ANTHELMINTIC ACTIVITY OF PLANT EXTRACTS AND SYNTHESIZED GREEN METAL NANOPARTICLES AGAINST GUT HELMINTHS OF RUMINANTS

Abstract

India's economy is heavily dependent on its livestock industry. It improves the financial situation of rural impoverished people. It is a key agricultural source that boosts household income in rural regions and benefits the economy by generating jobs. Goats, cows, and buffaloes are raised for a number of purposes, including the production of leather, meat, and milk. Helminths are known for infecting humans, goats, cows, and buffaloes. The country's economy is impacted by these illnesses since they result in serious livestock ailments. kinds of synthetic drugs like albendazole, mebendazole, etc. are easily available in the local market, widely used for helminth control. However, long-term use of these synthetic medications reveals significant toxicity and adverse clinical side effects to both target and non-target species, including loss of appetite, nausea, vomiting, headaches, stomach discomfort, diarrhoea, and hepatotoxicity. It is therefore imperative to find anthelmintic medications that are more effective, less toxic, and have few to no adverse effects. The current review effort compiles research on medicinal plants' effectiveness against various cattle helminths conducted in vitro and in vivo. The development of efficient anthelmintic drugs with minimal side effects and non-resistance to parasitic helminths is expected to be possible using these plant-based herbal remedies. Recently, various types of plant synthesized-metal nanoparticles have proved highly effective in controlling helminth diseases, they have been examined in broad range of research field because they are safe, cost-

Authors

Jayeeta Khanrah
Laboratory of Parasitology
Vector Biology, Nanotechnology
Department of Zoology
The University of Gour Banga
Malda, West Bengal, India.

Dr. Anjali Rawani
Ph.D.
Assistant Professor
Laboratory of Parasitology
Vector Biology, Nanotechnology
Department of Zoology
The University of Gour Banga
Malda, West Bengal, India.

effective, and easily available having simple biosynthesis process. This review paper also emphasizes the therapeutic applications of diverse biologically produced metal nanoparticles, which presents a new avenue with pharmacological support for the successful treatment of numerous helminth illnesses.

Keywords: Anthelmintic activity, plantextract, synthesized green nanoparticles, parasitic helminth.

I. INTRODUCTION

Worldwide, helminth parasite diseases affect billions of people as well as ruminants (WHO 2010), with the majority of cases occurring in tropical and sub-tropical nations with low per capita incomes and unhygienic living conditions (Hotez et al., 2007). India is responsible for about 25% of all helminth infections worldwide. In the livestock industry, this infectious agent causes anorexia, anaemia, diarrhoea, weight loss, and significant production losses (WHO, 2017). The three groups of helminth parasites are cestodes (flatworm), trematodes (flukes), and nematodes (roundworms). Gastrointestinal (GI) nematodes, such as Haemonchus contortus, Bunostomum sp., and Trichostrongylus sp., are among these helminths and have a significant impact on the security of the food supply. All types of ruminants are adversely affected by helminths; some helminths are bloodsuckers and cause anaemia, while many others affect the body's physiology, metabolism, and immune system, leading to significant economic losses in the production of meat, milk, and wool as well as in reproduction (Suarez et al., 2009). Since a decade, broad spectrum synthetic anthelmintic medications like ivermectin, albendazole, and levamisole have been utilized to protect our animals against gastrointestinal helminth infections. The main source of resistance as well as the toxicities growing out of their use is the residue of all these dangerous synthetic medications in animals and animal products (Kundu et al., 2015). According to Devi et al. (2009), these sorts of dangerous medications exhibit high levels of toxicity and severe clinical symptoms such as loss of appetite, nausea, vomiting, headaches, abdominal discomfort, diarrhoea, and hepatotoxicity. The most recent strategy involves using herbal treatments either by alone or in conjunction with conventional anthelmintics. Researchers have shown that herbal anthelmintics contain natural plant components that are safe for the environment, non-toxic, cost-effective, and have very few or no side effects. Numerous researchers have examined plant anthelmintics and established their efficacy as complementary anthelmintic treatments. The majority of in vitro studies concentrated on how plant extracts and their fractions affected helminths while they were in their free-living phases. Animal feed was the main source of medicine for in vivo research, which revealed poorer efficacy than in vitro tests.To assess the anthelmintic effects of plant extracts and products, in vitro anthelmintic tests such as the egg hatch inhibition assay/test (EHIA/EHIT), adult mortality inhibition assay/test (AMIA/AMIT), larval development inhibition assay/test (LDIA/LDIT), larval mortality inhibition assay/test (LMIA/LMIT), larval migration inhibition assay/test (LMIA/LMIT), larval feeding inhibition assay. The most common tests, such as LMIT and AMIT, evaluate different plant extracts' abilities to affect helminth larvae and adult motility, and EHIT evaluates their ability to prevent egg hatching. Due to their quicker turnaround times and comparable cost-effectiveness, in vitro procedures are preferred to in vivo methods for testing plant materials on a wide scale.The faecal egg count reduction test (FECRT) and the controlled efficacy test (CET) are two in vivo anthelmintic tests that aren't the best due to their higher cost, lack of precision, and reproducibility due to inter-animal variation and the drug's pharmacodynamics in the host (O'Craven et al., 1999; Santos et al., 2019).

Botanical anthelmintics are known to be abundant in the plant kingdom (Satyavati et al., 1985). For primary healthcare and other health benefits, almost 80% of the world's population still uses our traditional medicines made from plant extracts (WHO, 2008). According to Temjenmongla and Yadav (2005), traditional medicines have a lot of potential as sources of easily accessible efficient anthelmintics drugs. In poor nations like India, China, Bangladesh, etc., helminthiasis is historically treated with a variety of folklore medicinal herbs (Choudhary et al., 2015). The anthelmintic efficacy of several fabled medicinal plants against liver fluke and other parasites has been investigated (Tandon et al., 1997; Mehlhorn et al., 2011). In order to cure parasite infection, plant-derived medications and herbal remedies are becoming increasingly popular (Mehlhorn et al., 2010; Dehuri et al., 2021). These herbal medications are appealing since they are easily accessible, affordable, have few to no adverse effects, and do not result in resistance (Wakayo and Pewo, 2015).

Recently, efficient green chemistry techniques for the synthesis of metal nanoparticles, which is of special interest to researchers, have been developed. They have done extensive research and have discovered a method for producing well-characterized nanoparticles that is both secure and environmentally benign. The use of organisms to produce metal nanoparticles is one of the approaches that is most frequently discussed. Among these creatures, plants seem to be the most appropriate and best option for the mass synthesis of nanoparticles. Compared to microbes, plants create nanoparticles that are more stable and synthesize them at a faster rate. In addition, the nanoparticles differ from those made by other animals in form and size (1-100 nm). Due to the advantages of employing plants and products made from plants for the biosynthesis of metal nanoparticles, researchers are investigating the mechanisms of metal ions uptake and bio-reduction by plants as well as the potential mechanisms of metal nanoparticle formation in plants. Typically, diverse biomolecules, particular medications, nucleic acids, peptides, and antibodies are carried by metal nanoparticles made of gold, silver, platinum, iron, silica, copper, zinc, and some lanthanides. For a variety of illness types, such as cancer, microbial infections, parasitic infections, cardiovascular disease, and neurological disorders, they can serve as diagnostic and therapeutic agents (Zhang et al., 2020). Metal nanoparticles derived from plants offer hope for new therapies for the management of parasitic illnesses.

Studies are done both in-vitro and in-vivo to determine the efficacy of plants with anthelmintic activity. Various medicinal plants and artificial green nanoparticles that may be effective against various gastrointestinal helminths (cestode, trematode, and nematode) have been described and tabulated in this review. These findings may pave the way for basic pharmacological studies that will result in the development of new anthelmintics to replace the traditional ones that suffer from anthelmintic resistance and high cost.

1. **Objectives:** The purpose of this review of the literature is to compile and update information on crude extracts and green metal nanoparticles created from medicinal plant extracts that have been suggested to have potential anthelmintic activities (ovicidal, larvicidal, and adulticidal) against various types of ruminant's gut helminth.

2. **Material and Methods:** The review of literature has been made by following various research articles including 8 databases (5 English databases: PubMed, Elsevier, Research Gate Google scholar, Science Direct) And (3 Persian databases: Scientific Information Database or SID, Magiran, and ISC) through the years between 2002 – 2022, where anthelmintic activity of plants extracts and green synthesis of Metal Nano particles were reported. The combination of the words “Herbal medicine,” “Plant extract,” “In vitro,”

"In vivo," "Anthelmintic", "Ruminant", "Green synthesis", and "Nano particles"were used for searching. I have collected those data from the relevant papers and enlistedthem in this review of literature.

3. **General concept about Helminth:** Helminth means parasitic worm in general term. They are invertebrates characterized by flat, elongated or round bodies. Flukes and tapeworms are examples of platyhelminthes, sometimes known as flatworms (the word "platy" is derived from the Greek for "flat"). Nematodes are roundworms; the term nemato means "thread" in Greek. These categories are further separated into the host organs that each group inhabits, such as intestinal roundworms, extra intestinal tapeworms, and lung flukes. The internal and exterior morphology of the egg, larval, and adult stages form the basis for the final classification. Aschelminthes and Platyhelminthes are the two phyla in which helminths are classified. In the Phylum Platyhelminthes, parasitic helminths largely belong to the two classes Trematoda and Cestoda, however in the Phylum Aschelminthes, there is only one class Nematoda that has parasitic helminth. These intestinal and blood endoparasites are the source of a number of illnesses referred to as helminthiasis.

4. **Cestodes (Tapeworms):** They are commonly known as tapeworms. The body of the cestode is divided into several segments known as proglottids and lacks cilia and an epidermis. Scolex is present on the front end and has hooks and suckers. They are always hermaphrodites. Adult tapeworms inhabit in the intestinal lumen and larva are cystic or solid, they inhabit in extra intestinal tissues. Some of the most widespread diseases caused by cestodes are Taeniasis *(Taenia saginata* and *Taenia solium),* Hymenolopiasis (*Hymenolepis nana*), Echinococcosis or Hydatid cyst disease *(Echinococcus* sp.), diphyllobothriasis *(Diphyllobothrium latum), Hymenolepis diminuta* etc.

5. **Trematodes (Flukes):** Flukes are flatworms with a leaf-like form that are adults and have distinct oral and ventral suckers that aid in maintaining posture. With the exception of blood flukes, all parasites are hermaphroditic. A snail serves as an intermediary host during the life cycle. Some of the most common and widespread diseases caused by trematodes are Schistosomiasis *(Schistosoma mansoni, Schistosoma japonicum* and *Schistosoma haematobium),* Opisthorchiasis or clanorchiasis *(Opisthorchis* sp.), paragonimiasis *{Paragonimus* sp.), Fasciolopsiasis *(Fasciolopsis buski),* Fascioliasis *(Fasciola hepatica).*

6. **Nematodes (Roundworms):** They are frequently referred to as roundworms because of their cuticle-covered body wall, lack of cilia, cellular or syncytial epidermis, and longitudinal muscles in four bands. In most cases, internal fertilization happens in dioecious animals. Both the larva and the adults have a cylindrical form and are bisexual. They reside in both intra- and extraintestinal locations. The most common widespread diseases caused due to infestation with the nematodes are Ascariasis (*Ascaris* sp.), Ancylostomiasis (*Ancylostoma duodenale*), Enterobius (*Enterobius vermicularis*), Trichuriasis (*Trichuriasis trichura*), Trichinosis (*Trichinella* sp.), Filariasis (*Wucheraria bancrofti*), Loiasis (*Loa loa*), Onchocerciasis (*Onchocerca volvulus*).

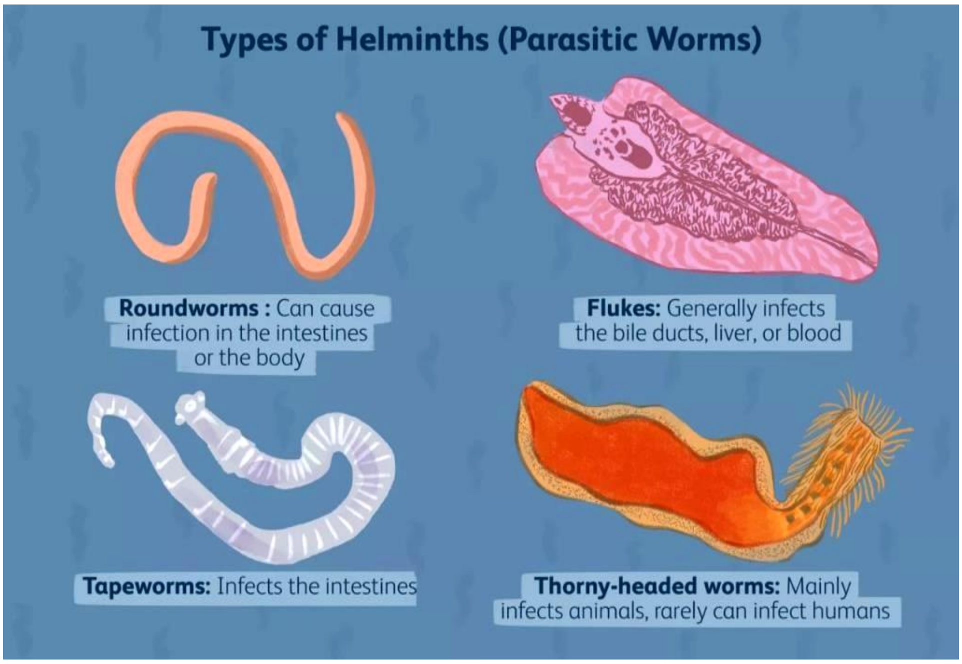

Figure 1: Types of helminths (parasitic worms) (Source: https://www.verywellhealth.com/helminths-5207511)

II. ABOUT NANOPARTICLES

The word nanoparticles come from the Greek word "nano". Nano is a very small size. According to Horikoshi and Serpone (2013), nanoparticles are particles with sizes between one and one hundred nanometers. Any unit can have it as a prefix to denote a billionth of that unit. The active substances are dispersed, trapped, encapsulated, adsorbed, or connected to micromolecular components that make up these products. It is a colloidal particle that is solid.

Green synthesis is a method for creating nanomaterials that is clean, safe, economical, and ecologically beneficial. The green synthesis of nanomaterials uses microorganisms like bacteria, yeast, fungi, algal species, and some plants as substrates. The green synthesis method offers quick, inexpensive, and repeatable methods for producing metallic nanoparticles that are environmentally benign.

Metal-based nanoparticles are widely used in engineering and medicinal sciences. Their market has expanded considerably over the past few years, and it is not expected to decline. AgNPs, CuONPs, AuNPs, and ZnONPs are a few examples of the several types of nanoparticles that are frequently utilized in pharmaceutical and medical applications (such as antibacterial, antifungal, antiviral, antiamebic, anticancer, and anti-angiogenic drugs).

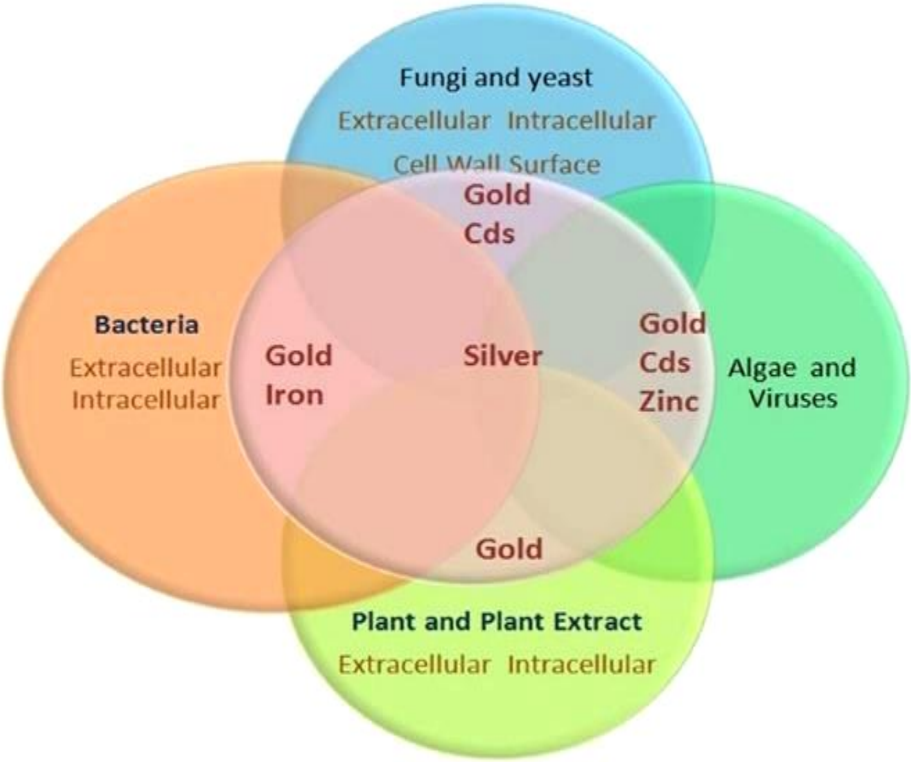

Figure 2: Different metal Nanoparticles (Gold, Silver, Zinc, Cadmium, Iron)(Source: https://www.frontiersin.org/articles/10.3389/fchem.2020.00799/full)

III. MODE OF ACTION OF PLANT AS AN ANTHELMINTICS

According to the WHO (2002), two-thirds of the world's population rely on plants as their main source of medical treatment. According to Newman and Cragg (2016), between 50,000 and 70,000 plant species are employed in both traditional and Western medical practices, and 25% of prescription drugs are made from plants or secondary metabolites obtained from them (Hammond et al., 1997; Akhtar et al., 2000; Githiori et al., 2006). Even today, at least 25% of medications are still derived from plants, and many more are semi-synthetic and constructed on plant-derived prototype chemicals (Kalia, 2005).All plant anthelmintics essentially kill helminth by paralyzing or starving them to death. If a paralyzed parasite loses their ability to hold their position in the stomach for a while, they will also die (Schoenian, 2010). Scanning electron micrograph (SEM) showed that plant Anthelmintic mostly causes tegumental damages, sucker disruption, scolex and entire body shrinkage in helminth and transmission electron micrograph (TEM) showed loss of parenchymal layer and chromatin clumped in nucleus occurs in helminth in most cases. Phytoconstituents showing anthelmintic effect includes tannins, alkaloids, polyphenols, saponins, flavonoids etc.

1. Alkaloids operate on the CNS, which causes paralysis, reduce the support of glucose to the helminths, and inhibit the transfer of sucrose from the stomach to the small intestine (Roy, 2010).

2. According to Wang et al. (2010), saponins cause vacuolization and the disintegration of teguments by interfering with the permeability of the helminths' cell membrane.

3. According to Tiwari et al. (2011), Sutar et al. (2010), and Mali et al. (2007), polyphenols and tannins increase the supply and absorption of digestible proteins by forming protein complexes in the rumen, which dissociate at low pH in the abdomen and release more protein for metabolism. They also suppress energy generation by uncoupling oxidative phosphorylation and reduce gastro-intestinal metabolism, which causes helminth paralysis and death.

4. By linking through H-H bonds, tannins bind to free proteins in the GI tract of the host animal or to the glycoprotein in the cuticle of helminths. This reactivity results in toughness in the skin, which renders worms immobile and non-functional. Tannins also reduce nutrient availability, which causes starvation in the larvae or reduced GI metabolism, which causes paralysis and then death (Vidyadhar et al., 2010). According to several reports, improving the availability of digestible protein helps sheep be more resilient and resistant to gastrointestinal nematodes. It also causes physiological changes in the host's gut, which leads to the rapid secretion of mucous and chemicals that are toxic to the helminths (Bachaya et al., 2009).

5. Steroidal alkaloid oligoglycosides prevent sucrose from being transferred from the stomach to the small intestine while decreasing the support of glucose in helminths and its antioxidant function. which inhibits the production of nitrate (which might be used in protein synthesis) and any potential inflammatory effects on the gastric and intestinal mucosa that might disrupt local homeostasis, both of which are necessary for the growth of helminths (Cruz, 2008).

6. According to Laverack (1963), ethanol extract can lower pH, which has the effect of starving the worms or causing osmotic anomalies.

7. On adult parasites, hydro-alcoholic extracts typically perform better than aqueous extracts. Recent research suggests that it may have occurred because hydro alcoholic extracts were more easily absorbed through the skin into the helminth's body than aqueous extracts. Hydro alcoholic plant extracts frequently include specific non-polar chemical components with lower polarity than aqueous extracts for improved anthelmintic activity. As a result, they are lipid soluble in comparison to aqueous extracts (Kumar et al., 2010).

Here some Medicinal plants list with proven anthelmintic effects are given below (in table 1).

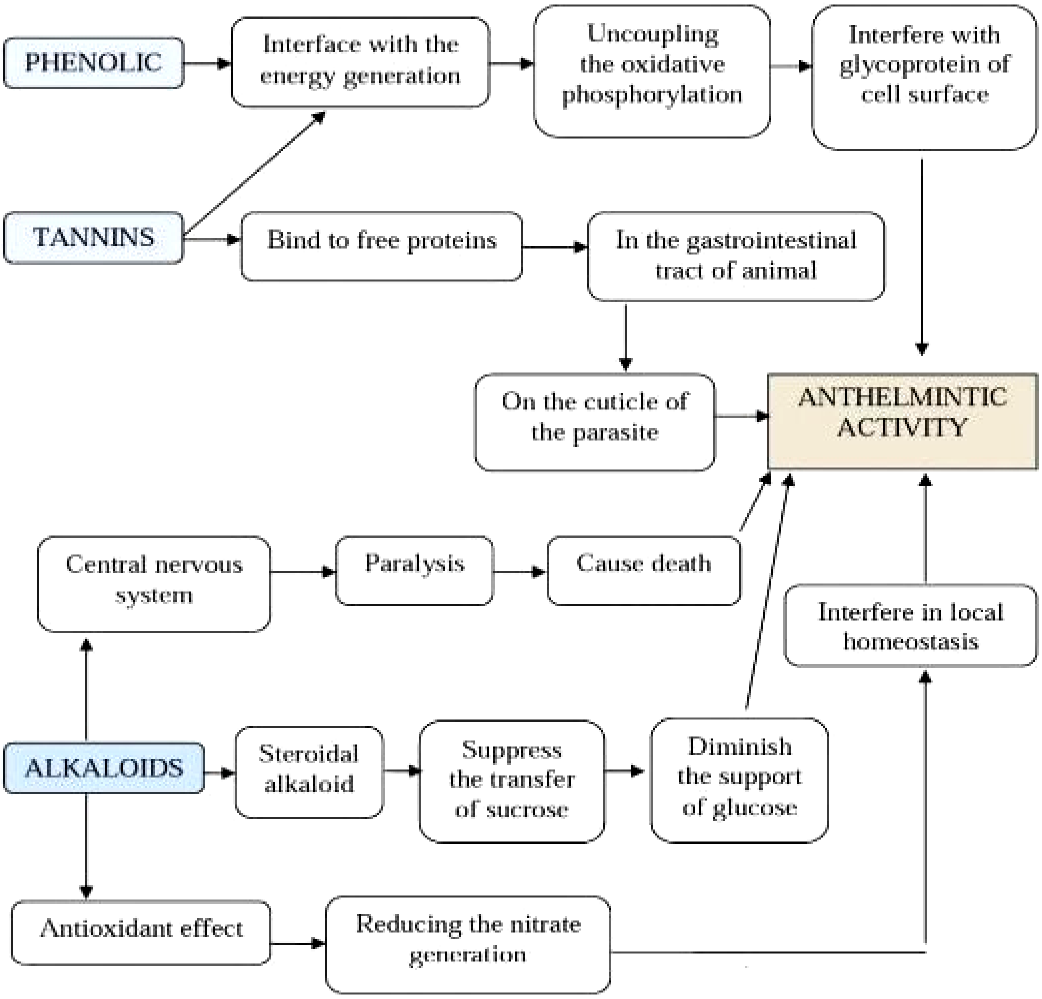

Figure 3: Different phytochemical's mode of action in Anthelmintic activity(Source: Kumar et al., 2010)

Table 1: Medicinal plants list with proven anthelmintic effects

Plant name	Family	Plant part used
Tamarindus indica	Caesalpiniaceae	Bark
Tephrosia purpurea	Fabaceae	Leaves
Terminalia arjuna	Combretaceae	Bark
Uncaria gambier	Rubiaceae	Leaves
Mimuosops elengi	Sapotaceae	Bark
Murraya koenigii	Rutacae	Root
Nicotiana tabacum	Solanaceae	Leaves
Albizia schimperiana	Fabaceae	Stem and root
Paederia foetida	Rubiaceae	Leaves
Pajanelia longifolia	Bignoniaceae	Bark
Portulaca oleracea	Portulacaceae	Leaves
Saraca indica	Leguminosae	Leaves

Spermacoce ocymoides	Rubiaceae	Leaves
Strobilanthes discolor	Acanthaceae	Leaves
Curcuma amada	Zingiberaceae	Rhizome
Diplazium esculentum	Athyriaceae	Rhizome
Drypetes sepiaria	Euphorbiaceae	Leaves
Ficus bengalensis	Moraceae	Fruit
Flacourtia sepiaria	Flacourtiaceae	Leaves
Gymnema sylvestre	Asclepiadaceae	Leaves
Hedychium spichatum	Zingiberaceae	Rhizome
Helicteres isora	Sterculiaceae	Fruit
Heliotropium indicum	Boraginaceae	Leaves
Physalis minima	Solanaceae	Leaves
Cotyledon orbiculate	Crassulaceae	Shoots
Achyranthes aspera	Amaranthaceae	Stem
Croton bonplandianium	Euphorbiaceae	Leaves
Baliospermum montanum	Euphorbiaceae	Root
Bambusa vulgaris	Bambusoideae	Leaves
Juglans regia	Juglandaceae	Stem bark

IV. MODE OF ACTION OF GREEN SYNTHESIS METAL NANOPARTICLES ASAN ANTHELMINTICS

The majority of research studies on the use of metal-based nanoparticles in the treatment of infectious diseases are built on preclinical analysis. In the treatment of helminth infections, combining metal nanoparticles with plant extract increased the anthelmintic activity. The nanoparticles that are currently being used have better cell interaction and uptake, and some of them even exhibit good selectivity when given specific functional modifications.

1. **Silver Nanoparticles:** Plant extracts and silver nanoparticles combined to produce effective anthelmintic action. Rashid et al. used fruit extract to show that polyaniline-coated silver nanoparticles have anthelmintic properties. While the plant extract contains phytochemicals that attach with the free proteins in the gastrointestinal system on the helminth's cuticle, causing paralysis and death, the +ve charge on the Ag ion was attracted to the -ve charged cell membrane of microorganisms by electrostatic interaction (Rashid et al., 2016).

2. **Gold Nanoparticles:** Gold nanoparticles, in addition to silver nanoparticles, have the potential to be anthelmintic agents. Kar et al. evaluated the anthelmintic activity of gold nanoparticles. Gold nanoparticles were produced by mixing gold chloride with a mycelia-free culture filtrate of the phytopathogenic fungus. The gold nanoparticles caused the helminth's paralysis and eventual death by directly affecting its physiological processes. The helminth's enzyme activity considerably changed following treatment with gold nanoparticles, illuminating the potential of these particles (Kar et al., 2014).

3. **Metal Oxide Nanoparticles (Zinc and Iron Oxide):** Nanoparticles made of iron oxide

andzinc oxide, for instance, have an antihelmentic impact on helminth parasites. Khan et al. (2015) revealed that zinc oxide nanoparticles have an anthelmintic effect on the helminth parasite that affects Indian livestock. By causing the helminths to create ROS, low nanoparticle concentrations caused oxidative stress. The flukes showed signs of a survivalstrategy by increasing the activity of antioxidant enzymes to scavenge the ROS. When they were treated with a high quantity of nanoparticles, the survival effort was hampered. The detoxification process was rendered ineffective because the worm's antioxidant enzymes were saturated. The antioxidant enzymes of the worm were saturated, rendering the detoxification process ineffective. It is hypothesized that the increased intracellular ROS level will change the contractile activity, interfere with the electron transport chain and make the cell membrane more permeable in helminths (Khan et al., 2015). Zinc oxide and iron oxide nanoparticles were tested for their anthelmintic properties against helminth by Dorostkar et al. (Dorostkar et al., 2017). Iron oxide nanoparticles were shown to be more effective than zinc oxide nanoparticles due to the nature of the nanoparticles.

Superoxide Dismutase activity (SOD) was increased following treatment with low doses of both nanoparticles. Because the enzyme was saturated at high nanoparticle concentrations, there was a noticeable decrease in SOD activity in helminths. High concentrations of the oxidative stress caused by the nanoparticles overwhelm ATP production and cause structural damage. According to Dorostkar et al. (2017), the anthelmintic action of metal oxide nanoparticles is caused by the development of oxidative stress.

Metal-based nanoparticles have beneficial biological interactions with biomolecules located within and on the surfaces of cells. They can also be modified to have improved therapeutic efficacy at the diseased site by introducing potent biological components with specific binding activity to choose target cells.

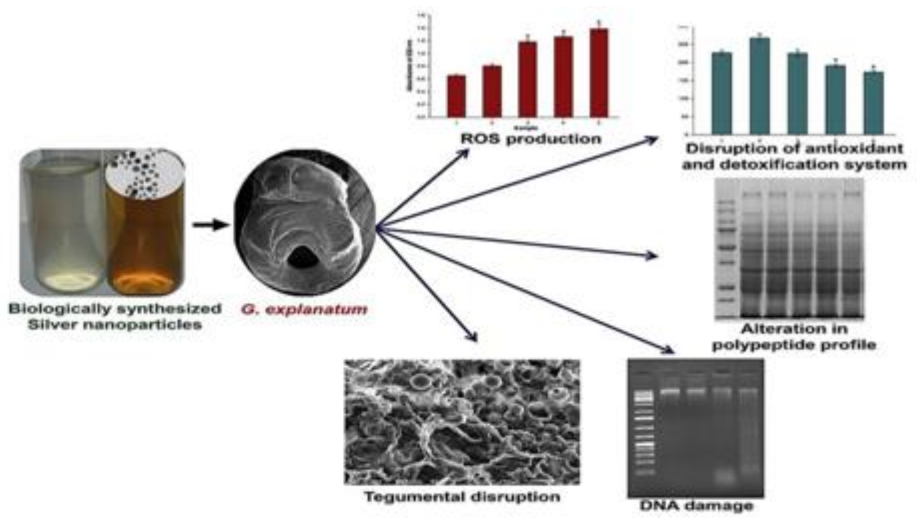

Figure 4: Morphological alternation in *Gigantocotyle explanatum* (Trematode) due to application of biologically synthesized silver nanoparticles.
(Source: Rehman et al., 2019)

Table 2: Plants reported for having Anthelmintic activity against cestode

Name of the helminth	Name of the plant	Plantpart used	Solventused	Stage of helminth	Test conducted	Result /LC50 values
Hymenolepis diminuta	*Oroxylum indicum*	Stem,Bark	Methanol	2nd stage of Juvenile & Adult inAlbino rat	In vitro and in vivo	In vitro, juveniles died after being exposed to 30 mg/ml of extract for the first time (0.25 ± 0.00 hrs.) of the extract reduced EPG counts by 79.3% andworm numbers by 70.8% in vivo.
	Cynodon dactylon	Whole plant	Methanol	Adult, EPG in Wister rat	In vitro and in vivo	The 40 mg/ml conc. resulted in worm paralysisand mortality in an invitro test after 4.12 ± 0.55 and 5.16 ± 0.34 hrs. respectively. 800 mg/kg administered orally for 5days in vivo showed up to 77.64% and 79.00% reductions in EPG counts.
	Pinus sp., Corylus avellana and *Trifolium repens*	Pine bark hazelnut Pericarp White clover flowers	Acetone/ water (7:3; v/v) Condense tannin	Cysticercoidsin beetle	In vitro and in vivo	In vitro, condense tannin from all three plant extracts had dose- dependent inhibitory effect, In vivo, hazelnut extract was most effective on cysticercoid development.
	Acorus calamus	Rhizomes	Methanol	EPG in rat	In vivo	800 mg/kg of rhizome extract for 5 days causes a 62.30% decrease in the EPG of faeces

						and an83.25% decrease in the number of worms.
	Psidiumguajava and *Lasia spinosa*	Leaves	Aqueous	Adult in rat	In vitro	40 mg/ml of aqueous extract showed best result.
	Caesalpinia bonducella and *Croton joufra*	Leaves	Methanol	2nd stage of Juvenile and adult inWister rat	In vitro	30 mg/ml of methanol extracts showed best result.
	Caesalpinia bonducella	Leaves	Methanol	Egg, Adult in mice	In vitro and in vivo	In vitro, 30 mg/ml of methanol extract caused mortality in 2.5 ± 0.2 hrs. In vivo 85% worm load reduction in rats.
Raillietina tetragona and *Ascaridia galli*	*Imperata cylindrica*	whole undergr ound parts	Chloroform	Adult in fowl	In vitro	Chloroform extract 20 mg/ml took time for *R. tetragona* 36.53 ± 2.66 hrs. to kill and took 81.56 ± 1.71 hrs. took for *A. galli* to kill respectively.
Raillietina tetragona	*Cassia alata*, *Cassia angustifolia* and *Cassia occidentalis*	Leaves	Alcohol	Adult fromfowl	In vitro	At 40 mg/ml, *C. alata* took less time (1.68 ± 0.27hrs.) to be paralyzed combination with any ofthis plant took shorter time to be paralyzed.
	Iiex khasiana	Leaves	Methanol	Adult in fowl	In vitro	20 mg/ml of the methanolic extract took 20.40 ± 2.55 h to kill all the adults.

Raillietina echinobothrida	*Lysimachia ramose*	Leaves	Crude & N-butanol	Adult in fowl	In vitro	At a dosage of 6 mg/ml of PBS, crude leaf extractand N-butanol fractioncaused adults' glycogen conc. to drop by 26–51%.
	Acmella Oleracea	Aerialparts	Methanol	Adult in fowl	In vitro	20 mg/ml the plant extract took 18.42 ± 0.95 hrs to kill the adults.
	Spilanthes acmella	Aerial parts of the plant	Chloroform	Adult in fowl	In vitro	Plant extract was effectiveat all conc.
	Carex baccans	Root	Aqueous	Adult in fowl	In vitro	50 mg/ml of the plant extract caused paralysis and death after 3.59±0.02 hrs and 4.13 ±0.06 hrs. of incubation respectively.
Moneizia expansa	*Abutilon indicum*	Leaves	Methanol	Adult,Egg in sheep	In vitro	At 100 mg/ml conc. the paralysis and death time were recorded at 66.3 ± 0.03 and 93.2±0.09 minutes respectively.
	Tephrosia purpurea	Root	Methanol	Adult in goat	In vitro	Methanolic extract of 125 mg/ml showing 1.29±0.17hrs. and 2.63±0.36 hrs. for paralysis and death, respectively.
Taenia saginata	*Gongronema latifolium,Piper guineense*and *Ocimum*	Leaves	Ethanol	Ova in cow	In vivo	8 hrs. of exposure to 50% conc. of *O. gratissimum* resulted in 100% death for each ovum.

	gratissimum					
Hymenolipes nana	*Punica granatum*	Peel	Methanol	Eggs in rat	In vivo	Methanolic extract withdoses of 0.5 ml, 1.0 ml and 1.5 ml decreased the number of worms at 15.6±2.6, 8.4 ±2.1 and 5.7±2.5 in treated groups respectively.
	FerulaAssa-foetida	Aerialparts	Methanol	Eggs in rat	In vitro	When compared to thecontrol, the highest conc. Of methanolic extract significantly reduced the number of eggs and helminths.
Taenia tetragona	*Acmella Oleracea*	Aerialparts	n-Hexane	Adult	In vitro	Lethal conc. (LC_{50}) of then-Hexane extract was 5128.61 ppm.

Table 3: Plants reported for having Anthelmintic activity against trematode

Name of the helminth	Name of the plant	Plant parts used	Solventused	Stages of helminth	Test Conducted	Result /LC5O values
Carmyerius spatiosus and *Paramphisto mum sp.*	*Cassia siamea*, *Plumbago zeylanica*, *Plumbago indica* and *Terminalia catappa*	Leaves, Heartwoods, Roots and Flowers	Ethyl acetate, n-butanol, Hexane and Water	Adult inCattle and Buffalo	In vitro	Most effective extract washexane having LC_{50} value 34.38 ppm and LC_{90} value 64.09 ppm.

Fasciolahepatica	*Acacia farnesiana, Acacia cornigera, Artemisia absinthium, Bocconia frutescens, Artemisia Mexicana, Cajanus cajan, Hibiscus rosa sinensis, Cordia spp, Leucaena diversifolia, Lantana camara, Melia azedarach, Mentha sp, Piper auritum, Ocimum basilicum* and *Teloxy sambrosioides*	Leaves	Hexane, Ethyl acetate and Methanol	Newly excysted flukes in ruminant	In vitro	*C. cajan*, *L. camara*, and *P. auritum* all demonstrated 100% efficacy at a dose of 500 mg/l, whereas *B. frutescens* and *A. Mexicana* demonstrated 100% efficacyat a level of 125 mg/l.
Schistosoma mansoni	*Corydalis crispa* and *Pleurospermum amabile*	Whole plant	Methanol	Adult inmice	In vitro	IC_{50} value is 8.6 µg/ml
	Eryngium triquetrum	leaves	Essential oil	Larva	In vitro	0.1 ppm had a prevalence of3.3%, which was less infectious than untreated, which had a prevalence of 44%.
	Teclea nobilis	Leaves	Essential	Eggs	In vitro	Essential oil showed LC_{50}
			oil			and LC_{90} values of 196.29 and 367.24 ppm respectively after30 mins.

	Ficus carica and *Olea europaea*	Leaves	Alcohol	Adult inmice	In vitro	The LC_{50} about both extractsmight have been 21. 35 and 47.98 after 120 hrs. ofexposure.
	Foeniculum vulgare	Fennel	Essential oil	Adult inmice	In vitro	Conc. of 100 μg/ml, was more effective against adult.
	Crocus sativus	Flower	Aqueous	Egg frommice	In vivo	Significant reduction in overall worm burden (7.00 ± 1.00) and significant increasein the number of dead ovules (13.11 ± 1.68).
	Mentha x villosa huds	Leaves	Essential oil	Adult inSwiss webstermice	In vitro	Essential oil caused the deathof all worms at 500 μg mL- 1 after 24 hrs.
Cotylophoron cotylophorum	*Nigella sativa*	Seeds	Ethanol	Adult in small ruminant	In vitro	After 8 hrs. of treatment, thehighest motility inhibition was seen at 0.5 mg/ml conc.
	Acacia concinna	Pods	Aqueous	Adult insmall ruminant.	In vitro	Effective at 0.5 mg/ml after 8hrs. of exposure.
	Syzygium aromaticum	Clove buds	Ethanol, Hexane, Chloroform and Ethyl acetate	Adult in small ruminant	In vitro	Ethanolic extract showed maximum inhibition in themotility at highest conc. 86.86%.

	Allium sativum	Bulb	70% Ethanol	Adult incattle	In vitro	Alcoholic extract showed highest mortality rate at a conc. of 1 mg/l after 8 hrs. exposure.
Gastrothylax indicus	*Azadirachta indica*, *Calotropis procera* and *Punica granatum*	Flower, Leaves and Fruit peel	Aqueous Ethanol	Adult in ruminant	In vitro	LC50 values were 12.05 mg/ml ± 3.24 and 23.52 mg/ml ± 6.4 for *C. procera* for ethanolic and aqueous extracts respectively.
Fasciola gigantica	*Curcuma aeruginosa*	Rhizome	Methanol	Adult incattle	In vitro	50% of *C. aeruginosa* extractshowed highest mortality. Allflukes died after 48 mins. of treatment.
	Terminalia catappa	Leaves	Ethanol	Adult incattle	In vitro	Maximum efficacy was observed in ethanolic extractof 1000 µg/ml, where 100 %death occur after 3 hrs. of incubation.
	Veitchia merrillii	Nut	96% methanol	Adult incattle	In vitro	50% of extract showed highest mortality. All flukesdied after 30 mins. of treatment.

	Dioscorea bulbifera L.	Bulbils	Methanol	Adult incattle	In vitro	The median lethal conc. values for liver fluke were 61.73 and 41.79 mg/ml forthe meat and peel extracts, respectively.
	Dregea volubilis	Leaves	Methanol	Adult incattle	In vitro	With a conc. of 100 mg/ml,the maximum fasciocidal activity was discovered at 38.83 3.41 minutes.
Fasciola spp	*Cantharellus cibarius* and *Ganoderma applanatum*	Mushroom fruiting bodies	Ethanol	Eggs and Miracidiastage in gall bladder of cattle	In vitro	*G. applanatum* ethanolic extract (GEE) tested at 8 mg/ml with 91.3% ovicidal activity was significant. higher than *C. cibarius* ethanolic extract (CEE) at thesame conc.
Gastrothylax crumenifer	*Microlepia Speluncae*	Leaves	Methanol	Adult insheep	In vitro	LC_{50} value was 3.666 with a95% confidence interval of 1.508-4.046.
	SpilanthesAcmella	Leaves	Hexane Ethyl acetate Methanoland Aqueous	Adult insheep	In vitro	Most effective in aqueous extract of callus at 5 mg/mlconc., caused onset of paralysis in 45.7 min and death in 87 mins.

Fasciolahepatica	*Eugenia uniflora, Harpagophytum procumhens, Psidium guajava* and *Stryphnodendron Nad stringens*	Leaves, Roots andBark	Alcohol	Eggs	In vitro	100% effective at 0.10% (*E. uniflora)* and 100 % effectiveat 0.25% *(H. procumbens).*
Paramphisto mum Microbothrium	*Balanites aegyptiaca*	Fruits	Methanol	Adult	In vitro	The fruit's 200 g/ml methanolic extract demonstrated the maximum potency.
Paramphistomum explanatum	*Drega volubilis*	Leaves	Methanol	Adultfrom buffalo	In vitro	100 µg/ml of methanolic extract took 10.67±0.61 mins. for death.
	Bombax malabaricum	Leaves	Methanol	Adult from buffalo	In vitro	100 µg/ml of methanolic extract took 22.17±0.48 mins.for death.
	Jatropha gossypifolia	Root	Petroleum ether extract (60-80°C) (PEJG)	Adult incattle	In vitro	PE extract of *J. gossypifolia* (PEJG) at 25 mg/ml killed the trematodes within 158.83 ± 4.94 mins.
Mixed trematodes inbird	*Punica gramatum*	Bark	Acetic acid	Adult infowl	In vitro	100 % mortality observed at 5 % conc. after 360 mins. of exposure.
Paramphistomum sp	*Clerodendrum viscosum, Eryngium foetidum, LippiaJavanica,* and *Murraya koenigii*	Leaves	Methanol	Adult incattle	In vitro	Paralysis and death time wererecorded at 0:56 ± 0:09 hrs. and 1:35 ± 0:07 hrs. *for L. javanica* at 50

						mg/ml conc.
Paramphistomum cervi	*Physalis minima*	Leaves and Stem	Ethanol	Adult incattle	In vitro	Paralysis took 10.5 mins. for leaves and 11.3 mins for stemand mortality took 28.8 mins.for leaves and 20 mins. for stem of worms by an ethanolic extract at 100 mg/ml.
	Carica papaya L.	Leaves	Ethanol	Adult incattle	In vitro	Higher conc. (100 mg/ml) ofethanolic extracts of the leaves responsible for the paralysis and death.
	Balanites aegyptica	Fruit, leaves and seed	Alcohol	Adult inbuffalo	In vitro	Alcoholic extract at 125 mg/ml conc. showed total mortality at 5 hrs.
	Ananas sativus, *Erythrinavariegata* and *Alocasia indica*	Leaves, Bark and Rootstock	Crude aqueous and Hydro-alcoholic extracts	Adult incattle	In vitro	The hydroalcoholic leaf extract of *A. sativus* showed paralysis in all three conc. (25, 50, and 100 mg/ml), withdeath times ranging from 7.26 to 26.76 and 15.40 to 35.55 minutes, respectively.

Faciola gigantica and*Schistosama sp.*	*Gongronema latifolium, Piper guineense and Ocimum gratissimum*	Leaves	Ethanol	Ova in ruminant,mice	In vitro	*P. guineense* at 75% conc. showed mortality after 2 hrs.of exposure to *F. gigantica* *O. gratissimum* at 75% conc.showed mortality after 4 hrs.of exposure to *Schistosoma sp.*

Table 4: Plants reported for having Anthelmintic activity against nematode

Name of helminth	Name of plant	Plant parts	Solvent used	Stages of helminth	Test Conducted	Result/ lc_{50} values
Meloidogyne sp.	*Asteriscus imbricatus, Lavendula dentata, Pulicaria mauritanica* and *Globularia*	Aerial parts	Petroleum ether Chloroform Distilled water	Egg and Larva in plant root	In vitro	At 2000 ppm, 89, 31 % and 92, 71% of mortality observed in A. imbricatus PE and chloroform extracts
Meloidogyne incognita	*Raphanus raphanistrum L., Peganum harmala L., Taxus baccata L. Ricinus communis L.* and *Sinapis arvensis L.*	Seed, Root and Aerial parts	Aqueous and Ethanol	Eggs and 2nd stage Juvenile in plant root	In vitro and In vivo	The extract of R. communis had the highest LC_{50} of all methanolic extracts in vitro, which was 0.75 ml/ml, whereas the extract of T. baccata had the lowest LC_{50} of all aqueous extracts, which was 0.51 ml/ml. After the application of methanolic extracts of the three plants,

	Abrus precatorius Linn., *Bunium persicum* Boiss., *Amaranthus virdis* Linn., *Dioscorea deltoidea* Wall. Ex Griseb., *Teraxacum officinale* Weber., *Malva neglecta* Wall., *Robina pseudoacacia* Linn. and *Podophylum hexandrum* Royle	Seed	Chloroform and methanol (50:50, v/v)	Eggs and 2nd stage Juvenile in plant root	In vitro	The highest rates of death were seen in seed extracts from T. officinale (93.67%) and B. persicum (89.66%) after 72 hrs.
	Azadirachta indica, Ocimum tenuiflorum, Arthemisia pallens, Ficus hispida and *Hibiscus rosasinensis*	Leaves	Methanol	Eggs and 2nd stage Juvenile in plant root	In vitro	The methanolic extracts of five plant species decreases the viability of nematodes as the conc. of the extracts increases.
	Curcuma longa	Root	Crude extract, Methanol, Chloroform Ethyle acetate and Hexane	Eggs and 2nd stage Juvenile in plant root	In vitro	The chloroform extract showed maximum mortality at highest Conc. .
	Lantana camara L.	Leaves	Aqueous	2nd stage Juvenile in plant root	In vitro	The highest mortality (98.6%) was recorded in 100% Conc. of leaf extract at 48 hrs of exposure period.
	Jatropha curcas	Leaves and Root	Distilled water	Eggs in root	In vitro	The highest % of nematode mortality was achieved by application of alkaloids

						(94.73%).
	Vernonia colorata, *Searsia lancea*, *Pelargonium sidoides* and *Cucurbita maxima*	Leaves	Methanol	Eggs and 2nd stage Juvenile in plant root	In vitro	100% of root gall growth was inhibited in seedlings given the methanolic extract of *V. colorata.* At 0.8 mg/ml, all 8 plant extracts demonstrated positive nematicidal action.
	Catharanthus roseus and *Solidago virgaurea*	Leaves	Aqueous, Ethanol	Eggs and 2nd stage juvenile	In vitro	Inhibition of egg hatching by *C. roseus* extracts was higher than *S. virgaurea* extracts. LC_{90} was found to be achieved by a conc. of almost 1 g D. Wt./L in *S. virgaurea.*
	Amaranthus viridis, *Solanum nigrum*, *Chenopodium album*, *Euphorbia hirta* and *Carica papaya*	Leaves, Stem and Fruit	Aqueous	Eggs and Larva in root	In vitro	Maximum reduction (24.3%) in egg hatching while using 2% concentrated *C. album* stem extract. Maximum larval mortality (33%) was noted in *C. album* leaf extract at 10% conc. after 48 hrs. of exposure.
	Tagetes erecta, *Tithonia diversifolia*, *Chromolaena odorata* and *Occimum gratissimun*	Leaves	Aqueous extract	Second stage of juveniles	In vitro	Within 24 hrs. of exposure, *T. erecta* resulted in 100% juvenile mortality. .

	Aloe vera	Leaves	70% Ethanol	2^{nd} stage of Juvenile, Adult male and adult female	In vitro	Highest efficacy was found at 80 mg/ml treatments.
	Mentha piperita, *Mentha spicata* and *Mentha pulegium*	Leaves	Aqueous and Essential oil	2nd stage of Juvenile	In vitro	The aqueous extract exhibited the EC_{50}/72 hrs.
Meloidogyne javanica	*Ochradenus baccatus*	Seedling, Stem, Flower, Root core and Root bark	Aqueous	Eggs and 2^{nd} stage Juvenile in plant root	In vitro	After 48 hrs. of exposure to the highest conc. (16%) in both trials, the aqueous extracts of stem and flower immobilised 40-7-100% of juveniles.
	Myrtus communis	Leaves	Methanol and Ethanol	2^{nd} stage of Juvenile stage and eggs in root	In vitro	Methanol or ethanol extracts showed the highest nematicidal activity among all extracts tested.
Haemonchus contortus	*Caesalpinia coriaria*	Fruit	Hydro-alcoholic and aqueous	Infective larval stage	In Vivo and in vitro	The in vitro findings demonstrated a clear larvicidal efficacy. In the in vivo trial, there was a 78.6% reduction in the elimination of EPG of faeces.
	Anacardium occidentale, Illicium verum, and	Shell, Seed and Fruit	Hydro-alcohol	Eggs, Infective larva and	In vitro	*A. Occidentale* shell caused adult worm mortality (LD_{50} = 1.0365 mg/mL) at a lower

	Artocarpus heterophyllus			Adult in sheep EHA, AMA		conc. (LD_{50}), larval paralysis (LD_{50} = 0.196 mg/mL), and 50% egg hatch inhibition (LD_{50} = 0.0255 mg/mL).
	Artemisia herba-alba, *Balanites aegyptiaca*, and *Allium sativum*	Stem, Leaves, Fruits and Cloves	Ethanol	Eggs and Larva in sheep	In vitro and in vivo	Clove ethanolic extract (CEE) of *B. aegyptiaca* demonstrated the greatest anthelmintic effect on adult worms in vitro. At 7 days after treatment, the CEE of *B. aegyptiaca* achieved faecal egg removal (100%) in vivo.
	Artemisia herba- alba and *Punica granatum*	Flower, Aerial parts, Peel and Root	Methanol	Eggs and Adult	In vitro AMA and EHIA	In vitro EHIA, flower methanolic extract of *A. herba-alba* exhibited 98.67% inhibition and 94.63 % at 1 mg/ml conc. of peel extracts of *P. granatum* respectively. In AMA, all helminths were dead within 5 hrs. at a conc. of 0.25 mg/ml.
	Chenopodium ambrosioides and *Castela tortuosa*	Aerial parts, Leaves and Stem	n-Hexane	Larvae in	In vitro and in vivo	The E-Cham extract produced an in vitro impact (96.3%) after 72 hrs. At 40 mg/ml, the maximum combined effect (98.7%) was attained after 72 hrs. Individual treatment of the

						E-Cato and E-Cham extracts decreased the parasite by 27.1% and 45.8%, respectively, in an in vivo experiment.
	Allium sativum and *Tagetes erecta*	Bulb and Flower	Aqueous	Larva in ruminant	In vitro and in vitro	Larvicidal activity% in vitro was 68% with *A. sativum* and 36.6% with *T. erecta* at a conc. of 40 mg/ml. Mortality was induced by the mixture by 83.3%. *A. sativum* and *T. erecta* extracts at a conc. of 40 mg/ml reduced the parasite burden in living organisms by 68.7% and 53.9%, respectively.
	Annona muricata and *Arachis pintoic*	Leaf	NP/PEG, Dragendroff Kedde reagents, Acetic acid, Methanol	Eggs Larva, Adult in ruminant	In vitro	Egg hatch test (EHT) and larval motility test (LMT) results at higher doses of *A. muricata* extract demonstrated 84.91% and 89.08% efficacy, respectively.
	Caesalpinia coriaria	Fruits	Methanol	Eggs and Infective Larvae in ruminant	In vitro	The highest activity of the extract at the highest conc. (with LC_{50} are 8.38 and 0.00064 mg/ml and LC_{90} % are 235.63 and 0.024 mg/ml, respectively, for larvae and

						eggs.
	Caesalpinia coriaria	Foliage	Acetone-water, Methanol-water, Acetone-water-dichloromethane and methanol-water-dichloromethane	Eggs and Larva in sheep	In vitro EHT, LEIT	For MWD, MW, AW, and AWD, the in vitro EC50 for EHT were 2947.0, 3347.0, 3959.6, and 4538.7 g/ml, respectively. For AWD, AW, MWD, and MW, the EC50 for LEIT were 2883.4, 5927.4, 9876.3, and 9955.4 g/ml, respectively.
	Caesalpinia pyramidalis	Leaves	Distilled water	Adults of either sex	In vivo	All groups treated with this extract had a positive FECR of 54.61% for G3 (2.5 mg/kg body weight) and 71.21% for G4 (5.0 mg/kg body weight).
Haemonchus placei	*Ocimum gratissimum* and *Cymbopogon citratus*	Leaves	Acetone	Adult in cattle	In vivo AMIA	For *C. citratus* and *O. gratissimum*, the best-fit LC_{50} values were substantially different (alpha 0.0001), coming in at 17.70 mg/ml and 56.04 mg/ml, respectively.
Toxocara canis	*Balanites aegyptiaca*	Fruit	Methanol	Adult in dog	In vitro	The most effective treatment used BAE methanolic extract at 120 g/ml.
Toxocara vitulorum	*Balanites aegyptiaca*	Fruit	Methanol	Eggs and Adult in	In vitro	The highest value, which was 240 g/ml in conc.,

				ruminant		achieved 100%.
Trichinella spiralis	*Lasia spinosa*	Leaves	Crude	Adult, Migrating larva and Encysted muscle larvae in rat	In vivo	800 mg/kg of plant extract administered orally resulted in a 75.30% decrease in adult worms.
Trichostrongylus sp. and Haemonchus contortus	*Cymbopogon citratus*	Leaves	Aqueous, Methanol	Eggs and Infective larva (L3) in sheep	In vitro	At 1000 g/ml, six fractions of *C. citratus* exhibited high ovicidal activity, and two fractions exhibited high activity at all tested conc.
Strongyloides sp.	*Piper tuberculatum, Lippia sidoides, Mentha piperita, Hura crepitans* and *Carapa guianensis*	Leaves	Crude aqueous	Eggs and Adult in sheep	In vitro and in vivo EHT, LDH	For EHT, the LC_{50} and LC_{90} of the extracts were 0.031 and 0.09 mg/ml for *P. tuberculatum.* For LDT, the LC_{50} and LC_{90} were 0.02 and 0.031 mg/ml for *P. tuberculatum.*
	Mangifera indica L.	Unripe fruit	Aqueous	Larva and Adult in sheep	In vitro LMIA	100 mg/ml of immature fruit aqueous extract completely inhibited the growth of larvae.
Ascaridia galli	*Areca catechu* L.	Leaves	Crude aqueous	Eggs in fowl	In vitro and in vivo EPG	In vitro, the *Areca catechu* L. aqueous extract (AAE) damaged the morphology. The average EPG in vivo reduced from 1485386.62 to 00.00 over the course of 14

						days of 79 mg/ml AAE treatment.
	Tagetes erecta Linn.	Leaves	Ethanolic and aqueous	Adult in fowl	In vitro	When compared to the aqueous extract, the ethanol extract at 100 mg/mL conc. had more significant activity.
	Schleichera olesa	Leaves	Ether Water Ethanol Chloroform Acetone	Adult in fowl	In vitro	Alpha-amylase was significantly inhibited by ethanolic and aqueous extracts, with IC50 values of 36.63 and 73.94 g/ml, respectively.
	Ocimum sanctum L.	Ethanol	Ethanol	Adult in fowl	In vitro	*O. sanctum* Linn. leaf ethanol extract had LC_{50} values of 14.8% at 6 hrs., 4.8% at 12 hrs., 3.0% at 24 hrs., and 9.1% at 24 hrs.
	Maytenus emarginata	Stem, Bark	Methanol, Aqueous and Hydroalcohol	Adult in fowl	In vitro	At a conc. of 50 mg/ml, methanolic, aqueous, and hydroalcoholic extracts all displayed significant anthelmintic efficacy.
	Acmella oleracea	Whole plant	Methanol	Adult in fowl	In vitro	At the conc. of 20 mg/ml plant extract killed all worms at 112.17 ± 0.88 hrs.
	Curcuma longa Zingiber officinale	Methanol	Crude aqueous	Eggs and Adult in fowl	In vitro and in vivo	The effectiveness of the extracts was demonstrated in vitro in a consistent time-dependent way. Compared to

						the in vitro study, the in vivo investigation with ginger and curcumin showed lower fatality rates.
Oesophagostomum columbianum, *Haemonchus contortus* and *Bunostomum spp*	*Cucurbita pepo*	seeds	Aqueous Ethanol	Eggs, larva in ruminant	In vitro EHA, LMIA	ED_{50} value of EHA was 3.5 mg/ml. Larval migration was inhibited by aqueous and ethanolic extracts, and the LM_{50} values were 1.75 and 0.32 mg/ml, respectively.
Syphacia obvelata	*Caesalpinia bonducella*	Leaves	Methanol	Adult in mice	In vitro and in vivo EPG	In vitro, 30 mg/ml conc. of methanolic extract caused mortality in 3.57 ± 0.16 hrs. 800 mg/kg dosage in mice showed a 93% reduction in worm load in vivo.
Ascaris suum and *Ascaridia* sp.	*Punica gramatum*	Bark	water with previous soak in CH3COOH 5 %, (2) water with previous soak in NaOH 5 %	Adult in pig and fowl	In vitro	*Ascaris summ*, 50 % died at 20% cone, of extract (Acid-DW solvent) after 1.30±2.3 mins of exposure while in *Ascaridia sp.* 50 % died at 20% cone, of extract (Acid-DW solvent) after 1.20±5.1 mins of exposure.
Ascaris suum	*Rhoicissus tridentata*	Root-Tuber	Ethanol Water	Adult in fowl	In vitro	Median effective doses of ethanol and water extract were 12.3 and 23.5 mg/ml respectively.

	Euphorbia heterophylla	Aerial whole plant parts	Ethanol water	Adult in pig	In Vitro	In a dose-dependent manner, both crude extracts reduced worm motility by 100% in the 48 hrs. following treatment, with the median effective doses being 26.85 mg/ml, 4.60 mg/ml, and mg/ml, respectively.
	Pinus sylvestris, *Onobrychis viciifolia*, *Ribes nigrum*, *Ribes rubrum* and *Trifolium repens*	Bark, Whole parts, Bushes, Flower	Condense tannin	Eggs, L3, L4 larva and Adult in pig	In vitro EHA, LMIA	All larvae subjected to 1 mg/ml of tannins died, and against the L3 and L4 stage, motility was seen at the lowest conc. of 111 g/ml.
Ascaris lumbricoides	*Gongronema latifalium*, *Piper guineense*, and *Ocimum gratissimum*	Leaves	Ethanol	Eggs in faeces	In vitro	100% mortality at 75% conc. of *P. guineese* after 4 hrs. of exposure and 50% mortality at 25% cone. of *O. gratissimum* after 8 hrs. of exposure.
Cooperia punctata	*Leucaena leucocephala*, *Gliricidia sepium*, *Guazuma ulmifolia* and *Craty lia argentea*	Leaves	Aqueous, Acetone water, Acetonic and polyethylene glycol (PEG)	Eggs in faces of cattle	In vitro	The best-fit LC_{50} values for *G. sepium*-AC and *L. leucocephala*-AQ were 1.03 0.17 and 7.90 1.19 mg/ml, respectively.
Trichuris muris	*Corydalis crispa* and *Pleurospermum amabile*	Whole plant	Methanol	Eggs and Adult in mice.	In vitro and in vivo	The IC_{50} range in vitro is 9.7–20.4 g/ml. One oral dose of 100 mg/kg was considerably (27.6%) better in vivo than the control group.

Heterakis gallinarum	*Cassia alata* *Cassia angustifolia* and *Cassia occidentalis*	Leaves	Crude and Ethanol	Adult in fowl	In vitro	With *C. angustifolia*, *C. alata*, and *C. occidentalis*, respectively, at a conc. of 40 mg/ml, the animals lost their motility at 5.71, 6.60, and 13.95 hrs.
Ascaridia perspicillum	*Acmella oleracea*	Aerial parts	Hexane	Adult in fowl	In vitro	The lethal conc. (LC_{50}) of the plant extract was 8921.50 ppm.
Mixed species of gastro-intestinal nematode	*Cratylia mollis*	Leaves	Leaf decoction extract	Eggs in sheep	In vivo FECRT	Significant faecal egg reduction (FEC) 61.1%.
	Ananas comosus, *Allium sativum*, *Aloe ferox*, *Warburgia salutaris* and *Lespedeza cuneata*	Leaves	Ethanol	Eggs in Sheep	In vivo EPG	*A. comosus* and *L. cuneata* treatments had the highest efficacies of 58% and 61%.
	Prunella vulgaris	Leaves, Stem and Flower	Aqueous, Methanol	Eggs and Adult in sheep EHA, AMA and FECRT	In vitro	The highest value for AMA caused 75% mortality after 8 hrs. of exposure at 50 mg/ml. Crude methanolic extract shows stronger inhibitory effects on EHA ($LC_{50} =$ 2.48 mg/ml). Methanolic extract produced FECRTs of 81.47% and 92.86% in vivo at dosage levels of 1 g/kg body weight and 2 g/kg body weight, respectively.
Strongylus spp.	*Ferula asafoetida*	Leaves	Hydro-alcohol	Larva in	In vitro	Hydroalcoholic extract of *A.*

	and *Allium sativum* L.			horse		*Sativum* extract at the conc. of 50 and 100 mg/ml killed over 95% of larvae ($p<0.05$).
Protoscoleces of *Echinococcus granulosus*	*Salvadora parsica*	Root	70% Ethanol	Larva in sheep	In vitro	*S. persica* extract at a conc. of 50 mg/ml, killed 100% of protoscolices after 30 mins.
	Nigella sativa and *punica granatum*	Essential oil and Peel	Cold-macerated petroleum ether (40-60) % Aqueous	Larva in camel	In vitro	After 120 minutes of exposure, *N. sativa* oil at 100 mg/ml conc. showed a 100% maximum mortality rate for protoscolices.
Setaria cervi	*Terminalia bellerica, Terminalia chebula* and *Terminalia catappa*	Leaves	Hexane Chloroform Methanol Acetone	Microfilari	In vitro	After 4 hrs. of incubation, larger doses (at higher doses of 5 and 10 mg/m)l after of *T. Bellerica*, *T. Chebula*, and *T. Catappa* demonstrated a decrease in the worms' motility in vitro.
Heligmosomoides bakeri	*Saba Senegalensis*	Leaves	Aqueous decoction (AD) hydroethanolic macerate (HEM)	Eggs	In vitro	Emax = 100% and an LC_{50} = 900 µg/ml.
	Cucurbita pepo L.	Seed	Hot and cold aqueous extract, Ethanol	Adult and Eggs	In vitro and In vivo	In vitro, all seed extracts exhibited a nematicidal activity. The dose of 8 g/kg that produced the maximum FECR was measured (IC_{50} against H. bakeri = 2.43;

						95% Cl = 2.01-2.94).
Setaria digitata	*Azadirachta indica*	Leaves	Diethyl ether, Chloroform, Ethanol and Methanol	Eggs, Third stage larvae	In vitro LMA, LDA, LMIA	After 135 minutes of incubation, the methanol and ethanol extracts showed the maximum mortality rate of microfilariae at a conc. of 200 g/ml.
Haemonchus contortus	*Curcuma longa*	Rhizome	Ethanol	Infective larva (L3) in sheep	In vitro	Within 24 hrs. of exposure, the highest dose rate of 200 mg/ml resulted in a 78% worm mortality rate.
	Iris kashmiriana	Rhizome	Aqueous and Methanol	Eggs and Adult in sheep	In vitro and in vivo AMIA, FECRT	In vitro, LC_{50} values of methanolic extracts of rhizome on adult worms was 16.66 mg/ml. In vivo, ECR in sheep treated with methanolic extracts at 1 g kg−1 body weight on day 15 after treatment (33.17% ECR).
	Rhus glutinous, Syzygium guineensa and *Albizia gumifera*	Leaves	Condense tannin extract	Eggs and Larva in sheep	In vitro EHA, LDA	According to IC_{50} and IC_{90} values, the condensed tannin-enriched extracts are the most effective at inhibiting EHA and LHA for R. glutinosa in in vitro tests.
	Saba senegalensis	Leaves	Aqueous	Eggs and Adult	In vitro, AMA,	LC_{50} on adult worms was 6.79 mg/ml for the leaves.

					EHA	Inhibition of EHA showed a conc. dependent inhibition of 93.63% at the conc. of 15.00 mg/ml.
	Indigofera tinctoria L.	Leaves	Aqueous	Eggs and Adult	In Vitro and in vivo AMA, FECRT	Adults were dead at a dose of 220 mg/ml (93.33% mortality) after 8 hrs. of treatment in vitro, whereas in vivo, the treatment group's maximum FECRT value occurred at a dose of 62 mg/ml on the 14th day following treatment.
	Camellia sinensis L. and *Albizia lebbeck* L.	Leaves	Ethanol	Adult	In vitro AMA	Following an 8 hrs. of treatment period, both ethanolic extracts showed 88% and 95% mortality at 6 and 8 mg/ml of doses.

Helminth species	**Plant part used**	**Plant name**	**Stages**	**Size & shape of nanoparticle**	**Test Conducted**	**Results**
Haemonchus contortus (Nematoda)	Leaf Aqueous extract	*Azadirecta indica* (Neem tree) Meliaceae family	Egg and Adult in small ruminant	Silver nanoparticles (AgNps) 15-25nm and Spherical shape	In vitro EHIA and AMIA	For AgNps the IC50 value for EHI was at 0.001 μg/ml, and AMI was produced at 7.89 μg/ml (LC50).

	Leaves Aqueous extract	*Ziziphus jujuba* (Common Jujube) Jujube family	Egg and Adult in small ruminant	Silver nanoparticles (AgNps) 28-44 nm and Spherical shape	In Vitro EHA and Adulticidal	The greatest conc. of AgNPs inhibited egg hatching by 91 1.76%. EHA had IC50 and IC90 Values of 0.007 Ppm and 7.71 ppm, respectively.
	Fruit Aqueous extract	*Lansium parasiticum* (Schisandraceae family)	Eggs, Adult and L3 stage of larva in small ruminant	Silver nanoparticles (AgNps) ~16 ± 5 nm and Spherical shape	In vitro	Silver nanoparticles (AgNPs) showed LD50 values of 65.6 ± 32.8 nM (12 hrs.), 139.6 ± 39.9 nM (12 hrs.) Against adult male, female, and L3 larvae, respectively. EHA with an IC50 value of 144.4 ± 3.1 nM at 48 hrs. of exposure.

Gigantocotyle explanatum (Trematode)	Seed Ethanolic extract	*Tribulus terrestris* caltrop family (Zygophyllaceae)	Adult in water buffaloes	Silver nanoparticles (AgNps) ~8 nm and Qausi-spherical shape	In Vitro Adulticidal	AgNPs resulted in pronounced tegumental damages, complete deformities with deep lesions.
Raillietiina sp. (Cestode)	Mycelia-free culture filtrate	*Nigrospora oryzae* (Trichosphaeriaceae family)	Adult in fowl	Gold nanoparticles (AuNps) ~6 nm to -18 nm and Cubic shape	In vitro Adulticidal	Paralysis time of 1.47 hrs. and death time of 2.55 hrs., for dose of 1.0 mg/ml.
Ancylostoma caninum (Nematode)	*Duddingtonia flagrans* Fungus Orbiliaceae family	Larva L3 stage in dog	Silver nanoparticles (AgNps) 14.51±3.25 nm And Spherical shape	In vitro Larvicidal	Penetrates the larvae's cuticle, Altering the tegument and ultimately leading to the nematode's death.	
Strongylus sp. (Nematode)	Seed Aqueous extract	*Moringa oleifera* (Moringa) Moringaceae family	Eggs in small ruminant	Silver nanoparticles (AgNps) 10-30 nm and Cubic shape	In vitro EHA	At 8 mg/ml conc., AgNPs from M. oleifera seeds generated a maximum 80.59 ± 5.65% inhibition of egg hatching.

V. DISCUSSION

Infections with helminth parasites are regarded as neglected tropical diseases. Helminths are parasitic worms with elongated, rounded, or flat bodies that are an invertebrate (Hotez et al., 2008; Headly et al., 2017). The most common helminths include intestinal nematodes, schistosomes, and filarial worms. In the past, it was calculated that the sheep, goat, and cow industries suffered a significant loss of Rs. 31.43 million annually (Iqbal et al., 2014). Along with livestock, it primarily affects kids and can weaken nutritional status, leading to stunted growth and memory impairment. Helminth infections are treated with enhanced hygiene, a combination of medications, and health education. Anthelmintic medications are used to treat helminthic disorders, however some of these infections are drug-resistant and have serious side effects. Nearly 80% of the global population uses traditional medicines made from plant extracts for primary healthcare and health benefits (WHO, 2008). In developing nations like India, China, and Bangladesh, helminthiasis is historically treated with a variety of folklore medicinal herbs. In order to effectively cure parasite illness, plant-derived medications are therefore receiving a lot of research (Neogi et al., 1964; Dehuri et al., 2021). There are several medicinal plants and their different crude products, solvent extracts and active components have been reported, which are analyzed for helminthic infection control (Kozan et al., 2006). Plants have been widely used to treat gastrointestinal helminths of medical and veterinary value since ancient times and in folklore in order to test and validate their anthelmintic properties. Researcher's use the whole/parts of plant extract (aqueous/ethanol/methanol/acetone/ethyl acetate) to conduct various tests which has been described underneath (Tandon et al., 1997; Dehuri et al., 2021).Condensed tannins, alkaloids, saponins, phenol, and flavonoids are a few of the secondary metabolites found in plants that are typically linked to their anthelmintic effects (Rawani and Gope, 2021). The development of efficient anthelmintic drugs with minimal side effects and non-resistance to parasitic helminths is expected to be possible using these plant-based herbal remedies. The better anthelmintic action and new herbal anthelmintic medicine are partly explained by the screening for phytogenic chemical components like tannins, alkaloids, phenol, saponin, flavonoids, etc. Silver, gold, and metal-based oxide nanoparticles including zinc oxide and iron oxide have all been investigated for their potential to treat a variety of diseases. Recent research state that they work as very effective larvicides and adulticides against many helminth species that are significant in medical science and veterinary medicine (Zhang et al., 2020).

VI. CONCLUSION

According to the study, medicinal plants have been employed as a part of traditional medicine from the beginning of time. The study reported that, whole plants or plant parts in crude form, solvent extract, and artificial green nanoparticles all have the potential to be effective against parasitic helminth. Although some metal nanoparticles shown lesser biological activity due to their design, metal composition, and lack of selectivity for the target cells, it has been demonstrated that metal nanoparticles have the potential to be therapeutically useful. When the metal compounds were included into particular drug delivery methods, these restrictions were overcome in those instances. There is an urgent need for developing metal-based nanoparticles that are affordably priced and have outstanding therapeutic outcomes because there are few publications on the use of metal-based nanoparticles for the treatment of parasite infections in comparison to other infectious diseases. Research is also needed on the pharmacokinetics and toxicological properties of medications based on different metals nanoparticles. Metal-based nanoparticles may be able to circumvent drug resistance, which is characteristic for most organic molecules. Metal-based nanoparticles are without a doubt promising future treatments for the management of various infectious illnesses. However, it is important to understand the detailed mode of action of herbal products through in vivo studies as they will be used for further commercial purpose.

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