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EFFICACY OF MEDICINAL PLANTS AGAINST HAEMONCHUS CONTORTUS; A REVIEW

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Abstract

Nematodes, or parasitic roundworms, significantly reduce output from agriculture and cause serious illness and death in farmed animals around the world. A method for managing the parasitic nematode that attacks small ruminants, *Haemonchus contortus*, at different phases of their life cycle, is the use of medicinal plants (MP) that contain bioactive chemicals. The purpose of this review is to carefully analyze the effectiveness of various plants against *H. contortus*, the anti-haemonchiasis activity's mode of action and the active phytocompounds in various medicinal plants. Medicinal plants inhibit the larval development of parasite by releasing the bioactive compounds that disrupts the digestive enzymes and impairing the vital proteins involved in metabolism as well as damaging cuticle that leads to impaired growth. Medicinal plants have been studied as a substitute to chemical substances used to control such parasites, as they have fewer adverse effects on the small ruminants and the quality of the meat. Because of its great prevalence, which has been documented in numerous investigations, *H. contortus* is considered the most important nematode parasite in small ruminants. Its occurrence in small ruminants causes disruptions in nutritional metabolism and deprivation of feed absorption, which in turn causes deprived performance as well as large economic losses in the herds, particularly in rural areas of emerging nations. The parasite feeds on the blood of its host causing weakness, anemia, and poor weight gain which can leads to death in severe infections. This parasite reduces livestock productivity that can lead to significant economic losses. In this review activity of various medicinal plants have been described such as, Zingiber officinale, Allium sativum, Azadirachta indica, Coriandrum sativum, Matricaria recutita, Matricaria chamomilla, Chenopodium album, Chenopodium ambrosioides, Solanum torvum, Solanum nigrum, Moringa oleifera, Artemisia afra, A. campestris, Artemisia herba-alba,A. maritima, A. vestita, Artemisia cina, Eucalypyus citriodora, Musa paradisiaca, Catharanthus roseus, Punica granatum, Annona crassiflora, Nicotiana tabacum. Parts of these plants or the whole plants have been reported to have activity against *H. contortus* infection in small ruminants.

Keywords

Haemonchus contortus; Nematode; Medicinal plants; Haemonchosis; Small ruminants

1. Introduction

In addition to significant losses to food production, parasitic infections are a major source of disease and death in animals worldwide. As an illustration, one of the most important parasite illnesses impacting livestock globally is haemonchosis, which affects hundreds of millions of small ruminants (such as sheep and goats) and costs the livestock sector billions of dollars annually in reduced productivity (Kumarasingha *et al*., 2016). The L3 larvae of H. contortus develops outside the host body then get ingested from contaminated grass, after that animals get infected. Larvae might take 14-19 days to attain sexual maturity inside their host. After this point, mature H. contortus females start to deposit eggs; a single female can lay anywhere from 5,000 to 15,000 eggs every day. The host excretes eggs in its feces. Larvae of H. contortus molt to the infectious L3 form following hatching (Rychlá *et al*., 2024). Around the world, Haemonchus contortus is widely distributed, particularly in tropical and subtropical regions where its life cycle is boosted by warm, humid conditions. It affects animals in parts of Europe, South America, Asia, as well as Africa. The range of infection rates is wide, ranging from around 30% to over 90%, based on climate, animal husbandry, and deworming procedures (Parvin *et al*., 2024). Gastrointestinal nematode infection is still one of the primary reasons of decreased productivity in small ruminants in tropical developing nations, and it can be lethal. Due to its enormous frequency and virulence, Haemonchus contortus is considered one of the most significant species (Hounzangbe-Adote *et al*., 2005). Anemia, malnourishment, low feed conversion, low reproductive indices, and the mortality of young animals are the detrimental impacts of haemonchosis on sheep herds. While some helminthes infections have no symptoms at all, in others, the infection can have more serious or long-lasting consequences that include headaches, myalgia, stomach discomfort, and cramping in hosts with a high worm load. These symptoms can also cause organ damage as well as fluid buildup (Calvin *et al*., 2023). The widespread approach to treating these parasite illnesses depended on the strategic and regular use of anthelmintics. However, the emergence of resistant populations of parasites has weakened the effectiveness of chemical control, necessitating the employment of conventional medicinal herbs as additional alternative control measures (Davuluri *et al*., 2020). People have depended on plants for medical purposes throughout history. Despite being utilized for decades to combat parasites, medicinal herbs are still employed for this purpose in many parts of the world. It's quite likely that humans have always prioritized controlling parasites (Saqlain *et al*., 2024). In this case, investigating possible plant antiparasitic might be a good option because they are widely available and reasonably priced (Ranasinghe *et al*., 2023). Due to their scarcity or high expense, small-holder farmers in the majority of developing nations, including Ethiopia, have restricted access to veterinary services as well as commercial anthelmintic. As in some other regions of the world, this means that the majority of farmers must rely on ethnoveterinary medicine. One alternative and sustainable approach that is easily adapted to rural agricultural communities is the use of plant preparation as anthelmintic (Eguale *et al*., 2011).

1.1 Zingiber Officinale

Zingiber officinale rhizomes washed with tap water and shade dried. When it fully dried ground into crude powder. The queous extract prepared through cold maceration method, 20 g of plant powder dissolved into 100ml of water and kept at room temperature for 5 days. After that, the extract filtered and kept at 4 C in refrigerator. Zingiber officinale was 100% effective in eliminating H. contortus worms after two hours (h) of exposure. Sheep naturally infected with mixed types of gastrointestinal nematodes were given crude powder (CP) with dosage of 1 and 3g/kg as well as crude aqueous extract (CAE) of dried ginger (1-3 g/kg). On day 10 of the therapy, CP and CAE both showed a dose- and time-dependent anthelmintic impact, with maximal reductions in eggs per gram (EPG) of faeces of 25.6% as well as 66.6%, respectively. The results of this study validate the long-standing custom of using ginger to treat helminth infestation in sheep by demonstrating its in vivo anthelmintic action (Sawleha *et al*., 2010)

1.2 Allium Sativum

Intestinal parasites are commonly treated with garlic. Researchers have been interested in the anthelminthic activity of garlic (Adil *et al*., 2015). Acetylcholinesterase (AChE) activity in Haemonchus contortus is inhibited by the ethanolic extract of A. sativum, which impairs locomotion via interfering with cholinergic synaptic transmission. This causes paralysis, which stops the parasite from moving food and eating. This causes the parasite to lose energy and become malnourished, which finally causes it to die. Garlic contains sulfur-containing chemicals called allicin as well as ajoene, which bind to parasite proteins by changing their thiol (-SH) groups, which are necessary for the structure as well as function of proteins. By creating disulfide bonds along with cysteine residues, these substances can interfere with important enzyme functions and cellular processes in parasites, changing the way proteins fold and function. The metabolism, movement, and survival of the parasites are all hampered by this interference, which finally causes their demise (Adil *et al*., 2015).

1.3 Azadirachta Indica

Neem, or Azadirachta indica, is a widely recognized plant with several therapeutic and medical benefits. As per the findings of the study, neem exhibited the highest efficacy in methanol extract at concentrations of 5% and 10% (100%) as well as in 10% aqueous extract (100%) against adult and methanol extract at concentrations of 10% (100%) against L3 stage larvae (Akther *et al*., 2015). In this study, aqueous extracts from the leaves of Azadirachta indica were tested for their ability to inhibit the growth of adult worms and eggs of Haemonchus contortus. The extracts caused decreases in fecal egg counts in sheep of 89%, 87%, and 36% after 12 days, respectively. An LC50 of 74% was reported after two hours in the adult motility experiment, which showed a significant decline in motility with time. Overall, the findings imply that these plant extracts successfully display anthelmintic qualities in a way that is dependent on time and dose (Nawaz *et al*., 2014).

1.4 Coriandrum Sativum

Regarding the ovicidal impact shown in sheep gastrointestinal nematodes, coriander essential oil demonstrated a strong anthelmintic potential; hence,

it may be deemed appropriate for additional testing. The significant ovicidal action of coriander stems from its complex chemical makeup, which includes linalool, camphor, and α-pinene, among other chemicals (Štrbac *et al*., 2022). Prior research has demonstrated that essential oil derivative from C. sativum exhibit anthelmintic effect when it comes to H. contortus adult motility or larval growth, with 97.8% inhibition at 10 mg/mL (Helal *et al*., 2020). The fact that coriander extract-treated infected sheep did not exhibit a statistically significant rise in total peroxide values throughout the course of the experiment may be explained by their redox potential, which is crucial for adhering as well as neutralizing free radical (Štrbac *et al*., 2022). 24 sheep that had been intentionally infested with Haemonchus contortus were split into four categories of six animals each at random for the in vivo investigation. The first two groups received doses of 0.45 and 0.9 g/kg of crude aqueous extract of Coriandrum sativum, the third group received a dosage of 3.8 mg/kg of albendazole, as well as the last group received no treatment at all. Total worm count reduction (TWCR) and faecal egg count reduction (FECR) were used to measure efficacy. Significant FECR was seen on day 2 of therapy in groups receiving greater doses of albendazole ($p< 0.001$) and Coriandrum sativum ($p< 0.05$). Significant FECR was not seen for either of the Coriandrum sativum dosages on days 7 or 14 after treatment ($p>0.05$). Notable ($p< 0.05$) only when Coriandrum sativum dosage was higher than in the untreated group was TWCR found. Male worm reduction was greater than that of female worms. The mice treated with albendazole exhibited a substantial rise ($p< 0.05$) in PCV, but the animals treated with both dosages of Coriandrum sativum failed to show any improvement or maintenance in PCV (Eguale *et al*., 2011). In this investigation, the effects of coriander and geraniol on H. contortus adult and larval motility were further examined. The findings showed that the coriander significantly inhibited both adults along with larval motility in a dose-dependent manner, with up to 77.8 as well 90.6% inhibition at concentrations of 1 mg/mL within two hours of exposure, respectively. The most often used technique for assessing anthelmintic is still the inhibition of adult as well larval movement, which indicates worm viability following treatment incubation (Khairuzzaman *et al*., 2024).

1.5 Matricaria spp.

Antioxidants, phytochemicals, as well as variety of bioactive compounds are abundant in chamomile, which also possesses a broad range of traditional and pharmacological qualities (Parveen *et al*., 2023). Using different solvent extracts, the phenolic components of Matricaria recutita were measured and the plant exhibited both in vitro antioxidant as well as anthelmintic properties. Higher levels of polyphenol, flavonoid, as well as tannin were found in both the methanolic and aqueous extracts; the methanolic extract exhibited the greatest antioxidant activity (IC50 = 1.19 µg/ml). The motility of adult worms and egg hatching of Haemonchus contortus was considerably decreased with both methanolic (IC50 = 1.559 mg/ml) as well as aqueous (IC50 = 2.559 mg/ml) extracts (Hajaji *et al*., 2018). The M. chamomilla extract exhibits only avicidal and larvicidal activities against the gastrointestinal

parasite Haemonchus contortus, which affects small ruminants, have been studied. It shows 37.5% efficacy in the egg hatch test as well 84% efficacy in the larval development test (Sánchez *et al*., 2022).

1.6 Chenopodium Album

Different dosages of C. album methanolic extracts were investigated in vitro against H. contortus. At 150 µg/mL dosages, the C. album extract resulted in 100% death in both cases. These findings thus indicate C. album is very efficient against parasites caused by H. contortus (Islam *et al*., 2023). The anthelmintic action of C. album, both in its crude aqueous as well as methanolic forms, is demonstrated against H. contortus in a dose- and time-dependent manner. This is evident from the worms' reduced motility or eventual mortality upon exposure to various extracts. After an 8-hour treatment at a 50 mg/ml concentration, the methanolic extract of C. album showed the maximum worm death (100%) whereas the aqueous extract showed 70% mortality (Lone *et al*., 2017).

1.7 Chenopodium Ambrosioides

The effects of Chenopodium ambrosioides at 24 and 72 hours after contact are responsible for the 50% and 90% in vitro lethal doses against L3. The application of Chenopodium ambrosioides showed the strongest lethal impact against L3 (Adil *et al*., 2015).

1.8 Solanum Torvum

Using tests for egg hatch and larval growth, the study evaluated the effectiveness of Solanum torvum leaf extracts (ethyl acetate, acetone, and methanol) against Haemonchus contortus. After 48 hours, the extracts showed modest antiparasitic efficacy in a study done in 24-well plates with five duplicates. Remarkably, at a dosage of 25 mg/ml, the methanol extract totally prevented the hatching of eggs and the growth of larvae (Kamaraj *et al*., 2011).

1.9 Solanum Nigrum

The anthelmintic activity of crude methanol extract as well as subsequent solvent fractions of Solanum nigrum L. (Solanaceae) against Haemonchus contortus, a kind of intestinal worm that infects sheep. At a dosage of 0.05 mg/ml, the ethylacetate extract demonstrated a strong anthelmintic activity with a high worm death rate at hourly intervals. According to the data, S. nigrum polar fractions with high phenolic and flavonoid concentrations have strong anthelmintic activity (Saddiqe and Maimoona, 2013).

1.10 Moringa Oleifera

Since practically every portion of the Moringa oleifera tree may be utilized for food or has other beneficial qualities, it is regarded as one of the most beneficial trees. It is utilized as cattle fodder in the tropics and as a medical remedy in many other places (Devendra *et al*., 2011). Asthma, anemia, intestinal worms, cardiovascular disease, headaches, skin infections, and various other conditions are treated with M. oleifera. Numerous pharmacological actions, including anthelminthic, anti-inflammatory, antibacterial, anti-oxidant, hepatoprotective, anti-glycemic, and anti-dyslipidemia properties, are exhibited by plant extracts (Mbikay, 2012). The findings indicate that the maximum percentage of third-stage larva (L3) fatality was 68.19% at 1.25 mg/mL at 72 hours, whereas 85.88% inhibition of H. contortus egg hatching was observed at a dose of 20 mg/mL at 48 hours. The ethyl acetate leaf extract of M. oleifera Lam. was shown to have considerable

promise in the fight against agricultural nematodes (Páez-León *et al*., 2022). At 5 mg/ml, this macerated aqueous extract reduced 99% ± 2% of H. contortus eggs from hatching. When it came to its ability to affect larvae, the ethanolic extract was the most effective; at 5 mg/ml, it caused 98.8% ± 2.5% and 100% ± 0% mortality in L1 and L2 larvae, respectively. This study demonstrated the potential larvicidal along with ovicidal effects of all three M. oleifera extracts tested against H. contortus (Tayo *et al*., 2014). M. oleifera seed extracts consisted of phytoactive substances in plants with anthelmintic properties against the eggs as well L3s of H. contortus (Cabardo and Portugaliza, 2017). This study assessed how Moringa oleifera proteins affected the mortality of H. contortus worms' physical appearance subjected to the lectins. After the lectins were incubated, extracts from adult worms both male and female showed increased proteolytic activity. Alterations in the cuticle crests, longitudinal striations, and at the vulva were indicative of morphological alterations brought on by the lectins (Medeiros *et al*., 2020).

1.11 Artemisia spp.

The genus Artemisia, which belongs to the Asteraceae family of plants, is well-known for its anthelmintic qualities (Khan *et al*., 2015). Sesquiterpene lactones have anthelmintic action, are abundant in plants belonging to this family. Sesquiterpene lactones as well as antioxidant chemicals found in abundance in Artemisia spp. may have positive effects on the health of humans as well as animals. Artemisia spp. along with artemisinin have antiparasitic properties against a variety of parasitic organisms in animals, such as Haemonchus, Trichostrongylus, Eimeria (coccidia), and Fasciola (Ferreira, 2009). The experimental plant Artemisia was gathered, let too dry in the shade, ground into a coarse powder, and then used to make an ethanolic and crude aqueous extract. According to the experiment, aqueous extracts at amount of 10 mg/ml totally stopped egg hatching, but crude ethanolic extracts at a dosage of 5 mg/ml did not. In comparison the ivermectin (0.025mg/ml) totally stopped egghatching (Karim *et al*., 2019). Three doses of acetone as well as aqueous extract from Artemisia afra were investigated on egg hatch, larval development, and larval mortality tests. The plant reduced some percentages of egg hatch along with larval mortality, but at all doses, it completely impeded larval development. In comparison to the positive control and the effect was similar of Albendazole (0.075 mg/ml) (Molefe *et al*., 2012).

1.12 Eucalypyus Citriodora

Eucalyptus spp. which is generally known as Blue Gum in English and Safeda in Hindi, is essentially an Australian native plant. The qualities of leaves include those of a stimulant, carminative, expectorant, febrifuge, antibacterial, antifungal, antiseptic, antimalarial, anti-inflammatory, as well as anthelmintic (Kuamr *et al*., 2015). The study evaluated the anthelmintic characteristics of Eucalyptus citriodora leaf extracts in terms of crude powder (CP), crude aqueous (CAE), as well as crude methanolic (CME) extracts in relation to the parasite Haemonchus contortus. Concentrations ranging from 0.156% to 10% were used in a variety of in vitro techniques, such as the Larval Paralysis Test (LPT), Egg Hatch Assay (EHA), along with Adult Motility Test (AMT). At doses of 1.25% to 10%, the

AMT showed total inhibition of motility as oxfendazole (0.025mg/ml) shows the total inhibition of motality; in the EHA, CAE was more effective than CME (ED50=0.997 mg/ml). At higher doses, both extracts completely inhibited egg hatching, and at 100 mg/ml in the LPT, CAE as well as CME completely paralyzed larvae (Sastya *et al*., 2018).

1.13 Musa Paradisiaca

The Musa species belongs to the Musaceae (banana family) family. The herb possesses anthelmintic qualities. Studies have shown that musa plants have the potential to be therapeutic; they are commonly used either orally or topically as treatments in traditional medicine. Reports indicate that it contains phenolic chemicals and is well-known for its many pharmacological properties (Kumar *et al*., 2021). Strong in vitro anthelmintic activity and notable inhibiting impacts on H. contortus egg hatching were demonstrated of M. paradisiaca. The plant demonstrated time- and dose-dependent anthelmintic effects on both the hatching of eggs and live worms. According to the research, M. paradisiaca has potent anthelmintic action both in vivo as well as in vitro (Hussain *et al*., 2021). This research revealed Musa paradisiaca stem and leaf have the extremely considerable aptitude to inhibit larval development (>67% inhibition for each extract) as well as to negatively affect adult worm mortility (43% inhibition of mortility after 24 hours of incubation) when compared to negative controls, suggesting that the stem and leaf have anthelmintic properties towards H. contortus (Kumar *et al*., 2021). Banana leaf had no effect on H. contortus in lambs, according to the results of the first experiment. As demonstrated by the second study, banana foliage likely has an impact upon the fecundity of adult worms due to the large favourable effect it had on the number of faecal eggs discovered (Marie-Magdeleine *et al*., 2010).

1.14 Catharanthus Roseus

Many deadly illnesses are treated using Catharanthus roseus (L.), due to its antibacterial, antifungal, antioxidant, anticancer, as well as antiviral activities are only a few of the many pharmacological properties of this plant that have been discovered. Research has shown that Catharanthus roseus has been utilized as an anthelminthic herb from the traditional era (Gajalakshmi *et al*., 2013). The plant's known bioactive compounds were used in in silico molecular docking as well as pharmacokinetic prediction experiments against the parasite's tubulin and glutamate dehydrogenase. This was most likely due to an indirect anthelmintic effect via immunomodulation, antioxidant as well as anti-inflammatory qualities, and direct anthelmintic action through glutamate dehydrogenase, tubulin depolymerization, along with uncoupling (Rahal *et al*., 2022).

1.15 Punica Granatum

Pomegranate, or Punica granatum L. (Punicaceae), is a plant used in traditional medicine to heal a variety of ailments. It has lately been called "nature's power fruit." Anti-cestodial, anti-nematoidal, along with anti-protozoan properties are exhibited by P. granatum. The fruit peel, root bark, as well as bark of pomegranates are the portions utilized as anthelmintic herbs (Amelia *et al*., 2017). In helminth parasites, glutathione S-transferase is essential for the detoxification of a variety of hazardous

compounds. The glutathione S-transferase activity of H. contortus was significantly inhibited by parasites cultured in P. granatum juice (PJ) at different sub-lethal doses (10, 20, and 30%). By inhibiting H. contortus GST activity, the parasites lose their main defensive mechanism (SIVACHANDRAN *et al*., 2021). PEE's most notable in vitro anthelmintic impact was at 400 mg/ml, which resulted in 86% adult worm motility inhibition, a 0.87 mortality index, noticeable cuticular microscopic abnormalities in adult worms, and 100% larval death (Hassan *et al*., 2020). This investigation demonstrated that the L3's migration was hindered by the Punica granatum extract. Following a 2-hour incubation period in the leaf extract (5 mg/ml), nematode larvae showed a 56±12.29% inhibition in migration as compared to the control group (Siti Futri *et al*., 2018).

1.16 Annona Crassiflora

A natural fruit tree with great nutritional, functional, as well as economic potential is Annona crassiflora. Folk medicine has been using this herb for many years to cure many medical problems (Machado *et al*., 2015). The pharmacological actions of Annona crassiflora extracts include those that are anti-inflammatory, antitumoral, hepatoprotective, antidiabetic, antioxidant, analgesic, skin healing, antidiarrheic, antimicrobial, antiparasitic, insecticidal, and herbicidal (Arruda *et al*., 2019).

1.17 Nicotiana Tabacum

Known by most as tobacco, Nicotiana tabacum L. (family Solanaceae) is a well-known plant utilized for its narcotic qualities. Furthermore, it is used as an anthelmintic, anti-inflammatory, as well as anti-rheumatic substance in ethno-veterinary treatment (Iqbal *et al*., 2006). The leaves (decoction) have been used in ethnomedical practices for diuretic, expectorant, emetics, antispasmodic, sedative, and to treat rheumatic swellings (Rawat *et al*., 2013). The investigation found that all of the extracts of Nicotiana tabacum included secondary metabolites, that are thought to be the chemical components responsible for the various therapeutic properties of various medicinal plants. At 8 hours posttreatment, the concentrations of all the extracts demonstrated a robust and similar nematocidal impact on H. contortus, with no significant difference ($p<0.05$) between them and the positive control (Mumed *et al*., 2022).

Conclusion

To sum up, our review shows the potential of medicinal plants as a supplemental or alternative strategy to manage infestations of Haemonchus contortus. The plants under investigation in this study had strong anthelmintic activity, which prevented H. contortus parasites from proliferating and surviving. But according to our findings, medicinal plants might be essential in creating new, efficient, and eco-friendly methods of managing H. contortus and other parasitic nematodes, which would ultimately improve livestock productivity and health while lowering the need for synthetic anthelmintics. Limited clinical trials as well as inadequate standardization of bioactive components are the main research gaps in medicinal plants inhibiting Haemonchus contortus. By carrying out thorough in vivo investigations and creating standardized, verified phytochemical formulations, this gap can be closed. In order to mitigate medication resistance in cattle and reduce

dependency on synthetic anthelmintics, medicinal herbs provide a natural option for managing Haemonchus contortus. Additionally, they offer environmentally friendly, long-lasting solutions for managing parasites in animal health. The absence of standardized doses, which can impact efficacy, and the diversity in bioactive ingredient concentrations are significant challenges to employing medicinal plants to be anthelmintic drugs.

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