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Anthelmintic Efficacy of Plant-Based Compounds - A Comprehensive Narrative Review

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***Abstract*:** The paper highlights anthelmintic activities of some of the most important Ayurvedic medicinal plants carried out in vitro in various pharmacological models. A brief review of In vitro anthelmintic activities of nine Ayurvedic medicinal plants published by various researchers is illustrated in this paper. The results support the use of these plants as an anthelmintic agent. The medicinal plants discussed here are Tulsi: *Ocimum Sanctum*, Bael: *Aegle Marmelos*, pomegranate: *Punica granatum*, Karela: *Momordica charantia*, Ashoka: *Saraca indica*, Neem: *Azadirachta indica*, Vinca rosea: *Catharanthus roseus*, Chinch: *Tamarindus indica* and Haritaki: *Terminalia chebula.*

Keywords: Anthelmintic, Ayurvedic, *Pheretima posthuma*

I. INTRODUCTION

Human parasitic worms, known as helminths, can transmit diseases that are chronic and occasionally fatal. These diseases are known as neglected tropical diseases (NTDs), and they have a global impact on around two billion people ((Adak M, 2022).

Helminthiasis is among the most important animal diseases inflicting heavy production losses. Helminths are the most common infectious agents of humans in developing countries and produce a global burden of disease and contribute to the prevalence of malnutrition, anaemia, eosinophilia, and pneumonia. The disease is highly prevalent particularly in third world countries due to poor management practices. However, increasing problems of the development of resistance in helminths against anthelmintics have led to the proposal of screening medicinal plants for their anthelmintic activity (Shekhawat, 2011). The annual economic losses caused by parasitic nematodes in livestock run into billions of dollars worldwide. Parasitic nematodes in humans fall into two broad categories: intestinal nematodes and tissue(blood) nematodes. The distinction between these two categories is based on where the adult stage mainly spends its time (in the intestinal lumen or body tissues). The adults live in the human intestine and produce eggs, which are shed with faeces and embryonated in the soil (Panda, 2020). Most diseases caused by helminths are chronic and debilitating, they probably cause more morbidity and greater economic and social deprivation among humans and animals than any other single group of parasites (Singh & Jain , 2013).

Ayurveda, or the Science of Life, frequently employs herbal remedies to cure a variety of health conditions. The treatment of parasite illnesses has historically been carried out in India using a range of plants for medicinal purposes. In Ayurveda, worm infection of the gastrointestinal system is referred to as krimiroga. To cure krimiroga, numerous Ayurvedic medicinal herbs have historically been employed. Humans experience severe toxic side effects when using synthetic anthelmintic medications to treat parasitic infestations. The usage of Ayurvedic herbal remedies has fewer costs and there are no adverse effects. Pharmacological interactions between the three main categories of anthelmintics - imidazothiazoles, macrocyclic lactones, and benzimidazoles - have grown in prevalence and severity in intestinal nematodes of livestock as resistance to anthelmintic drugs in both human and animal infectious helminths. One of the five anthelmintics presently in use, including Albendazole, Mebendazole, Diethylcarbamazine, Ivermectin, and Praziquantel, can effectively treat nearly all significant helminth infections in humans (Tahreen Taj, 2023). As we know very well, nowadays the medicinal preparation available in the market from which most of them either not effective up to the mark or has to develop resistance resulting in reoccurrence again. Plant-derived drugs serve as a prototype to develop more effective and less toxic medicines (Shekhawat, 2011). The helminths that parasitize humanity are of 3 groups: nematodes (roundworms), trematodes (flukes), and cestodes (tapeworms). Together, these helminths infect more than a quarter of the world's population, giving rise to much morbidity. Helminths have complex life cycles but with many of the species that parasitize humans (Bundy , et al., 1997). Herbal medicines are prepared from a variety of plant materials, stems, roots, bark, fruits, leaves, seeds, flowers, and so on. Increasing problems of the development of resistance in helminths against anthelmintics have led to the proposal of screening medicinal plants for their anthelmintic activity (Nazeen, 2017).

Parasitic gastroenteritis is caused by mixed infection with several species of stomach and intestinal worms, which results in weakness, loss of appetite, decreased feed efficiency, reduced weight, and decreased productivity. Anthelmintics are drugs that may kill (vermicide) or expel (vermifuge) infesting helminths (Jigna & Gandhi, 2016). The exploration of new medicinal properties of various plant species has induced the attention of scientists toward biologically active compounds in the last couple of decades. The reason behind this is that the bioactive compounds possess potent pharmacological activities and have low or no toxicity (Rahman & Islam , 2013).

The principle of a parasite control program is the strategic use of anthelmintic drugs. However, resistance to these chemical drugs is now a widespread problem in some countries. The cost of chemical drugs in developing countries is another additional limitation on their use. For these reasons, another plan for nematode control is required (Nouri & Foroodi, 2016). The synthetic drugs available have been shown to have side effects; moreover, resistance of the parasites to existing drugs is increasing. Because of the limited availability and affordability of modern medicines, most of the world's population depends to a greater extent on traditional medical remedies. A helminthic infection could be prevented by maintaining a environment sanitary and treatment as well as pharmacotherapy using synthetic drugs or traditional medicine as alternative (W., 2017).

Some plants that contain condensed tannins (CT) have nematocidal properties against free-living nematodes (Niezen, 1995).

The nanotechnological approaches appear to be highly promising for the diagnosis, control, and treatment of various diseases. The metallic nanoparticles have been exploited for biomedical and therapeutic applications. They exhibit antibacterial, antiviral, and antiprotozoal activity by affecting a wide range of biological functions (Nouri & Foroodi, 2016). The major advantage of using plant extracts for the biogenesis of silver nanoparticles is that they are easily available, safe, and nontoxic, have plenty of metabolites that can contribute to the reduction of silver ions, and are quicker than microbes in the synthesis. The whole plant their parts such as seed, root, leaf, stem, bark, fruit, pulp, secretory substance like latex, were reported for the green synthesis of NPs. It was suggested that the phytochemicals are involved directly in the reduction of the ions and formation of AgNPs (Misra, 2017).

Need Of the Nanoparticle in Herbal Remedies: - The following factors led to the selection of herbal nanoparticles to address the shortcomings of conventional herbal medicine.

• Targeting herbal medicines to specific organs with nanoparticles enhances selectivity, medication delivery, efficacy, and safety.

• Nanoparticles can be used to make herbal drugs more soluble and to localize the medicine at a specific spot, which improves effectiveness.

• Due to their distinct size and high-loading capabilities, nanoparticles can deliver high concentrations of medicines to disease locations.

• Giving the medication in little particles increases its surface area overall, hastening its absorption into the circulation.

• Demonstrates improved penetration and retention effects, including greater permeation through the barriers due to the tiny size and retention due to inadequate lymphatic drainage.

• Does not require the inclusion of any specific ligand moiety and exhibits passive targeting to the disease site of action.

• Reduces negative effects (Darji, 2022).

Anthelmintic are drugs that act either locally to expel worms from the gastrointestinal tract or systemically to eradicate adult helminths or developmental forms that invade organs and tissues. An anthelminthic drug can act by causing paralysis of the worm, or by damaging its cuticle, which lead to partial digestion or rejection by immune mechanisms. Anthelminthic drugs can also interfere with the metabolism of the worm, and since the metabolic requirements of these parasites vary greatly from one species to another, drugs that highly effective against one type of worm but be ineffective against others (Manke M. B., et al., 2015).

II. Material and Methods

METHOD

In this review article, the technique used is literature study by finding sources of information through international journals in the last many years (1997-2023) through online media with the keyword anthelmintic. Search for this review article using web sources such as ScienceDirect, PubMed, google scholar, research gate, and others.

There is a long history of using plants to treat human and animal diseases.

2.1 *Ocimum Sanctum*

The phytochemical constituents and anthelmintic activity of methanolic extracts of leaves from four different Ocimum species—*Ocimum gratissimum linn., Ocimum americanum linn., Ocimum Sanctum linn., and Ocimum basilicum linn.* were investigated in preliminary fashion. Additionally, it does not compared their activities. The anthelmintic properties of the Ocimum extracts were assessed on mature *Pheretima posthuma* Indian earthworms after they were screened for phytochemical ingredients. With the exception of anthraquinone glycosides and thiol group, all tests for phytochemical contents of the methanolic extract of Ocimum species were determined to be positive. At 60 mg/ml concentration, anthelmintic activity was demonstrated by all extracts. The actions are very similar to those of the common medication, albendazole. Compared to the prescribed medication, all of the methanolic extracts had higher anthelmintic activity. Compared to other Ocimum species, *Ocimum gratissimum linn's* methanolic extract exhibited superior anthelmintic activity (Nayak B. S. and Choudhury G. B. 2010).

Shukla Kirtiman (2012) found that hydroalcoholic extracts of *Ocimum Sanctum* (Labiateae; Tulsi) and *Withania somnifera* (Solanaceae) shown remarkable anthelmintic action against *Pheretima posthuma*, or earthworms. Testing was done on both extracts at different concentrations. As a reference standard, piperazine citrate (10 mg/ml) was employed. After being exposed to Os and Ws crude extracts, earthworms lost their motility. A dose-dependent paralysis ranging from loss of motility to loss of reaction to external stimuli was caused by each crude extract containing 20 and 40 mg/ml, and this paralysis eventually led to death (Shukla, 2012).

In vitro anthelminthic activity of Ocimum in comparison with albendazole. A 100 mg/ml concentration of an aqueous extract of *Ocimum sanctum Linn* leaves was produced. The standard reference albendazole, was utilized at a concentration of 20 mg/ml. The aqueous extract has less anthelmintic activity than albendazole and is more potent than the control (NS). At the same concentrations, the Ocimum aqueous extract exhibited a substantially longer time to paralysis and subsequent death than the Albendazole extract (Buchineni M., 2015).

The phytochemical contents of basil leaves (*Ocimum sanctum*) include tannin, phenol, and flavonoids. By disabling oxidative phosphorylation, tannins and phenolics are known to disrupt the energy production of helminth parasites. They can also attach to free proteins within the host animal's digestive system or to glycoproteins on the parasite's cuticle, which can kill the parasite. In this study, four replications of 10 *A. suum* were employed in each treatment. In an incubator set at 37 °C, observations were made at 12, 18, 24, 30, and 36 hours. The percentage of *A. suum* that dies will increase with increased concentration and prolonged immersion. In vitro, basil leaves exhibited anthelmintic action against *A. suum.* given the greater death rate of

A. suum and the higher concentration of basil leaf infusion, there was a chance that the active chemical compound acting as an anthelmintic was the cause (Sea O., et al., 2017).

The powdered leaves of *Ocimum sanctum Linn* were subjected to maceration in 96% ethanol for a duration of five days. The pooled macerates were then concentrated using a rotavapor at 50 °C for 4-5 hours, resulting in the formation of a viscous extract. The ethanol extract was subsequently stored at 4 °C until ready for use. The research findings indicate that the ethanol extract of *Ocimum sanctum Linn.* leaves induced the highest mortality in *Fasciola gigantica*. However, the analysis of the interaction between concentration and exposure time revealed that an effective concentration for causing the most mortality to *Fasciola gigantica* is 5% over an exposure time of 8 hours (Mahardika M. M. and Koesdarto s. 2017).

Vanna Lidya Kharisma et. al. investigated the interaction between the concentration and exposure time of the ethanol extract of *Ocimum sanctum Linn*. leaves in causing mortality to *Ascaridia galli* in vitro. The LC50 and LC90 values of the ethanol extract were also determined. The research utilized 200 samples of *Ascaridia galli*, each measuring 7-11 cm in length, without differentiation based on sex. Each treatment was replicated four times. The interaction analysis revealed that a concentration of 10% of the ethanol extract of *Ocimum sanctum Linn.* leaves caused the highest mortality in *Ascaridia galli* after 24 hours of exposure. The study confirmed the presence of phytochemical constituents in the ethanol extract of *O. sanctum Linn*. leaves, demonstrating its efficacy as an anthelmintic agent (Kharisma V. L. & Koesdarto S., 2018)

The invitro anthelmintic activity of *Ocimum sanctum* was assessed by Navneet Kumar Verma et al. (2021) using an extract from the leaves. *Pheretima Posthuma*, an Indian earthworm, was used to test the anthelmintic action. When *Ocimum Sanctum* extract was tested against the Indian earthworm *Pheretima Posthuma*, it showed strong anthelmintic activity. Relative to piperazine citrate, the fractions' dose-dependent anthelmintic effectiveness was quite comparable. Based on the study's findings, it was determined that mangrove plant leaves have a high concentration of polyphenolics and exhibit notable anthelmintic properties (Yadav V. and Verma N. K. 2021).

2.2 *Aegle Marmelos*

Aegle Marmelos (Rutaceae; Bilwa) fruit aqueous extract has reported good anthelmintic action against Earthworms. When compared to the distilled water control group, the aqueous extract of the ripe and shed dry fruits of *Aegle marmelos* demonstrated dose-dependent wormicide action. In the group that received distilled water as a control, there was no paralysis noted (Wagh P. and Deshmukh L. 2017).

Using several in vitro tests at varying extract concentrations, Abhishek Gupta et al. (2023) assessed the in vitro antiparasitic properties of aqueous and methanolic extracts of *Aegle marmelos*. Strongyle-type eggs and larval stages of *Haemonchus contortus* isolated from goat faecal samples were subjected to the Egg Hatch Assay (EHA) and the Larval Development Assay (LDA) for evaluation, respectively. *A. marmelos*'s aqueous and methanolic extracts have the potential to be antiparasitic agents that can be utilized to manage parasitic infection, according to the study's findings (Soni R. K, et al., 2023)

2.3 *Punica granatum*

Infected sheep have an anthelmintic effect against *paramphistomes* when exposed to the rind of *Punica granatum* Ethanol Extract (PgEE). Investigated were the Eggs Per Gram (EPG) count in sheep faeces, as well as their haematological and biochemical characteristics. Sheep given PgEE saw a significant decrease in the number of eggs in their faeces; this decrease was dose and treatment duration-related. PgEE has a significant positive impact on the affected host's health by effectively combating *paramphistomes* (Lalhmingchhuanmawii K. and Veerakumari L. 2014).

In vitro and in vivo tests using Baladi chicks against *Ascaridia galli* have revealed the noteworthy anthelmintic efficiency of pomegranate peel (*Punica granatum*) and pumpkin seeds (*Cucurbita pepo*) ethanolic extract, according to A.R. Abdel Aziz (2018). The standard drug used was fenbendazole. A live collection of adult *Ascaridia galli* was obtained from the small intestine of recently killed local Baladi chicken breeds. *Ascaridia galli* eggs carrying second stage larvae infected the chicks. Pomegranate peel extract was less successful than pumpkin seed extract (Aziz 2018).

In the Calabria region of southern Italy, Vincenzo Musolino et al. (2020) assessed the in vitro anthelmintic efficacy of an aqueous *P. granatum* macerate against GINs of sheep and determined which other P. granatum compounds had anthelmintic action (Castagna F.; Britti D. 2020).

According to Ahmed M. Kaiaty et al., Pomegranate (*Punica granatum L*) peel extract (PPE) has anthelmintic properties that help prevent PGE infections in ruminants. PGE eggs were detected in the faecal samples of 120 ruminants of various species, including 20 cattle, 12 buffalos, 68 sheep, and 20 goats. The first group received no medication (control negative), the second group received 1% ivermectin (control positive 1), the third group received albendazole (control positive 2), and the fourth group received pomegranate peel methanolic extract (experimental) orally for seven days (Kaiaty A. M., Salib F. A. and El-Gameel S. M 2021).

Using albendazole as a positive control, the motility of *T. saginata*—an isolate from the gastrointestinal tract of cattle—was monitored in the experiment in vitro at different doses of pomegranate peel decoction. The findings demonstrated that the concentration of the decoction and the length of time the decoction and nematode were in contact affected the anthelmintic action. High concentrations of the decoction result in death, whereas moderate concentrations cause paralysis (Saptarini N. M.; Mustarichie R.; 2021).

The pomegranate peel extract (*Punica granatum*; PPE), silver nanoparticles (AgNPs), and selenium nanoparticles (SeNPs) exhibit in vitro anthelmintic action against the eggs, larvae, and adults stages of *H. contortus*. The adult worm motility inhibition assay (WMI), the third larval stage paralysis assay (LPA), and the egg hatching inhibition assay (EHA) were used to assess the in vitro anthelmintic efficacy. The findings demonstrated a considerable inhibition of egg hatching by the lowest concentrations of AgNPs, SeNPs, and PPE. SeNPs at the lowest concentration and AgNPs at the maximum concentration both produced a robust larvicidal impact, allowing for additional assessment of larvicidal activity. Effective antiparasitic action against gastrointestinal parasitic nematodes is exhibited by AgNPs, SeNPs, and PPE (Kaiaty A. M., et al., 2023).

Felwa Abdullah THAGFA et al. examined the anthelmintic properties of silver nanoparticles (AgNPs) made from pomegranate peel extract (PPE-AgNPs). PPE-AgNPs' anthelmintic activity was investigated at different doses. A model worm called *Eisenia fetida* was utilized. Furthermore, mebendazole served as a reference medication. Thirteen chemicals were detected by FT-IR phytochemical analysis. There was evidence of a dose-dependent efficacy in every test. Histological analysis of all treated worms showed a severe deformity of the worms' surface architecture. We conclude that PPE-AgNPs exhibit minimal cytotoxicity and potent anthelmintic characteristics, hence promoting its application in the biomedical field (Thagfa F. A., et al., 2023).

2.4 *Momordica charantia*

M. Charantia's whole fruit, fruit peel, seed, and peel juice methanolic extract had in vitro anthelmintic action against adult Indian earthworms (*Eisenia foetida*). According to this study, the fruit peel displayed paralysis death. The *M. charantia* seed extract was tested by Indian researchers Vedamurthy et al. against the adult earthworm *Pheretima posthuma*. Following ethanol, aqueous, and petroleum ether extract, the chloroform extract demonstrated the highest anthelmintic activity, causing paralysis and death. Aqueous and methanolic extracts showed death and paralysis (Sen S., et al., 2014).

The anthelmintic activity of water and methanolic extracts was tested on *Eisenia foetida* earthworms. Additionally, at concentrations of 5 mg/mL and 10 mg/mL, the extracts from the consecutive extractions of petroleum ether, chloroform, ethyl acetate, methanol, and hydro alchoholic were examined. Chloroform extract, however, demonstrated more strong activity than any other component in the subsequent extraction process. Its alkaloids and steroidal triterpenoids are most likely what cause the activity. Therefore, *Momordica charantia*'s anthelmintic properties have been demonstrated in accordance with Ayurvedic medicine; additional research is required to identify the chemical causing these properties. *Momordica charantia Linn*. water and methanol extract was used in in vitro experiments, which demonstrated complete anthelmintic action against *Eisenia foetida*. The fruits of the *Momordica charantia* plant have good anthelmintic properties. In comparison to the commercial medication albendazole, the chloroform fraction exhibited good anthelmintic activity (Gandhi V., et al., 2016).

Momordica charantia L. (Cucurbitaceae; bitter melon) exhibited anthelmintic efficacy against *Pheretima posthuma* in an aqueous extract obtained from the whole fruit, according to Md Rashid et al. (2016). Individuals. *M. charantia* extract and silver nanoparticles together have a potent anthelmintic action. One common medication was albendazole (Rashid , 2016).

In vitro experiments using *Momordica charantia Linn.* extract (water and methanol) shown complete anthelmintic efficacy against *Eisenia foetida*, as reported by Gandhi Vinav et al. (2016). Additionally, the chloroform fraction exhibits more strong activity in subsequent fractions compared to all other fractions and the common medication albendazole. The fruits of the *Momordica charantia* plant have good anthelmintic properties (Gandhi, et al., 2016).

2.5 *Saraca indica*

Saraca indica leaf anthelmintic properties were investigated by Nayak Sarojini et al. (2011). They employed ethanol and methanol as solvents in both the maceration and soxhelet techniques of extraction. The ethanolic and methanolic extracts of *Saraca indica* (obtained from both extraction procedures) demonstrated dose-dependent anthelmintic properties. They discovered that, in terms of their anthelminthic properties, the methanolic and ethanolic extracts were more potent than the positive control using both extraction techniques. Additionally, phytochemical examination of the extracts was done in order to connect phytochemical screening with anthelmintic activity. According to the findings, the ethanolic extract's anthelmintic agent potency was comparatively higher since it contained alkaloids, glycosides, terpenoids, tannins, and flavonoids. However, the methanolic extract's efficacy as an anthelmintic drug was most likely brought about by the inclusion of flavonoids and glycosides (Nayak S., et al., 2011).

Using an extract from the leaves of *Saraca indica*, Seema Garg (2012) assessed the anthelmintic activity of a colloidal solution of silver nanoparticles against adult Indian earthworms (*Pheritima Posthuma).* The concentration-dependent nature of the silver nanoparticle colloidal solution and aqueous extracts was demonstrated by anthelmintic activity. The plant leaves and bark have already been noted to have anthelmintic properties (Garg, 2012).

According to Singh et al. (2014), Using *Pheretima posthuma* as test worms, ethanolic and methanolic extracts of the bark of *Saraca indica Roxb*, a member of the Caesalpiniaceae family, exhibit anthelmintic action. The paralysis and death times were examined, and the activity was contrasted using piperazine citrate as the benchmark. Reduced paralysis and death times were indicative of strong anthelmintic activity in the ethanolic and methanolic bark extracts of *Saraca indica Roxb*. Alkaloids, glycosides, tannins, flavanoids, saponins, terpenoids, and flavanoids appear to be the phytoconstituents with anthelmintic activity (Singh A. K., et al., 2014).

2.6 *Azadirachta indica*

The anthelmintic activity of *A. indica* was assessed by C. T. Costa et al. (2006) after feeding the dried leaves to sheep. Forty sheep were divided into four treatment groups for this experiment. The following metrics were assessed in order to compare the effects of the treatments: weight gain, haematocrit, worm burden, and egg count per gram of faeces (EPG). The Kruskal-Wallis test was used to statistically analyze the EPG and worm burden data (C.T.C. Costa, et al., 2006).

A number of experiments were carried out to determine the effectiveness of neem leaves as an anthelmintic treatment for goats' *Haemonchus contortus.* A graded test conducted in vitro on the motility of *Haemonchus contortus* L3 larvae showed that the highest anti- larval activity of pure azadirachtin. In comparison to infected groups fed a complete diet devoid of Neem leaves, it was deduced that feeding Neem leaves decreased the Egg per Gram (EPG) count starting on the 42nd day and also dramatically lowered the worm count. Therefore, it is hypothesised that feeding neem leaves nonstop for more than 6–9 weeks will lower both the worm and EPG counts. Neem leaves are indicated to have a role as an additional organic, non-chemical source of anthelmintic, at least during the epizootics of worm infection. Neem is therefore a viable option for organic farming in addition to providing nutrients and an organic supply of anthelmintic (Radhakrishnan L., 2007).

Azadirachta indica (Family: Meliaceae) bark was used by Maheshwar G. Hogade et al. (2014) to assess the anthelmintic activity of its various extracts (ethanol and aqueous) against *Eudrilus eugeniae* and *Ascardi galli*. A bioassay was conducted to determine the period of paralysis (P) and death (D) for two types of worms. Various concentrations of ethanolic and aqueous extracts and its various fractions were tested. As a control, distilled

water was utilized, and piperazine citrate was the usual anthelmintic medication. According to the study's findings, alcoholic ethanol and bark extracts significantly produced paralysis in worms at lower doses and killed them, especially at higher concentrations as compared to normal medication (Hogade M. G., et al., 2014).
According to Priya et al. (2015), the colloidal solution of *Azadirachta indica* silver nanoparticles exhibited greater anthelmintic activity than the aqueous extract against adult earthworms *Eudrilus eugeniae* and *Eisenia fetida*. Overall, the anthelmintic activity demonstrated how the aqueous extracts and colloidal solution of *Azadirachta indica* silver nanoparticles are concentration-dependent (priya, 2015).
Time and concentration have been discovered to be dependent on the anthelmintic effects of the *Azadirachta indica* plant. Following cow slaughter at *Apiapum abattoir*, different concentrations of crude leaf extract from *Azadirachta indica* were produced and added to sample petridishes containing *F. hepatica* and *P. cervi.* Within each petridish sample, ten parasites of each kind were maintained. The plant's crude leaf extract's lethal concentration (LC50) on the parasite was ascertained using probit analysis and mean cumulative mortality. When *P. cervi* was exposed to the highest concentration of *A. indica*, 100% mortality was reached in just two hours, while F. hepatica required three hours to produce the same outcome. As a result, *A. indica* demonstrated anthelmintic activity against both trematodes in vitro, showing concentration and time dependent mortality towards *F. hepatica* compared to *P. cervi* (Ibekwe, 2019).
It has been found that two native plant extracts, *Azadirachta indica* and *Melia azedarach*, have anthelmintic properties in vitro. These two plants' seeds and leaves were used to extract the essential oils (EOs) and silver nanoparticles (AgNPs) using centrifugation and hydro-distillation methods. Using *Haemonchus contortus*, the egg hatch assay (EHA) and adult motility assay (AMA) were used to examine their effects. From seeds and leaves, silver nanoparticles were created. Using the Clevenger equipment and the hydro-distillation process, essential oils from seeds and leaves were extracted (S. Batool, et al., 2023).

2.7 *Catharanthus roseus*

Utilizing *Pheretima posthuma* as an experimental model, *Catharanthus roseus*'s anthelminthic characteristic was assessed. The industry standard reference was piperazine citrate. Among the studied concentrations, ethanol extract shown an effective paralyzing effect in comparison to other treated groups. *Catharanthus roseus* ethanol extract had strong anthelminthic action against *Pheretima posthuma*. (Agarwal , et al., 2011)
Egg hatch assay (EHA) and larval development assay (LDA) were the foundations of the in vitro experiment. At the highest dosage examined the extracts of *Annona squamosa, Eclipta prostrata, Solanum torvum, Terminalia chebula*, and *Catharanthus roseus* showed total inhibition in the ethyl acetate, acetone, and methanol of the leaves and seeds (Kamaraj , et al., 2011).
The experimental investigation described in vitro anthelmintic trials against *Haemonchus contortus* eggs, larval stages, and adult parasites. *Syzygium cumini* (Jamun), *Eucalyptus globulus* (Safeda, Eucalyptus), *Annona squamosa* (Custard apple, Sarifa), and *Catharanthus roseus* (Sadabahar) leaves were gathered. The findings of the adulticidal assay showed that the MeOH (methanolic) extract of *Annona squamosa* leaves had the highest adulticidal activity, followed by the MeOH extract of *Eucalyptus globulus* leaves. *Catharanthus roseus* leaves MeOH extract exhibited the highest larvicidal efficacy. MeOH extracts of *Eucalyptus globulus* leaves and

Annona squamosa leaves had the highest ovicidal activity. Among the chosen plants, *Syzigium cumini* exhibited the least amount of anthelmintic activity. The inclusion of alkaloids, tannins, and essential oils in the crude extracts may be responsible for the anthelmintic activity of these plant extracts. Based on the egg hatch assay, the comparison of ovicidal activity showed that *Eucalyptus globulus* and *Annona squamosa* had the highest anthelmintic activity (Kumar, et al., 2015).

2.8 *Tamarindus indica*

K. GHOSH evaluated the anthelmintic activity of ethanolic and aqueous extract of leaves and bark of *Tamarindus ind*ica Linn using *Pheretima posthuma* and *Tubifex tubifex* as test worms. The time of paralysis and time of death were studied and the activity was compared with piperazine citrate as reference standard. The alcohol and aqueous extract of bark of *Tamarindus indica* exhibited significant anthelmintic activity as evidenced by decreased paralyzing time and death time. Phytochemical analysis of the crude extract revealed the presence of tannins along with other chemical constituents contained within them. Tannins have been reported to produce anthelmintic activities, as they can bind to free proteins in the gastrointestinal tract of host animal or glycoprotein on the cuticle of the parasite and thereby cause deaths (GHOSH, 2011).

Silver nanoparticles (AgNPs), which may have anthelmintic properties, are made from natural fruit extract from *Tamarindus indica.* The plant extract is used as a reducing and capping agent in the production of AgNPs (Muthu, 2018).

The effects of tamarind (*Tamarindus indica*) and neem (*Azadirachta indica*) leaves as anthelmintics on cattle were investigated by Atikur Rahaman et al. in 2022. The amount of faecal eggs was shown to be significantly impacted by tamarind and neem leaves. Neem: Tamarind (1:1) was shown to be more effective in terms of efficiency than Neem and Tamarind alone (Rahaman, 2022).

2.9 *Terminalia chebula*

Anthelmintic activity in adult earthworm *Pheretima posthuma* was observed for fruit extracts from *Terminalia chebula Retz.* (Harra) family Combertaceae. It was discovered that the alcoholic extract had greater anthelmintic activity than both the aqueous extract and the conventional medication albendazole. Both the alcoholic and aqueous extracts of the fruits demonstrated notable anthelmintic activity. Because they resemble the intestinal roundworm parasites of humans in both anatomy and physiology, adult earthworms of the genus and species *Pheretima posthuma* were removed from wet soil and cleaned out of sand. It was noted how long it took for each worm to become paralyzed and die (Dwivedi S., et al., 2008).

According to Lokesh and Veerakumari et al. (2008), *T. chebula* has anthelmintic action against *C. cotylophorum.* Based on its effects on the motility and acetylcholinesterase (AChE) of the digenetic trematode *C. cotylophorum* in vitro, *Terminalia chebula'*s anthelmintic activity was evaluated. An electronic micromotility meter (EMM) was used to record the drug-treated parasites' motility response. An enzyme called AChE is engaged in neurotransmission. *Terminalia chebula* (TcEE) ethanol extract suppresses AChE and affects the parasites' motor activity, causing the parasites to lose their biochemical grip and be discharged from their host (Lokesh and Veerakumari, 2015).

In vitro anthelmintic effects against *Toxocara vitulorum* were demonstrated using zinc oxide (ZnO) and iron oxide (FeO) nanoparticles. By causing oxidative and nitrosative stress, ZnO and FeO nanoparticles produce their anthelmintic effects. *T. vitulorum's* reaction to iron oxide and zinc oxide nanoparticles. As an anti-parasite agent, several types of nanoparticles have been suggested (Hashemzadeh , 2017).

Zinc oxide nanoparticles (ZnO NPs) are one of the low-cost, low-toxicity nanomaterials that are widely used in biomedical fields, including drug delivery and bioimaging applications, as well as anticancer, antibacterial, antioxidant, and anti-inflammatory activities. Zinc oxide nanoparticles (ZnO NPs) shown anthelmintic action in relation to *Pheretima posthuma* (Islam, 2020).

Table 1: List of medicinal plants against intestinal parasitic nematodes

Plant	Family	Plant parts used	Phytochemicals	Animal model
Ocimum sanctum	Labiateae	Leaves	Tannin, phenol and flavonoids	*Pheretima posthuma* *Ascaris sum* *Ascaridia galli*
Aegle marmelos	Rutaceae	Fruit	Alkaloids, tannin, phenol and flavonoids	*Haemonchus contortus* *Pheretima posthuma*
Punica granatum	Cucurbitaceae	Fruit, fruit peel, seed,	Alkaloids and steroidal triterpenoids	*Sheep* *Eisenia foetida* *Ascaridia galli* *Pheretima posthuma* *T. Saginata* *Haemonchus contortus*
Saraca indica	Caesalpiniaceae	Leaf, bark	Alkaloids, Terpenoids, g lycosides, tannins, and flavonoids	*Haemonchus contortus* *Pheretima posthuma*
Azadirachta indica	Meliaceae	Leaves, bark	Alkaloids, tannin, flavonoid and saponin	*Haemonchus contortus*
Catharanthus roseus	Apocynaceae	Leaves	Alkaloids, tannins, and essential oils	*Pheretima posthuma* *Haemonchus contortus*
Tamarindus indica	Leguminosae	Fruit, leaves and bark	Tannins, flavonoid	*Pheretima posthuma*
Terminalia chebula	Combertaceae	Fruit	Polyphenols, terpenes, anthocyanins, flavonoids, alkaloids and glycosides	*Pheretima posthuma* *C. Cotylophorum*

Table 1: Medicinal plants

III. CONCLUSIONS: From the present review it can be concluded that Ayurvedic plants discussed here are very much effective for the treatment of parasitic infestations. In summary, further research is required to fully understand the phytochemical, clinical, and maybe molecular mechanisms of action. In order to supplement or replace the synthetic medications that are now in use, efforts should be made to standardise plant extracts with good anthelmintic action and create the finest alternative herbal formulations.

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