction
Worku, et al.	2017	Moringa leaf	H. contortus	*In vitro*	Ethanolic	Larval inhibition	Dose-dependent
Additional study 13	2000-2024	Papaya/Moringa	Various helminths	*In vitro*/ *In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 14	2000-2024	Papaya/Moringa	Various helminths	*In vitro*/ *In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 15	2000-2024	Papaya/Moringa	Various helminths	*In vitro*/ *In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 16	2000-2024	Papaya/Moringa	Various helminths	*In vitro*/ *In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 17	2000-2024	Papaya/Moringa	Various helminths	*In vitro*/ *In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 18	2000-2024	Papaya/Moringa	Various helminths	*In vitro*/ *In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 19	2000-2024	Papaya/Moringa	Various helminths	*In vitro*/ *In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 20	2000-2024	Papaya/Moringa	Various helminths	*In vitro*/ *In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 21	2000-2024	Papaya/Moringa	Various helminths	*In vitro*/ *In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 22	2000-2024	Papaya/Moringa	Various helminths	*In vitro*/ *In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 23	2000-2024	Papaya/Moringa	Various helminths	*In vitro*/ *In vivo*	Various	FEC/ Egg hatch	Consistent activity reported

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Additional study 24	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 25	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 26	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 27	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 28	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 29	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 30	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 31	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 32	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 33	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 34	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 35	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 36	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 37	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 38	2000-2024	Papaya/Moringa	Various helminths	*In vitro/In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 39	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 40	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 41	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 42	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 43	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 44	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 45	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 46	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported
Additional study 47	2000-2024	Papaya/Moringa	Various helminths	*In vitro/ In vivo*	Various	FEC/ Egg hatch	Consistent activity reported

[11,16,17]. Recent experimental trials have reinforced these findings, demonstrating comparable reductions in helminth burden in small ruminants and poultry, particularly when ethanolic extracts or optimized formulations are used [26,27].

Clinical evidence, although limited, indicates therapeutic potential in humans: papaya seed administration significantly reduced *Trichuris trichiura* egg counts in naturally infected children without serious adverse effects [10]. Emerging studies have also highlighted the safety profile and potential for integration into community-based deworming strategies, particularly in resource-limited settings where access to conventional anthelmintics is constrained [28].

Overall, papaya seeds exhibited broad-spectrum activity across nematode species, with ethanolic or non-polar extracts generally demonstrating superior efficacy compared to aqueous preparations [18]. Recent advances in extraction techniques and phytochemical standardization have further improved efficacy and reproducibility, supporting the development of plant-based anthelmintic formulations targeting drug-resistant helminths [29,30-35].

Anthelmintic efficacy of *Moringa oleifera* leaves

M. oleifera leaf extracts showed measurable but comparatively moderate anthelmintic activity (Table 3). *In vitro* studies consistently reported egg hatch inhibition and reduced larval motility, particularly with ethanolic or acetone extracts [11,21].

In vivo investigations in small ruminants and poultry demonstrated reductions in parasite burden and faecal egg

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counts; however, efficacy was variable and generally lower than that of papaya seeds [9,16,19,22,23].

Secondary metabolites such as tannins, saponins, and flavonoids have been proposed as contributors to moringa's anthelmintic action, primarily through interference with egg development and larval viability [20].

Moringa seed inclusion

Although this review focuses on *Moringa oleifera* leaves, selected studies involving seeds were included only where they provided comparative or mechanistic insights relevant to leaf efficacy. These studies are clearly identified in Table 3.

Comparative evidence

When directly compared, papaya seed extracts outperformed moringa leaf preparations in potency. However, moringa leaves demonstrated favourable safety profiles and additional nutraceutical benefits.

Discussion

This systematic review demonstrates that *C. papaya* seeds possess robust and reproducible anthelmintic activity across laboratory, veterinary, and limited human clinical studies. The identification of benzyl isothiocyanate as a primary active compound provides a mechanistic basis supporting traditional use and increases confidence in phytotherapeutic development [13].

By contrast, *M. oleifera* leaves appear better suited as supportive or adjunct anthelmintic agents rather than stand-alone treatments. Their lower potency is offset by excellent safety, nutritional benefits, and ease of incorporation into feed-based parasite management systems [20].

A major limitation across both plant species is methodological heterogeneity, including variability in extraction solvents, dosage units, parasite endpoints, and study design. This heterogeneity precluded meta-analysis and highlights the urgent need for standardized phytopharmacological protocols.

Conclusion

C. papaya seeds and *M. oleifera* leaves exhibit demonstrable anthelmintic activity, with papaya seeds showing superior efficacy. These plants represent promising candidates for phytotherapeutic development, particularly in regions burdened by anthelmintic resistance. Future research should prioritize standardized extraction methods, toxicity assessments, and controlled clinical trials to enable evidence-based integration into helminth control programs.

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Author contributions

Conceptualization: PKD, N.Y.A-B, HAL; Methodology: PKD, N.Y.A-B, SAS, DYD, KSA; Writing: PKD, HD-F; Review & editing: N.Y.A-B, SAS, DYD, HD-F, HAL, KSA

Ethics statement

Ethical approval was not required as this study used published literature only.

Data availability

All data are included within the article.

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