Chapter 23

Exploring the Potential of Plant Extract, Green Nanoparticles, and Oil Formulation for the Control of Disease Caused by Cestodes: Trends and Challenges

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ABSTRACT

Cestode infestations severely compromise animal health and result in significant financial losses because of excessive levels of sickness and death, costly medication, and decreased production. Because of the emergence of drug susceptibility and climate change, the efficacy of conventional control methods, such as periodic anthelmintic medication along with control measures, are being put under increasing pressure. This chapter highlights the importance of using plant extracts, essential oils, and green nanoparticle technologies to reduce livestock cestode infestations. The increasing acceptance of natural remedies can be attributed to their strong antiparasitic characteristics and ability to offer a persistent resolution for problems related to animal infestation. Plant extracts that are effective in the management of parasitic diseases include ginger, eucalyptus, coriander seeds, neem, garlic, and pumpkin seeds. These extracts are rich in bioactive components that demonstrate potent anti-cestode activity. Similarly, essential oils derived from Ajowan, European black pine, garlic, black cumin, and turmeric, along with green nanoparticles manufactured from plant sources, such as eucalyptus and neem, possess beneficial antiparasitic, antibacterial, and antifungal qualities. Future proposals call for the undertaking of further research and studies to improve formulations for the large-scale production and application of essential oils, green nanoparticles, and plant extracts with a specific focus on the management of cestode infections. Furthermore, there is need of effective integration of these natural therapies into current frameworks for controlling livestock illness necessitates collaboration between researchers, veterinarians, and legislators.

KEYWORDS		
Cestode, *Moniezia*, *Echinococcus granulosus*, *Hymenolepis*, *Raillietina*, *Taenia*, Anthelmintic treatment, Plant extracts, Essential oil, Green nanoparticles, Scolicidal, protoscolex.	Received: 19-Jun-2024 Revised: 18-Jul-2024 Accepted: 16-Aug-2024	A Publication of Unique Scientific Publishers

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INTRODUCTION

Cestodes, also referred to as tapeworms, are significant endoparasites that affect both livestock and humans (Siles-Lucas and Hemphill, 2002). The genus cestode consists of around 5,000 species that are distributed globally (Trevisan et al., 2021). These parasites can be transmitted from animals to humans and vice versa (Jeon and Eom, 2024), thereby having a major impact on both the human and livestock sectors. Almost all the cestodes have complicated life cycles (Fig. 1), involving both final and intermediate hosts with severe clinical manifestations such as sparganosis, neurocysticercosis, and echinococcosis (Jeon and Eom, 2024). Apart from the complex life cycle, they are distinct in a few ways, such as tapeworms absorbing nutrients through the integument and lacking an alimentary canal. They have a scolex (head) and neck that are joined to repeating segments called proglottids. Terminal proglottids release eggs that are expelled through the stool, where they hatch into oncospheres. These oncospheres then move to the various organs, where they mature into cysticercus larvae (or hydatid larvae, depending on the species) (Panda et al., 2022). Cestodes species cause infection in livestock, leading to significant economic losses and jeopardizing food production in many parts of the world. (Abdel-Ghaffar et al., 2011).

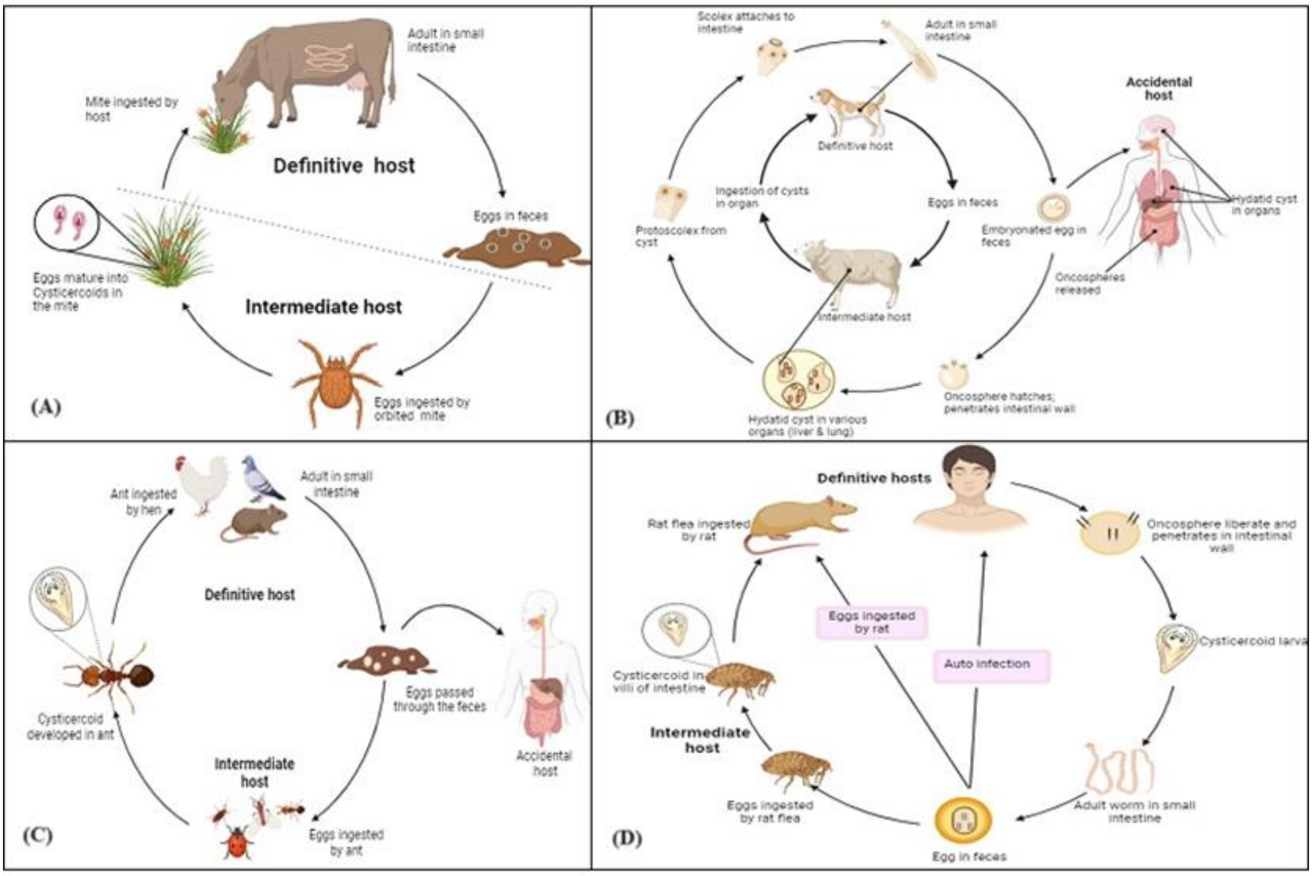

Fig. 1: Life cycle of cestodes along with their intermediate and definite host (a) *Moniezia* spp. (b) *Echinococcus granulosus* (c) *Raillietina* spp. (d) *Hymenolepis* spp.

Recently, many studies have primarily focused on natural therapies because of increasing anthelmintic resistance and side effects of synthetic drugs. Some plants have been proven to be effective against helminthic parasites, but there are many more plants that haven't been studied so far (Kundu et al., 2012). For this purpose, a program launched by the World Health Organization (WHO) in 2000 formally advocated the study of goods produced from plants (Abdel-Ghaffar et al., 2011), that will ultimately have a beneficial outcome for the development of new and effective green anthelmintic drug. Although there are a limited number of medications that are effective against intestinal helminths, over one-third of the world's population does not have access to basic medications, and that number rises to over 50% in many under-developed nations. In this context, traditional medicines, primarily relying on herbs and trees, can provide a significant and readily available source of healthcare for people and their livestock. Medicinal plants have served as crucial sources of therapeutic remedies for thousands of years and remain essential in modern times too (Yadav and Temjenmongla, 2011). With advances in technologies, Plant-based natural products (NP) are being produced and experimentally studied to determine their efficacy against cestode parasites. The production of green nanoparticles (NPs) is inexpensive, scalable, and environmentally harmless (Gour and Jain, 2019). Concurrently Maggiore and Elissondo (2014) have found that certain essential oils and their constituents exhibit anthelminthic effects, however, additional research is needed.

This chapter discusses the utilization of naturally occurring compounds, such as essential oils, green nanoparticles, and plant extracts, as pharmaceuticals for treating cestodes of veterinary importance. There are many benefits of these naturally occurring compounds as they are safe to consume, readily available, and do not have any detrimental effect on our ecosystem.

Current Challenges to Anthelminthic Research and its Application

Pakistan's economy depends heavily on its livestock sector. Livestock can contract several parasite illnesses because of insufficient care, an unhygienic environment, severe weather conditions, and close proximity to infected animals (Gadahi et al., 2009). Tropical countries in South Asia have a rich biodiversity that could offer natural products for anthelmintic activity. However, challenges like limited research, funding, awareness, industry partnerships, and technological innovations hinder anthelmintic research in the region (Kamal et al., 2023). Systematic deworming of livestock with a broad-spectrum anthelminthic cannot be suggested to pastoralists due to high pricing, unavailability or inaccessibility of medications and veterinary services. As a result, low-cost locally applied measures such as the use of plant-based remedies against GI parasites should be systematically evaluated for their effectiveness against the most common helminth species in the South Asia region (Raza et al., 2014).

Exploring the Efficacy of Medicinal Plants in Cestode Parasite Control

The control of parasites often relies on commercial drugs, but these are expensive, making them inaccessible to many low-income farmers. Additionally, some parasites have developed resistance to these drugs and their use can contribute to environmental pollution (James et al., 2009). Because of the challenges with expensive and potentially environmentally harmful commercial drugs, farmers have turned to alternative methods, such as using the medicinal plant to treat and control livestock parasites. There's a belief that natural products are perceived as safe and harmonious with the biological system (Sanhokwe et al., 2016).

Plants have the ability to produce beneficial synthetic compounds. Extracting and identifying these active compounds from medicinal plants have led to the discovery of new drugs with significant therapeutic benefits (Huie, 2002). Plant extracts can function as scolicidal agents for cestodes, in the distant past plant-based helminthic treatments were widely used. In 1974, a successful treatment in Taiwan involved thirty-two individuals with taeniasis using a combination of a mixture of boiled areca nuts and pumpkin seeds (Chung and Ko, 1976). In 2009, extracts from pumpkin seeds were utilized for the treatment of *Tenia solium* (Ito et al., 2013). The efficacy of wormicidal plant extracts from *Melia azedarach* surpassed that of piperazine phosphate in the treatment of *T. solium* (Szewezuk et al., 2003). In general, the efficacy of an extract against a specific worm load is influenced by the choice of extraction fluid, such as methanolic, ethanolic, aqueous, acetonitrile, chloroform, etc. (Mehlhorn et al., 2011) (Fig. 2). Below, we shall discuss promising studies on the plant extract produced by using various extraction fluids.

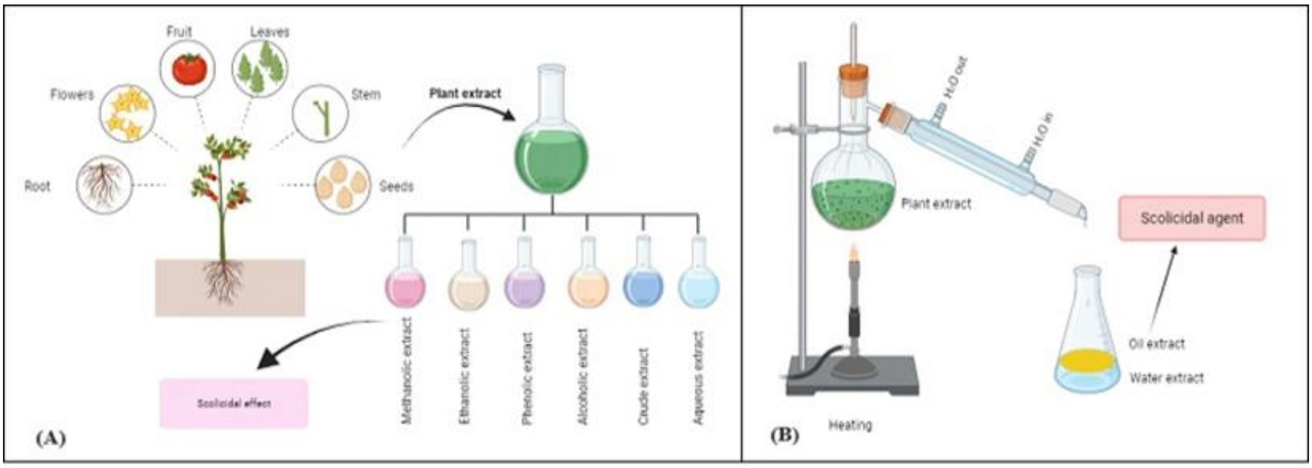

Fig. 2: Various plant parts can be utilized to make plant extracts (A) and essential oils (B) through the use of different extraction mediums.

Methanolic Extract

The methanolic extracts of ginger (*Zingeber officinale*) and eucalyptus can be used to treat *E. granulosus*. The extract of ginger at a concentration of 100mg/ml and eucalyptus at concentrations of 50 and 100mg/ml exhibited a 100% kill rate of protoscolices after 40 minutes. Additionally, all concentrations of the methanolic extract of ginger and eucalyptus can show a significant effect on protoscolex (Faizei et al., 2015) (Table 1). Another methanolic extract of Shirazi thyme (*Zataria multiflora)* is used for the treatment of cestodes at a concentration of 25mg/ml shows 100% scolicidal effect after 1 minute. These findings suggest that the methanolic extract of *Z. multiflora* exhibits strong scolicidal activity and could be considered an effective agent against parasites (Moazeni and Roozitalab, 2012).

Phenolic Extract

Phenolic extract obtained from coriander (*Coriandrum sativum)* seeds can be used to treat *E. granulosus*. Further study revealed that higher concentrations of this extract correlated with reduced protoscolices viability, and the number of deceased protoscolices increased over time. Particularly, after three days of therapy, a concentration of 0.75gm/ml had the greatest effect on the persistence of protoscolices, therefore could help in eliminating the parasite (Dawwas, 2008) (Table 1).

Ethanolic Extract

Ethanolic extract of ginger (*Zingeber officinale*) has anti-protoscolicidal properties. Ginger is one of the most well-known spices in the world, and it has been used for centuries for its medicinal advantages. Protoscolices of *E. granulosus* can be eliminated at concentrations of 150mg per milliliter after one hour of exposure (Baqer et al., 2014). There is another ethanolic extracts of mint (*Mentha spicata*), garden thyme (*Thymus vulgaris*), and tulsi (*Ocimum basilicum*) which may act as an effective alternative to anti-protoscolices. The garden thyme and mint extracts had the maximum efficacy at 100%, whereas tulsi had 98.8% efficacy after a 20-minute exposure to 75 milligrams per milliliter, greatly diminishing the viability of protoscolices. However, the extract revealed time-dependent consequences (Abed and Ibrahim, 2021).

Alcoholic Extract

An alcoholic extract from coriander (*Coriandrum sativum*) seeds has been used to treat parasitic illnesses. Specifically, administering doses of *C. sativum* at five hundred and seven hundred fifty milligrams per kilogram shows complete efficacy after fifteen days of therapy. The addition of a thousand milligrams per milliliter of *C. sativum* extract has been shown to remove worms in a thirty-minute timeframe. According to Hosseinzadeh et al. (2016), the extract of *C. sativum* has potential in combating *Hymenolepis nana* (Table 1).

Aqueous Extract

A scolicidal agent has been found in the aqueous extract of Mediterranean saltbush (*Atriplex halimus*) leaves. Following 120 minutes of incubation, the death rates were 99.36 and 100%, at doses of 60 and 100mg/ml, respectively. Scanning electron microscopy (SEM) pictures showed these plant's extracts affected the parasite tegument, illustrating the potential benefits of *A. halimus* extract as a possible scolicidal therapy for hydatid cysts (Bouaziz et al., 2021).

Raw Extract

The unrefined extract of santonica (*Artemisia cina*), has anthelmintic properties. Through *in-vitro* and *in-vivo* experiments, the efficacy of the raw plant extract has been demonstrated at different concentrations. The plant extract was effective in vitro at all doses, and microscopy examination demonstrated that the worms' different structures such as scolex and microtriches of the external tegumental surface, were notably damaged. Using anthelminthic treatment to treat severely affected animals resulted in the complete elimination of infection. The results of fecal examinations after the treatment showed that there are no eggs of parasites in the feces of animals (Bashtar et al., 2010). A mixture of onion extract (*Allium cepa*) and coconut extract (*Cocos nucifera*) combined with milk powder has shown effectiveness in treating Moniezia spp. When a dose of 60g of this extract was administered daily for 8 days, the worm stages disappeared from the feces (Mehlhorn et al., 2010).

Table 1: An overview of the latest findings on the efficacy of plant extract in controlling Cestodes of veterinary importance

Plant Extract	Parasites	Dose	Exposure Time	Mortality (%)	Effects	References
Ocimum basilicum, *Mentha spicata* and *Thymus vulgaris*	*Echinococcus granulosus*	75mg/ml	20 min	98.8, 100	Kill protoscolex	Abed and Ibrahim (2021)
Allium cepa and *Cocos nucifera*	Moniezia spp.	60gm	9 - 20 days	100	Disappearance of proglottids	Mehlhorn et al. (2010)
Coconut and Onion	*Hymenolepis diminuta*, *Hymenolepis microstoma* and*Taenia taeniaeformis*	Variable	33 days	100	Death of worms	Ghaffar et al. (2010)
Coriandrum sativum	*Hymenolepis nana*	500 and750mg/kg	15 days	100	Death of worms	Hosseinzadeh et al. (2016)
Zingiber officinale, *Artemisia aucheri* and Eucalyptus	*E. granulosus*	50,100mg/ml	40 min	100	Scolicidal effect	Faizei et al. (2015)
Atriplex halimus	*E. granulosus*	60mg/ml,100mg/ml	120 min	93.36, 100	Scolicidal effect	Bouaziz et al. (2021)
Artemisia cina	Moniezia spp.	40mg/ml	9 days	100	Absence of eggs in faeces	Bashtar et al. (2010)
Zingiber officinale	*E. granulosus*	150mg/ml	60 min	100	Zero percent viability rate of protoscolex	Bakqer et al. (2014)
Coriandrum sativum	*E. granulosus*	0.75gm/ml	3 days	100	Kill protoscolex	Dawwas (2008)
Zataria multiflora	*E. granulosus*	10mg/ml	1,2,3 min	68.9, 93.7, 100	Scolicidal effect	Moazeni and Roozidalab (2012)
Sambucus ebulus	*E. granulosus*	100 mg/ml	60 min	98.60	Scolicidal effect	Gholami et al. (2013)
Dendrosicyos socotrana and *Jatropha unicostata*	*E. granulosus*	1000µg/ml	N.A	N.A	Significantly reducing protoscolex	Barzinji et al. (2009)
Zingiber officinale	*E. granulosus*	150g/ml	60 min	100	Scolicidal agent	Baqer et al. (2014)

Green Defense: the Role of Essential Oil in Managing Cestode Parasites

Essential oils (EO), or volatile oils, are aromatic and oily liquids extracted through distillation from various plant parts such as buds, seeds, leaves, twigs, bark, wood, fruits, and roots (Mrabti et al., 2023). These oils are organic solvent extracts (using substances like ethanol, methanol, toluene, or other organic solvents) or steam-volatile extracts that have been traditionally used for centuries in various regions worldwide. Approximately all the essential oils can be obtained through hydrodistillation method; encompasses three key physicochemical processes: hydro diffusion, hydrolysis, and heat decomposition (Oreopoulou et al., 2019).

Essential oils have scolicidal effect against many cestodes species. Research has revealed that the root oils of *Hedychium coronarium* and *H. spicatum* exhibited more effective results against tapeworms compared to piperazine phosphate. Additionally, oils derived from *Gardenia lucida*, *Cyperus rotundus*, *Inula racemose*, *Psitacia integrrima*, *Litsea chinensis* and *Randia dumetorum* demonstrated notable effects on tapeworms (Tandon et al., 2011). In another study, oils from plants *Artemisia pallens*, *Eupatorium triplinerve*, *Artabotrys odoratissimus*, *Capillipedium foetidum* and *Cymbopogon martini* exhibited strong impacts on Ascaris and *T. solium* (Nakhare and Garg, 1991).

Pelargonium roseum and *Ferula gummosa* are identified as potential sources of novel natural products with the potential for developing effective and environmentally friendly scolicidal drugs. The main chemical components, β-pinene and citronellol, present in both essential oils, demonstrate scolicidal activity against *E. granulosus*, with 50% lethal concentration (LC50) values of 8.52 and 17.18µg/mL, respectively (Tabari et al., 2019) (Table 2). Ajowan (*Trachyspermum ammi*), known for its various therapeutic properties, investigated for its scolicidal properties against *E. granulosus*. Their main chemical components thymol, γ-terpinene and p-cymene showed scolicidal activity. Moazeni et al. in 2012 reported, the ajowan EO with a concentration of 10 milligrams per milliliter after ten minutes demonstrated complete scolicidal efficacy. Similarly, the EO obtained from European black pine kills protoscolices of *E. granulosus*. Varied outcomes were observed when different doses were administered at different time intervals. Best efficiency (100%) shown at the higher concentration of 50 milligrams per milliliter (Kozan et al., 2019) (Table 2).

The essential oil of black cumin (*Nigella sativa*), together with its main chemical constituents (thymoquinone, p-cymene, carvacrol, and longifolene) exhibited scolicidal activity against *E. granulosus*. A study conducted by Mahmoudvand et al. (2014) showed various concentrations of the black cumin EO (ranging from 0.01 to 10mg/ml) applied for different time durations (5 to 60 minutes) had different scolicidal effects. Moreover, *Myrtus communis* EO has also shown promising scolicidal results on hydatid cyst protoscolices. The results of the investigation revealed that after five minutes of exposure, 100µl/ml of *M. communis* EO killed 100% of protoscoleces. Hence can be used as a natural scolicidal drug during hydatid cyst removal (Mahmoudvand et al., 2016). Similarly, the turmeric EO is useful against protoscolices of *E. granulosus* following a five-minute treatment with 200µl/mL, all protoscolices were completely destroyed (Mahmoudvand et al., 2019) (Table 2).

The EO from dried garlic bulbs has the capability to damage the scolex of *Moniezia expansa*. After 24h of incubation with 100µg/ml, the scolex appears shrunken with a highly deformed and folded tegument (Shalaby and Farag, 2014).

Table 2: Updates on the effectiveness of essential oil against cestodes.

Essential Oil	Parasites	Dose	Mortality (%)	Effect	Reference
Pelargonium roseum and *Ferula gummosa*	*Echinococus granulosus*	50µg/ml	100	Kill protoscolex	Tabari et al. (2019)
Trachyspermum ammi sprague	*E. granulosus*	10,000µg/ml	100	Kill protoscolex	Moazeni et al. (2012)
Pinus nigra spp. *pallasiana,*	*E. granulosus*	10mg/ml	61.69	Kill protoscolex	Kozan et al. (2019)
Allium sativum	*Moniezia expansa*	100µg/ml	100	Shrunken scolex with distorted and folded tegument	Shalby and Farag (2014)
Nigella sativa	*E. granulosus*	100µg/ml	21.60	Scolicidal activities	Mahmoudvand et al. (2014)
Myrtus communis	*E. granulosus*	100µl/ml	100	Natural scolicidal agent for hydatid cyst	Mahmoudvand et al. (2016)
Curcuma longa	*E. granulosus*	200µl/ml	100	Kill protoscolex	Mahmoudvand et al. (2019)
Ferula macrecolea	*E. granulosus*	150and300µl/ml	100	Kill protoscolex	Alyousif et al. (2021)
Saturega khuzistanica	*E. granulosus*	5mg/ml	100	Scolicidal activities	Moazeni et al. (2012)
Bunium persicum	*E. granulosus*	25µl/ml	100	Kill protoscolex	Mahmoudvand et al. (2016)

Sustainable Green Nanoparticle Solutions for Cestode Control

Green nanoparticles are emerging as a promising eco-friendly alternative for controlling cestodes and are suggested as an alternative to traditional chemical methods. One way to integrate nanotechnology and plants is through the use of green chemistry, known as plant-mediated production of nanoparticles (Fig. 3). Chemical methods can be problematic because of their complex composition, potentially causing reactivity and toxicity concerns. However the use of natural extract for the synthesis of nanoparticles is less toxic and more reliable (Hussain et al., 2016).

Fig. 3: Presents a potential method for synthesizing nanoparticles by using Plants (Green nanoparticle)

Green Gold Nanoparticle

Raziani et al. (2023) suggest that natural extract from the upper flowering part of savory (*Saturja khuzestanica*) can be used for the production of green gold nanoparticles and show a lethal effect for *E. granulosus.* The efficiency of these green nanoparticles depends on the dose and exposure time. At a concentration of 5mg/ml and 20 minutes exposure time, there was a maximum mortality rate of about 100 percent. Moreover, Barabadi et al. (2017) revealed the production of gold nanoparticles by the use of mycelia-free culture filtrate of *Penicillium aculeatum* showing scolocidal activity. These nanoparticles exhibit 94% scolocidal effect at a dose of 0.3mg/ml with a long exposure time of 2 hours. These experiments are helpful for understanding the efficiency of nanoparticles. However, further research is necessary to reveal the efficacy of Au NPs in both *in-vivo* and *in-vitro* studies.

Green Silver (Ag) Nanoparticles

Green silver nanoparticles (Ag NPs) were prepared from the aerial extract of *Penicillium aculeatum* that were effective scolocidal agent against *E. granulosus*. Dosage of 0.1 and 0.15 milligram per milliliter after two hours of exposure time results in death rates of 83 and 90% respectively (Rahimi et al., 2015). These nanoparticles can also be synthesized from *Ziziphus spinachristi*, according to Salih et al. (2020) which is commonly referred to as Christ's thorn jujube. They have considerable activity against protoscolices of *E. granulosus*. Scolocidal activity varies according to the dose and exposure time. Maximum efficiency was 100% at a dose of 0.4mg/mL for 120 minutes (Jalil et al., 2021). These results are consistent with the findings of Norouzi et al. (2020), who showed the highest scolocidal activity of Ag NPs at 1mg/mL after one hour, with an 80 percent death rate by inducing major changes in their external encasing of protoscolices. Another study reported that the anthelmintic action of plants (flowers of hill glory bower; *Clerodendrum infortunatum*) can be improved by blending it with Ag NPs. When these green nanoparticles were used against *Raillietina* spp. there was destruction of the scolex and alterations in morphology (Majumdar and Kar, 2023).

Green Zinc Oxide (ZnO) Nanoparticle

Shnawa et al. (2021) reported Zinc oxide nanoparticles with Horse mint (*Mentha longifolia*) leaf extract with notable in vitro protoscolicidal efficacy. In the latter studies, ZnO-NPs synthesized from Christ's thorn jujube (*Z. spinachristi*) displayed the highest antiparasitic activity at 400µg/ml after 60 minutes, resulting in 100 percent mortality of treated protoscolices. Both findings emphasize the effectiveness of the green manufacturing of nanoparticles of zinc oxide with strong scolicidal potential (Shnawa et al., 2021).

The anthelminthic activity of the bark or leaves of willow has also been shown to be improved by the addition of ZnO nanoparticles. It has been shown that *E. granulosus* can be treated by using salicylate-coated zinc oxide nanoparticles (SA-ZnO NPs). The remarkable efficacy of SA-ZnO-NPs against protoscoleces resulted in 100% mortality after 20 minutes of treatment at 2000µg/ml. The drug has a significant effect on the survival and morphology of these parasites as the rostellum of protoscoleces showed abnormalities, external wrinkling of the tegument, and apoptogenic changes after administration (Cheraghipour et al., 2023). Similarly, according to recent study an aqueous extract of grape (*Vitis vinifera*) seeds and ZnO showed effective therapy against *E. granulosus*. The treatment was administrated twice, one with 0.100mg/ml and other with 0.050mg/ml concentration. The mortality rates for these therapies were 97 and 100% respectively (Mahmmoud et al. 2020). The aforementioned research demonstrates that green synthetic ZnO-NPs exhibit scolicidal efficacy against *E. granulosus*.

Biosynthesis of Copper Nanoparticles

The study found that an in vitro combination of albendazole, capparis fruit and Cu nanoparticles at a dose of 750mg/mL demonstrated the greatest protoscolicidal activity.

After 60 min of exposure, 73.3% of protoscoleces were killed. Moreover, when Cu nanoparticles at the same concentration were combined with albendazole (200mg/mL), the mortality of protoscoleces reached 100% after only 10 minutes of exposure (Ezzatkhah et al., 2021).

Biosynthesis of Chitosan Nanoparticle

Chitosan nanoparticles containing curcumin have an impact on protoscolices of the hydatid cyst *in-vitro*, with highest fatality rate 68% at a concentration of 4mg/mL. The most significant effect was observed at 4mg/mL after 60 min of exposure, impacting the tegument, hooks, and suckers, including the collapse of the sucker region (Napooni et al., 2019).

Table 3: An overview of the latest findings about the efficacy of green nanoparticles in combating Cestodes.

Green Nanoparticles	Parasites	Dose	Exposure time	Mortality (%)	Effects	References
Au+ *Saturja khuzestanica*	*Echinococus granulosus*	5mg/ml	20min	100	Morphological changes	Raziani et al. (2023)
Ag+ *Pencillium aculleatum*	*E. granulosus*	0.1 and 0.15mg/ml	120min	83, 90	Larvicidal effect	Rahimi et al. (2015)
Ag+ *Zizyphus spinachristi*	*E. granulosus*	0.4mg/ml	120min	100	Morphological changes, no viable protoscolex	Jalil et al. (2021)
ZnO + *Mentha longifolia*	*E. granulosus*	400ppm	150min	100	Destruction of protoscolex	Shnawa et al. (2021)
Ag and Au+ *Clerodendrum infortunatum*	*Raillietina* spp.	125mg/ml			Destruction of scolex and morphological changes	Majumdar and Kumar (2023)
Aaronsohnia factorovskyi	*Hymenolepis nana*	0.5mg/kg	More than 10 days	100	Reduction of worms	Olayan et al. (2023)
ZnO+ grape seeds extract	*E. granulosus*	0.050mg/ml	60min	100	Destruction of protoscolex	Mahmmoud et al. (2020)
Cu + Capparis fruit+ Albendazole	*E. granulosus*	Cu-NPs 750mg/ml +ALZ 200mg/ml	10min	100	Destruction of protoscolex	Ezzatkhah et al. (2021)
Chitosan-Curcumim	*E. granulosus*	4mg/ml	60min	68	Collapsing of suckers and reduction in length of protoscoles.	Napooni et al. (2019)

Challenges

Plant extracts can be used to treat diseases caused by cestodes. Literature has shown notable progress in the treatment of animals from cestodes parasites. However, there are certain difficulties in treating parasitic infections using natural therapies. Such as, we need to utilize a very particular concentration of extract to get good outcomes. The determination of which extracts, at what concentration, should be mixed for a certain parasite is also essential. Another important aspect is the organism's body's weight. Because the dosage concentration changes with the age of the organism, therefore it is important to consider the age of the organism for efficient therapy (Abdel-Ghaffar et al., 2011).

Conclusion

The cestodes can be effectively treated by the use of plant products, e.g. green nanoparticles, plant extract, and essential oils. These remedies are frequently used for the treatment of parasitic infections like Monieziasis, Echinococcosis, Hymenolopsis and Taeniasis in livestock. Parasites have developed resistance against traditional drugs to overcome this problem; we should use plant products to cure livestock from parasitic infections. Commercial medicines are expensive and cause pollution in the environment, but these remedies are easily available and have no side effects. The utilization of these eco-friendly alternatives shows the potential for sustainable and effective practices in animal health.

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