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Harnessing Nature: A Comprehensive Review of Anthelmintic Plants for Parasite Control

Rasika. B. Landage *, Shirish. B. Nagansurkar, Sanjay K. Bais

Fabtech College of Pharmacy, Sangola, Solapur, Maharashtra, India

*Corresponding Author: rasikalandage@gmail.com

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Abstract

Helminthic infections present an important risk to both humans and animals, particularly in tropical and subtropical regions. Thanks to the long history of anthelmintic plant application, many plant species are used for centuries in order to cure worm diseases in traditional medical systems across the world. The function of anthelmintic plants is examined in this article, with a focus on their historical use and the bioactive phytochemicals that give them their medicinal properties. Alkaloids, flavonoids, saponins, tannins, and terpenoids are a few examples of phytochemicals that have been found to be important components with strong anthelmintic qualities. The methods of action of these chemicals are described; these include the inhibition of energy production, the disruption of parasite metabolism, and the impairment of worms' neuromuscular coordination. The also emphasizes the use of herbal anthelmintic herbs, such as Artemisia, Allium sativum, and Azadirachta indica. The review also focusses on herbal anthelmintic plants that have demonstrated noteworthy efficacy in both traditional applications and contemporary pharmacological research, such as Azadirachta indica, Allium sativum, Artemisia absinthium, and Punica granatum. The significance of these plants as possible substitutes for synthetic medications, which are frequently linked to side effects and drug resistance, is highlighted by this review. The article ends by speculating that additional investigation into these folk cures might result in the creation of more durable, safer anthelmintic medications.

Keywords - Anthelmintic activity, Helminthic infection, Active phytochemicals, Parasitic worms, Medicinal plants.

INTRODUCTION

A major section of the world population suffers with helminthic diseases, which are among the most common diseases in humans. They are a major public health risk in developing countries, where they also increase the risk of pneumonia, eosinophilia, anemia, and malnutrition. While most worm-related diseases can be limited to tropical regions, visitors may still get them after visiting those locations, and some may even develop in temperate climates [1]. Worldwide animal's results are severely hampered by helminthiasis, a disease spurred on by the Helminthes infection. As previously stated, chemotherapeutics continues to be the foundation of helminthiasis treatment by addressing a number of issues, including toxicity and chemical residues, rising costs, limited medication supply in faraway locations, and lack of drug adaptability [2].

Disease Information

The segmented bacteria are a subclass of soil bacteria which are members of the phylum Annelida. They are frequently observed in damp soil and feed on organic waste. This is due to the fact because digging promotes proper soil aeration and can improve fertility by removing earthworms or manure development. The dragon realm and the dragon world are found in India. Anatomy and morphology of worms are discussed here [3]. A major class of drugs used to treat diseases attributed to helminth parasite worms is referred to as anthelmintics or helminthics. There's an extensive number of species of worms in this group that can infect different parts of the body, such as the liver, lungs, intestines, and other organs. Helminthic infections pose significant difficulties to the worldwide public health community, particularly in regions with poor hygiene and limited access to clean water sources. Helminths, which include roundworms (nematodes), tapeworms (cestodes), flukes (trematodes), and threadworms (nematodes), are the source of illnesses in humans. Different obstacles arise for diagnosis and therapy for each category. Helminthics function in two ways: either they directly destroy the parasites or they impede their ability to grow and spread throughout the host's body. Mebendazole, albendazole, praziquantel, and ivermectin are among the helminthic drugs that are frequently suggested. According to the specific parasite and the level of infection, these drugs can be taken orally or, in some cases, parenterally. Treatment plans range considerably, from shorter courses lasting a few days or weeks to more extensive single-dose therapy. Preventive measures are vital for managing helminthic infections in addition to pharmaceutical therapies. One of these is the introduction of deworming programs, particularly in endemic areas and among populations at risk such as pregnant women and children. Other actions include promoting handwashing and other hygienic habits. Continuous research and development efforts are essential in handling problems like medication resistance and a need for more economical and potent therapies. In addition, public health initiatives that raise awareness, encourage multidisciplinary collaboration, and facilitate access to healthcare services are vital for the effective treatment and prevention of helminthic illnesses worldwide [4].

Helminths: A Definition

The goal of a class of drugs known as anthelmintics, or helminthics, is to treat diseases caused by helminth parasite worms. These worms can infect a variety of body parts, including the intestines, liver, lungs, and other organs. Helminthics work by receiving clear of the parasites directly or stopping them from multiplying and spreading throughout the body. Mebendazole, albendazole, praziquantel, and ivermectin are common helminthics. Helminthic infections are essential for managing and controlling the disease since they are widespread worldwide, particularly in areas with poor sanitation and limited access to clean water [5]. Parasitic worms called helminths can infect both people and animals. They can be discovered in multiple species and can lead to a number of diseases, including fluke, tapeworm, and roundworm infections. Usually, medicine is used to eliminate the worms [6].

The search for better anthelmintic chemicals is motivated by the parasites' resistance to current pharmaceuticals and their high cost [7]. The majority of tests that have been documented have been conducted in vitro with worm samples such as *Ascarida galli, Ascaris lumbricoids,* and *Indian earthworm Pheretima posthuma.* Because *Pheretima posthuma,* an adult Indian earthworm, like the intestinal roundworm parasite that humans carry, it is frequently employed as a test worm in anthelmintic screens. Additionally, ascardia galli worms are employed as appropriate patterns for anthelmintic medication examining due to their simple availability. These cultured cells tests are important because they provide the groundwork for more live research [8-22].

Plant-based healthcare continues to be the most common alternate treatment for many illnesses in the whole country. This is mostly caused by the absence of pharmaceutical products, the health service

places' costly distance, the cost of conventional drugs to smallholder farmers and livestock farmers, the development and reappearance of certain diseases, and the emergence regarding medication resistance bacteria or Helminthes [23]. In various sections of the nation, the plant is used to cure various illnesses and medical issues. But helminthic infections remain a serious risk to people's health, particularly for those who living in tropical poor nations. According to current estimates, more than 50% of people on the planet is containing intestinal Helminthes, including worms such as, Tapeworms, Trichuris, Ascaris, and Hookworms. In poor nations, the majority of affected individuals reside in isolated rural locations [24,25].

The majority of parasite control efforts include biological control, immunization, feeding management, food management, chemotherapy, and ethnoveterinary medicine (EVM) [26]. Control of chemotherapy approaches have generated a number of issues, including the emergence of parasite resistance to many chemical anthelmintic families, issues with chemical residues and toxicity, unfeasibility, lack of flexibility, and unavailability of medications in distant places [27].

Increasing knowledge of the mechanisms causing its anthelmintic action may also help design targeted treatments with a lower chance of resistance building. Studying the anthelmintic efficacy of Z. gibbose plant extract in vitro and/or in vivo is the goal of this investigation within this framework. We want to clarify the therapeutic potential of Z. gibbose in the context of helminthic infections by examining its efficacy against helminthic parasites, such as intestinal worms or filarial worms. Our goal is to add to the growing body of evidence supporting the use of medicinal herbs as a source of new anthelmintic medications through careful research and analysis. Better understanding of the mechanisms underlying its anthelmintic effect can additionally create tailored treatments that have a lower chance of generating resistance. Within this framework, the aim of this work is to examine the anthelmintic activity of Z. gibbose plant extract, either in vitro or in vivo. We analyze Z. gibbosa's activity against helminthic parasites, namely intestinal worms and filarial worms, in order to clarify the drug's potential for treatment helminthic conditions. Our goal is to add to the growing body that is supporting the use of medicinal herbs as a source of novel anthelmintic medications through careful research and analysis. In the end, the discovery of Z. gibbosa's anthelmintic properties may help with the creation of novel therapeutic strategies that are effective, long-lasting, and accessible to people with limited resources. In order to address the global problem of helminthic infections and improve health outcomes for millions of people worldwide, this research project is necessary [28].

Helminths, commonly referred to as parasitic worms, may cause a variety of diseases, including schistosomiasis, ascariasis, and hookworm infection. They are a major health risk to both humans and animals. Medication resistance and adverse side effects are common difficulties faced by traditional therapy for these illnesses. Consequently, there is an increasing interest in studying natural compounds, such as those found in *Senegalia pennata*, as possible alternative or complementary therapies [29].

Traditional Uses of Anthelmintic Plants

Many older medicinal systems across the world, including Chinese, Arabic (Unani), and Indian (Ayurveda), are based on plants [30]. These conventional medical systems' treatments are founded on thousands of many years of experimental findings that some of which have been carefully record [31].

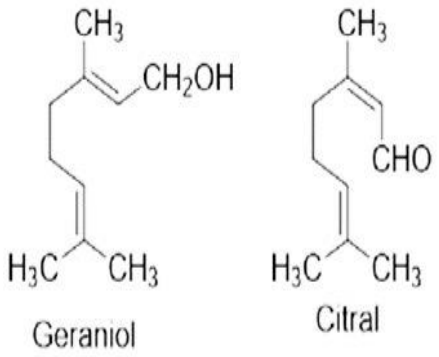
These traditional medical systems make use of a blend either a plant or an extract that include hundreds of separate substances with many different physiological-chemical characteristics. The actual oldest ancient medical practice is Ayurveda, commonly referred to as the study of living. It has a complete healthcare system that has its roots in India and dates back about 5000 years. Its main focus is on avoiding illnesses and health promotion. Ayurveda's main goal is to achieve ideal wellness and health by using a complete approach that takes into account each person's particular physical, emotional,

mental, and spiritual needs [32]. Ayurvedic medicine uses thousands of helpful herbs, many of which are recognized to have antiparasitic qualities. Within the Ayurvedic system, some of the most well-known plants are *Allium sati-vum* (garlic), *Justicia adhatoda* (Malabar nut), *Scholar's Alstonia* (blackboard tree), *Artemisia annual* (sweet wormwood), *Azadirachta indica* (neem), *Cantele asiatica* (gotu kola), *Curcuma* along (turmeric), and *Moringa oleifera* (drumstick). A historical kind of medicine, traditional for more than 2000 years, Chinese medicine (TCM) has been practiced in China. This medical system is founded on five components (Waxing), which together describe all natural occurrences in the universe, including humans, and two fundamental ideas (Yin-yang), which control lifespan and good health [33]. These organic events are they used in the detection and handling of illnesses. Medication uses medicine for to provide vital energy and to maintain or restore the equilibrium between these elements [34]. Plants such as *Panax ginseng* (ginseng), *Ephedra sinica* (Chinese seephedra), *Paeonia lactiflora* (Chinese peony), Traditional Chinese medicine (TCM) uses frequently *Glycyrrhiza glabra* (licorice), *Rheum pal-matum* (Chinese rhubarb), *Zingiber officinale* (ginger), and *Chinese peony.* Arabic traditional medicine is commonly referred to as unani, or Islamic medicine. "Greek" is the word Unani. Greek medicine, such as the teachings of Hippocrates and Galen, is credited with giving rise to the Unani medical system. The traditional Unani healers use a vast array of drugs derived from plants, minerals, and animals as well as various polyherbal-mineral mixtures [35]. Popular Unani plants include *Papaversomniferum* (opium poppy), *Ricinus communis* (castor), *Trachyspermum Ammi* (ajwain), *Allium cepa* (onion), *Carum carvi* (caraway), and *Crocus sati-vus* (saffron). The term "anthelmintic activity" describes the ability of a substance to combat diseases brought on by parasites. They can cause illnesses including schistosomiasis, hookworm infection, and ascariasis by infect different organs in both humans and animals. A substance's anthelmintic qualities are essential for both treating and preventing particular illnesses [36].

Active Phytochemicals in Anthelmintic Plants

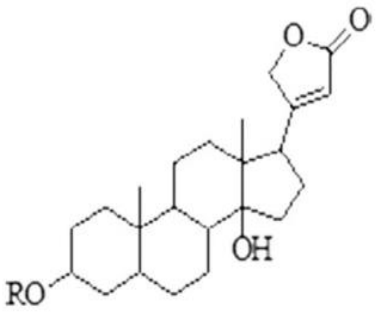
Terpenes

Various isoprene units combined to form terpenes (C5H8) [37]. It shows anthelmintic properties that harm the parasite's intestinal membrane [38]. For instance, β-element, borneol, and terpinen-4-ol all shown action against H. contortus by preventing egg hatching [39].



Glycosides

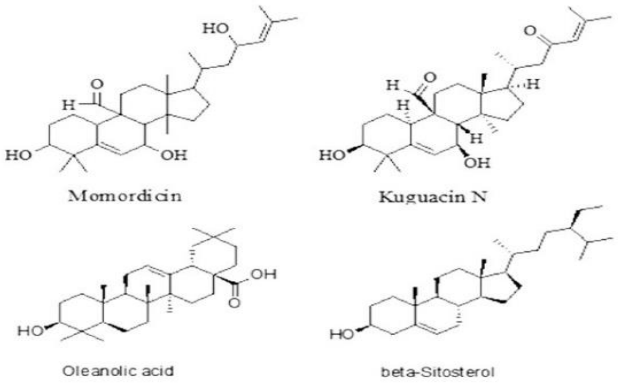
Glycosides exhibit strong anti-helminth action [40-41]. Cardenolide kills helminths by interfering with the transit of sodium and potassium ions into the helminths [42].



Cardenolide

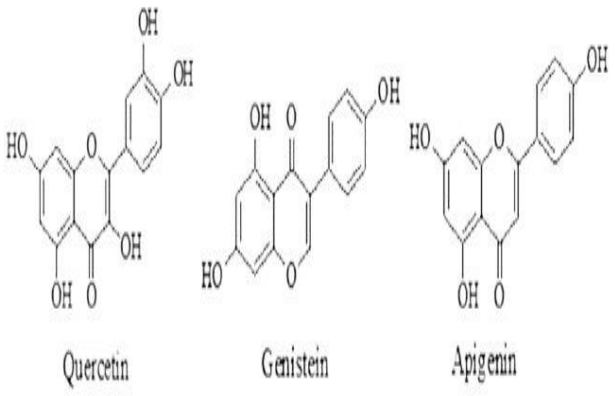
Saponins

The saponins comprises sugar-chained triterpene, or occasionally steroidal aglycone [43]. The saponins exhibit their anthelmintic action through preventing acetylcholinesterase from acting, which paralyses and eventually kills worms [44]. According to reports, they exhibit inhibitory effect against worms that parasitise animals, such as Haemanthus contort us IC50 for 44 β-Sitosterol was found to be 58 μM [45].



Flavonoids

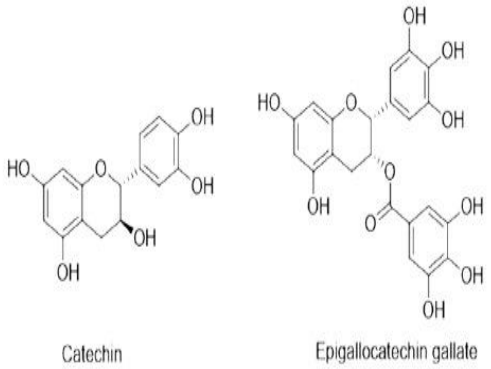
Flavonoids contribute to flower coloring, UV protection, allelopathy, and suppression of auxin transport [46]. The phosphorylation reaction is blocked by flavonoids, which impede the parasitic worms' ability to produce energy and ultimately cause their death [47]. At 10 mg/mL, quercetin had a paralysis time of 2.23 ± 4.51 minutes.



Tannins

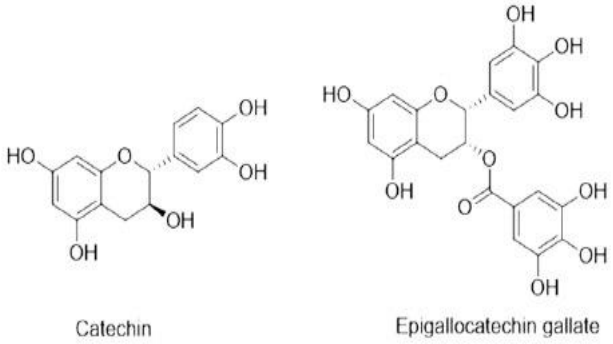
The polyphenolic group known as tannins is soluble in water and leads to the death of nematodes by preventing the worms' ability to take nutrients from the host cell or by binding to the intestinal

mucosa on absorption by the larvae of the parasitic worms [48]. This epigallocatechin got an IC50 value of 49 µM.



Alkaloids

By inhibiting the uptake of glucose and binding to the acetylcholine receptor, alkaloids have demonstrated anthelmintic effect. As a result, helminths perished from malnutrition [49]. Dicentrine has an EC90 of 6.3 µg/mL and an IC50 of 58 µM for san-guinarine.



Mechanism of Anthelmintic Action

Paralysis of the Neuromuscular

Numerous anthelmintic plants work by paralyzing helminths' muscles. By disrupting neurotransmitter pathways, this technique immobilizes the parasites by blocking muscular contraction. The worms are removed from the digestive system by regular peristaltic motions once they become paralyzed. As an illustration, alkaloids derived from Azadirachta indica (neem) and Punica granatum (pomegranate) cause paralysis by influencing ion channels necessary for muscle contraction and acetylcholine receptors.

Energy Metabolism Disruption

Certain plant chemicals cause disruptions to the digestive and metabolic systems of helminths, which impacts their energy metabolism. The parasites die as a result of malnutrition and energy depletion brought on by this. For instance, papain, a proteolytic enzyme found in carica papaya (papaya) seeds, weakens and inhibits the parasite's ability to utilize certain proteins in its system.

Reduction of Enzyme Inhibition

Phytochemicals found in many anthelmintic plants block important enzymes, such as those involved in metabolism, reproduction, and cellular integrity, which are essential for the survival of the parasite. As an illustration, the compound allicin, found in allium sativum (garlic), inhibits a number of enzymes essential to the survival of parasites by interfering with the metabolic pathways required for the organisms' development and reproduction.

The epidermis damage to the parasite

Helminths' exterior layer of protection, or cuticle, is vital to their existence. This barrier is damaged by several anthelmintic plants, which allows the parasites' internal contents to escape and presents them to the host's immunological system and digestive enzymes. For instance, saponins from Terminalia chebula and Moringa oleifera have surfactant qualities that cause the parasites' lipid membrane to break down, resulting in cell lysis.

Oxidative Stress Induction

Certain chemicals originating from plants cause helminths to experience oxidative stress by producing reactive oxygen species (ROS). These ROS have the ability to harm the lipids, proteins, and DNA that make up the parasites' cellular structures, which can result in necrosis or death. For instance, it has been observed that tannins from Terminalia chebula and flavonoids from Allium sativum cause oxidative stress in parasites, which results in cellular malfunction and death.

Reproductive Process

Inhibition In order to assist regulate the parasite population in the host, several anthelmintic plants particularly target the reproductive systems of parasites, either by decreasing egg production or by interfering with the reproductive cycle. As an illustration, azadirachtin, a substance present in Azadirachta indica (neem), prevents helminths from reproducing by interfering with hormonal pathways, which results in decreased egg production and the incapacity to mature

The regulation of immunity

Certain anthelmintic plants alter the host's immune system, strengthening the body's defenses against parasite illnesses. These plants have the ability to either activate immune cells to more effectively target the parasites or increase immunological responses to aid in the expulsion of the parasites. For instance, garlic (Allium sativum) has been shown to activate immune cells like macrophages, which improves the host's capacity to identify and get clear of parasites.

viii. Reduction in Uptake of Glucose

Some plants limit helminths' absorption of glucose, which is their main energy source. This causes the worms to run out of energy and eventually kill. Example: It has been demonstrated that phenolic compounds from plants like Punica granatum restrict parasitic worms' ability to absorb glucose, reducing their energy supply, which is essential for their survival and movement [50-58].

Herbal Anthelmintic Plants

Sr No.	Common Name	Scientific Name	Family	Part Used
1.	Papaya	*Carica papaya*	Caricaceae	Bark
2.	Neem	*Azadirachta indica*	Meliaceae	Leaf, roots & bark
3.	Garlic	*Allium sativum*	Amaryllidaceae	Leaves & bulbs
4.	Wormwood	*Artemisia absinthium*	Asteraceae	Leaves
5.	Pumpkin seeds	*Cucurbita pepo*	Cucurbitaceae	Seed
6.	Drumstick tree	*Moringa oleifera*	Moringaceae	Leaves
7.	Hari Taki	*Terminalia chebula*	Combretaceae	Fruit
8.	Black seed	*Nigella sativa*	Ranunculaceae	Seed
9.	Epazote	*Chenopodium ambrosioides*	Amaranthaceae	Leaf
10.	Pomegranate	*Punica granatum*	Punicaceae	Peel
11.	Ginger	*Zingiber officinale*	Zingiberaceae	Rhizome

12.	Flame of the forest	*Buteamonosperma*	Legumes	Leaf
13.	Fennel	*Foeniculum vulgare*	Umbellifers	Seed
14.	Bitter leaf	*Vernonia amygdalina*	Asteraceae	Leaf
15.	Holy basil	*Osmium sanctum*	Mints	Leaf
16.	Long pepper	*Piper longum*	Piperaceae	Root & fruit
17.	Tamarind	*Tamarindus indica*	Legumes	Bark
18.	Devil's tree	*Alstonia scholaris*	Apocynaceae	Leaf
19.	Coffee senna	*Cassia occidentalis*	Fabaceae	Leaf
20	Turmeric	*Curcuma longa*	Zingiberacea	Rhizome
21.	Clove	*Syzygium aromaticum*	Myrtaceae	Flower, bud
22.	Bitter melon	*Momordica charantia*	Cucurbitaceae	Fruit
23.	Betel nut	*Areca catechu*	Arecaceae	Seeds
24.	Thyme	*Thymus vulgaris*	Lamiaceae	Leaves
25.	Coriander	*Coriandrum sativum*	Apiaceae	Seeds, Leaves
26.	Marigold	*Tagetes erecta*	Asteraceae	Flower
27.	Fenugreek	*Trigonella foenum-graecum*	Fabaceae	Seeds, Leaves
28.	Sweet Annie	*Artemisia annua*	Asteraceae	Leaves, Stem
29.	Heliotrope	*Heliotropium indicum*	Boraginaceae	Leaves
30.	Horseradish	*Armoracia rusticana*	Brassicaceae	Root
31.	Sage	*Salvia officinalis*	Lamiaceae	Leaves
32.	Anise	*Pimpinella anisum*	Apiaceae	Seeds
33.	Senna	*Senna alexandrina*	Fabaceae	Leaves, Pods
34.	Tansy	*Tanacetum vulgare*	Asteraceae	Leaves, Flowers
35.	Liquorice	*Glycyrrhiza glabra*	Fabaceae	Root
36.	Rue	*Ruta graveolens*	Rutaceae	Leaves
37.	Barberry	*Berberis vulgaris*	Berberidaceae	Bark, Root
38.	Moringa	*Moringa oleifera*	Moringaceae	Seed, Leaves
39.	Costus	*Saussurea costus*	Asteraceae	Root
40.	Ash gourd	*Benincasa hispida*	Cucurtiaceae	Seeds

Table 1*: *Herbal Anthelmintic Plants

***Carica papaya* (Papaya)**

(Family-Caricaceae)

A traditional treatment for intestinal worms like roundworms and tapeworms, papaya, or Carica papaya, has been its anthelmintic qualities. Papain, an enzyme found in the seeds, aids in the breakdown of parasites' protective covering and helps the body to rid itself of them. For the aim of deworming, papaya seeds frequently eaten raw or broken down [59].

Figure 1*: *Papaya

***Azadirachta indica* (Neem):**

(Family: Azadirachta indica)

Neem's anthelmintic qualities make it a popular choice in traditional medicine for getting rid of parasitic worms like tapeworms, hookworms, and roundworms. The neem plant contains bioactive compounds called azadirachtin, nimbin, and saponins that paralyze, disrupt, and prevent worms from reproducing. Neem can be utilized in the form of leaf extracts, oil, or bark to treat parasite illnesses in both humans and animals [60].

Figure 2*: *Neem

***Allium sativum* (Garlic)**

(Family: Amaryllidaceae)

For centuries, people have utilized garlic's anthelmintic qualities to cure parasitic worm illnesses, including tapeworms, hookworms, and roundworms. Allicin, the chemical that is active in it, alters the metabolism of parasites, damaging their cellular structure and ultimately resulting in their discharge from the host. For its treating properties, garlic can be eaten raw, as an extract, or as an oil [61].

Figure 3*: *Garlic

***Artemisia absinthium* (Wormwood)**

(Family: Asteraceae)

Wormwood has long been used to cure diseases caused by parasitic worms, such as roundworms and pinworms. Its active ingredients, especially thujone and absinthin, cause the parasites' neurological systems to break down, which paralyzes them and causes them to be removed from the body. Because of its anthelmintic qualities, wormwood is commonly employed in teas and as a herbal extract [62].

Figure 4*: *Wormwood

***Cucurbita pepo* (Pumpkin seeds)**

(Family: Cucurbitaceae)

In the past, pumpkin seeds were used to cure parasitic infections, specifically roundworm and tapeworm infections. Cucurbitacin, its active ingredient, paralyses the worms so that the body can more easily eliminate them through bowel movements. Because pumpkin seeds naturally have deworming qualities, they are commonly eaten raw or as an extract [63].

Figure 5*: *Pumpkin seeds

***Moringa oleifera* (Drumstick)**

(Family: Moringaceae)

Infections with parasitic worms, especially roundworms, are historically treated using the drumstick tree, Moringa oleifera. Its bioactive substances, including flavonoids and alkaloids, hinder worm metabolism and improve the host's immune system, which makes it easier to get rid of parasites. Because of its anthelmintic properties, powdered or leaf extracts of moringa are frequently ingested [64].

Figure 6*: *Drumstick

***Terminalia chebula* (Hari Taki)**

(Family: Combretaceae)

Terminalia chebula, often known as haritaki, has long been used for its anthelmintic qualities, especially in the treatment of intestinal worms. Its active ingredients, which include flavonoids and tannins, harm parasitic worms by oxidative means, affecting their structure and metabolism and ultimately causing them to expel. Haritaki is frequently utilised as extracts or powders [65].

Figure 7*: *Hari Taki

***Nigella sativa* (Black seed)**

(Family: Ranunculaceae)

Nigella sativa, or black seed, has long been utilised for its anthelmintic qualities, especially in the treatment of intestinal worms. Thymoquinone, the molecule that is active in it, disrupts the reproductive cycle and metabolism of parasites, helping in their removal from the host organism. For deworming, black seed oil or extracts are frequently utilised [66].

Figure 8*: *Black seed

***Chenopodium ambrosioides* (Epazote)**

(Family: Amaranthaceous)

Dysphania ambrosioides, the plant that produces epazote, has long been utilised for its strong anthelmintic effects, especially against roundworms and hookworms. The substance that causes paralysis and removal in parasites is ascaridole, which interferes with their metabolism. Epazote is frequently used to treat parasite infections as an extract or tea [67].

Figure 9*: *Epazote

***Punica granatum* (Pomegranate)**

(Family: Punicaceae)

Pomegranate, Punica granatum, is traditionally used for its anthelmintic properties, especially against tapeworms. The bark and root contain punicalagin and alkaloids, which paralyze the parasites, allowing them to be expelled from the body. Pomegranate extracts or decoctions are commonly used to treat parasitic infections [68].

Figure 10*: *Pomegranate

***Zingiber officinale* (Ginger):**

(Family: Zingiberaceae)

Zingiber officinale, or ginger, has long been utilized for its anthelmintic qualities, especially against schistosomes and roundworms. Its potent ingredients, including shogaol and gingerol, cause parasitic worms to become paralyzed and eventually eliminated by upsetting their metabolism. For treating purposes, ginger is frequently utilized as extracts, powders, or tea [69].

Figure 11*: *Ginger

***Buteamonosperma* (Flame of the forest)**

(Family: Legumes)

Butea monosperma, also known as Flame of the Forest, is traditionally used for treating roundworms and tapeworms due to its anthelmintic characteristics. Its active ingredients, which include butrin and isobutrin, influence the movement and metabolism of parasites to help facilitate their removal from the body. Herbal worm control treatments frequently contain the seeds and bark [70].

Figure 12*: *Flame of the forest

***Foeniculum vulgare* (Fennel)**

(Family: Umbllifers)

The herb fennel, Foeniculum vulgare, has long been utilized for its anthelmintic qualities, especially with regard to intestinal worms such as roundworms. Its active ingredients, anethole and fenchone, cause paralysis and the elimination of parasites from the digestive system by interfering with their metabolic processes. For deworming, fennel seeds or extracts are frequently utilized [71].

Figure 13*: *Fennel

***Vernonia amygdalina* (Bitter leaf)**

(Family: Asteraceae)

Vernonia amygdalina, or bitter leaf, has long been utilized for its anthelmintic qualities, especially against roundworms and hookworms. The bioactive substances found in it, such as vernodalin and vernonioside, hinder the metabolism and movement of parasitic worms, causing them to be driven out of their host. For deworming, bitter leaf is frequently used in extract or decoction form [72].

Figure 14*: *Bitter leaf

***Osmium sanctum* (Holy basil)**

(Family: Mints)

Because of its anthelmintic qualities, holy basil, or Ocimum sanctum, is traditionally used to treat roundworms and tapeworms. Its bioactive ingredients, such as ursolic acid and eugenol, cause paralysis and elimination of parasitic worms by interfering with their nervous system and metabolic processes. For deworming, holy basil leaves or extracts are frequently utilized [73].

Figure 15*: *Holy basil

Piper longum **(Long pepper)**

(Family: Piperaceae)

Piper longum, or long pepper, has long been used for its anthelmintic qualities, especially against intestinal worms. Its active ingredients, including piperine and piplartine, interact with parasitic worms' reproduction cycles and metabolism, making it easier for the host to get rid of the worms. For treating purposes, long pepper is often used as an extract or in powder form [74].

Figure 16**:** *Long pepper*

Tamarindus indica **(Tamarind)**

(Family: Legumes)

The traditional use of tamarind, or Tamarindus indica, stems from its anthelmintic qualities, which are especially effective against intestinal worms like roundworms and tapeworms. Flavonoids and tartaric acid, two active substances found in the fruit and seeds, interfere with the metabolism of parasites and help in their removal. For removal of worm's tamarind juice or pulp are frequently taken [75].

Figure 17**:** *Tamarind*

Alstonia scholaris **(Devils tree)**

(Family: Apocunaceae)

Alstonia scholaris, commonly known as the Devil's Tree, has long been utilized for its anthelmintic qualities, especially in regards to roundworms and threadworms. Its active ingredients, which include diterpenes and alkaloids, cause metabolic disruptions in parasitic worms, resulting in their release and death. For deworming, the bark is frequently used in decoctions or extracts [76].

Figure 18*: *Devils tree

5.19 *Cassia occidentalis* (Coffee senna)

(Family: Fabaceae)

Senna occidentalis, sometimes known as coffee senna, has long been utilized for its anthelmintic qualities, especially against roundworms and other intestinal worms. Its active components, specially anthraquinones and sennosides, interfere with the worms' metabolism, resulting to their discharge from the body. For worm removal, coffee senna is usually taken in extract or decoction form [77].

Figure 19*: *Coffee senna

***Curcuma longa* (Turmeric)**

(Family: Zingiberacea)

Curcuma longa, or turmeric, has long been used for its anthelmintic qualities, especially against intestinal worms such as tapeworms and roundworms. Curcumin, its main ingredient, interferes with worms' reproduction and metabolism, facilitating their release. For removal of worm's turmeric is frequently used as an extract or in powder form [78].

Figure 20*: *Turmeric

***Syzygium aromaticum* (Clove)**

(Family: Myrtaceae)

Syzygium aromaticum, or clove, has long been used for its anthelmintic qualities; it works especially well against tapeworms and roundworms. Eugenol, its main ingredient, interferes with the neurological system and metabolism of parasites, causing paralysis and eventual expulsion. Clove oil or extracts are frequently used as treating agents [79].

Figure 21*: *Clove

***Momordica charantia* (Bitter melon)**

(Family: Cucurbitaceae)

Momordica charantia, commonly referred to as the bitter melon, has long been used for its anthelmintic qualities, which make it especially effective against roundworms and pinworms. Its bioactive ingredients, including charantin and momordicin, disrupt parasitic worms' metabolism and facilitate their removal from the host. For deworming, bitter melon juice or extracts are frequently utilized [80].

Figure 22*: *Bitter melon

***Areca catechu* (Betel nut)**

(Family: Arecaceae)

Areca catechu, the betel nut, has long been utilized for its anthelmintic qualities, especially against roundworms and tapeworms. Its active ingredients, like arecoline, immobilize the parasites and force them to exit the host's body. Betel nut is frequently taken as a component of treating herbal medicines [81].

Figure 23*: *Betel nut

***Thymus vulgaris* (Thyme)**

(Family: Lamiaceae)

Thymus vulgaris, the common thyme, has long been utilized for its anthelmintic qualities, especially against intestinal worms like roundworms and hookworms. Its active ingredients, which include carvacrol and thymol, cause disruptions to the neurological system and metabolism of parasites, resulting in their ejection and paralysis. For deworming, thyme is frequently used as an essential oil or in herbal infusions [82].

Figure 24*: *Thyme

***Coriandrum sativum* (Coriander)**

(Family: Apiaceae)

The herb coriander, or Coriandrum sativum, has long been used for its anthelmintic qualities, which make it especially useful against intestinal worms like roundworms and tapeworms. Its bioactive ingredients, such as linalool and terpenes, delay parasite metabolism and promote their removal. Coriander extracts or seeds are frequently used as a deworming agent [83].

Figure 25*: *Coriander

***Tagetes erecta* (Marigold):**

(Family: Asteraceae)

Tagetes erecta, or marigold, has long been utilized for its anthelmintic qualities; it works especially well against intestinal worms including roundworms and hookworms. Its potent ingredients, including thiophenes and flavonoids, cause parasitic worms' metabolism to be angry which impairs and removes the worms. Decoctions or extracts made from marigolds are frequently used to treat deworming [84].

Figure 26*: *Marigold

***Trigonella foenum-graecum* (Fenugreek)**

(Family: Fabaceae)

Trigonella foenum-graecum, often known as fenugreek, has long been utilized for its anthelmintic qualities, especially against intestinal worms like roundworms. Its active ingredients, which include flavonoids and saponins, hinder the worms' metabolism and encourage their removal from the body. Deworming is a frequent usage for fenugreek seeds or extracts [85].

Figure 27*: *Fenugreek

***Artemisia annua* (Sweet Annie)**

(Family: Asteraceae)

The herb Sweet Annie, Artemisia annua, has long been used for its anthelmintic qualities; it works especially well against intestinal parasites such as schistosomes and roundworms. Its primary ingredient, artemisinin, interacts with parasites' ability to metabolize nutrients, causing paralysis and finally elimination. Sweet Annie is frequently used as a deworming tea or extract [86].

Figure 28*: *Sweet Annie

***Heliotropium indicum* (Heliotrope)**

(Family: Boraginaceae)

The herb heliotrope, Heliotropium indicum, has long been used for its anthelmintic qualities; it works especially well against roundworms and other intestinal worms. Its active ingredients, including pyrrolizidine alkaloids, hinder the metabolism of the parasites and cause them to be expelled from the body. For deworming, heliotrope is frequently used as extracts or decoctions [87].

Figure 29*: *Heliotrope

***Armoracia rusticana* (Horseradish)**

(Family: Brassicaceae)

Horseradish, or Armoracia rusticana, has long been used for its anthelmintic qualities, which make it especially useful against roundworms and other intestinal worms. Its active ingredients, which include isothiocyanates and glucosinolates, interfere with parasites' metabolic functions and cause them to flee. Horseradish is frequently used in deworming treatments or root extract form [88].

Figure 30*: *Horseradish

***Salvia officinalis* (Sage)**

(Family: Lamiaceae)

Salvia officinalis, commonly known as sage, has long been utilized for its anthelmintic qualities, especially against intestinal worms such as roundworms and tapeworms. Its active ingredients, which include carnosol and thujone, affect the nervous system and metabolism of parasites, facilitating their ejection. For deworming, sage is frequently used in herbal infusions or extracts [89].

Figure 31*: *Sage

***Pimpinella anisum* (Anise)**

(Family: Apiaceae)

Because of its anthelmintic qualities, anise, Pimpinella anisum, has long been used to treat intestinal worms like roundworms and tapeworms. Anethole, its active ingredient, interferes with the metabolism of parasites, causing paralysis and evacuation. Commonly, extracts or seeds of anise are used to treat deworming [90].

Figure 32*: *Anise

***Senna alexandrina* (Senna)**

(Family: Fabaceae)

Traditional uses of senna, or Senna alexandrina, date back to its anthelmintic qualities, which are especially beneficial against intestinal worms like roundworms and tapeworms. Sennosides, one of its active ingredients, interfere with the digestion process of parasites and cause them to be expelled from the host. Senna is frequently used for deworming in the form of leaves or pods [91].

Figure 33*: *Senna

***Tanacetum vulgare* (Tansy)**

(Family: Asteraceae)

Tansy, or Tanacetum vulgare, has long been utilized for its anthelmintic qualities, which work especially well against pinworms and roundworms. The substance that causes paralysis and release in parasites is thujone, which interacts with their nervous system and metabolic processes. Tansy is frequently used for deworming in the form of extracts or infusions [92].

Figure 34*: *Tansy

***Glycyrrhiza glabra* (Liquorice)**

(Family: Fabaceae)

Glycyrrhiza glabra, or licorice, has long been utilized for its anthelmintic qualities, especially in relation to intestinal worms like roundworms and tapeworms. Glycyrrhizin and flavonoids, two of its active ingredients, interfere with parasites' metabolic processes and facilitate their ejection. Licorice root is frequently used to treat treating in teas or extract form [93].

Figure 35*: *Liquorice

***Ruta graveolens* (Rue)**

(Family: Rutaceae)

Ruta graveolens, the plant known as rue, has long been utilized for its anthelmintic qualities, which make it especially effective against intestinal worms like roundworms. Rutin and quercetin, two of its active ingredients, disrupt parasites' metabolic functions and cause paralysis and ejection. For deworming, rue is frequently used as extracts or infusions [94].

Figure 36*: *Rue

***Berberis vulgaris* (Barberry)**

(Family: Berberidaceae)

Berberis vulgaris, the barberry, has long been utilized for its anthelmintic qualities; it works especially well against intestinal parasites such as roundworms and tapeworms. Berberine, its active ingredient, causes disturbances in the metabolic and reproductive functions of parasites, ultimately resulting in their eradication. For deworming, barberry is frequently used in extract or decoction form [95].

Figure 37*: *Barberry

***Moringa oleifera* (Moringa)**

(Family: Moringaceae)

Traditional uses of moringa, or Moringa oleifera, date back to its anthelmintic qualities, which are especially useful against intestinal worms including roundworms and hookworms. Its bioactive ingredients, including as niaziminin and moringin, have anti-parasitic properties that cause the worms to expel themselves by upsetting their metabolism. For deworming, moringa leaves and seeds are frequently used as extracts or in powdered form [96].

Figure 38*: *Moringa

***Saussurea costus* (Costus)**

(Family: Astersaceae)

It is well known that the plant Costus, namely Costus speciosus, has anthelmintic qualities. It works especially well against intestinal worms like roundworms. Its active ingredients, which include various sesquiterpenes and costunolide, interfere with parasitic worms' metabolic activities and make it easier for them to leave their host. For deworming, costus is frequently used in extract or decoction form [97].

Figure 39*: *Costus

***Benincasa hispida* (Ash gourd)**

(Family: Cucurtiaceae)

The Benincasa hispida, or ash gourd, has long been utilized for its anthelmintic qualities, which make it especially useful against intestinal worms like tapeworms. Its active ingredients, which include polysaccharides and flavonoids, disrupt the metabolism and movement of parasitic worms, facilitating their release. Ash gourd pulp and seeds are frequently used for deworming [98].

Figure 40*: *Ash gourd

CONCLUSION

Anthelmintic plants are gaining significant attention as alternatives to synthetic anthelmintic drugs, which are commonly used to treat parasitic infections, particularly helminths (parasitic worms). Overuse and misuse of chemical anthelmintics have led to increasing resistance among parasites, especially in livestock and human populations. As a result, there is a growing need to explore plant-based remedies, which are often safer, eco-friendly, and cost-effective. Numerous medicinal plants have demonstrated promising anthelmintic properties, and research continues to uncover their mechanisms of action, efficacy, and potential for therapeutic use.

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