Zoonotic Parasitic Disease Control Strategies: Phytotherapy

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ABSTRACT

Zoonotic diseases have significant challenges to the global health by presenting a continuous threat to the animal and human populations. Ectoparasites and endoparasites are also responsible for transmission of zoonotic diseases. Ectoparasites like ticks, fleas, mosquitoes are responsible for transmission of Lyme disease, babesiosis, plague, malaria, dengue, zika and West Nile Viruses. Some arthropods like sandflies which transmit leishmania in humans and animals. Endoparasites like tapeworms are responsible of echinococcosis and cysticercosis and some soil transmitted roundworms and hookworms also cause toxocariasis and cutaneous larva migrans. Trichinella spiralis is the roundworm of pig and its spread by consumption of undercooked meat of pork and it's commonly known as pork worm. Some of protozoan water borne parasites like giardia and cryptosporidium are also responsible for gastrointestinal illnesses. Toxoplasma gondii oocyst shed in cat feaces and it's dangerous for pregnant women's and most of time it causes abortion in females. Many of these parasites develop resistance due to excessive use of synthetic acaricides like pyrethroids, macrocyclic lactones, organophosphate and carbamates. So its alternative is herbal or medicinal plants like garlic, neem, cloves and wormwood extract which contain bioactive compounds that can kill or inhibit parasites. Certain medicinal plants also offer nutrients to animal and boost the immune system along with antiparasitic properties. Phytotherapy along with conventional medicine reduce side effect and enhance the efficacy of treatment. In this book chapter we will focus on zoonotic parasitic control strategies through herbal or medicinal plants.

Key words: Phytotherapy, Ectoparasites, Endoparasites, Acaricides

CITATION

Akram W, Aslam MA, Qamar MF, Siddiq HMU, Zaman MA, Ehtisham-ul-Haque S, Jaleel S, Ali K, Mehnaz S, Rafique N and Fatima T, 2023. Zoonotic parasitic disease control strategies: phytotherapy. In: Abbas RZ, Hassan MF, Khan A and Mohsin M (eds), Zoonosis, Unique Scientific Publishers, Faisalabad, Pakistan, Vol. 2: 331-345. https://doi.org/10.47278/book.zoon/2023.74

CHAPTER HISTORY Received: 19-May-2023 Revised: 25-July-2023 Accepted: 17-Aug-2023

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1. INTRODUCTION

Zoonotic diseases have led to the production of significant challenges to global health by presenting a continuous threat to animal and human populations. The main causes of infection of transmission of zoonotic diseases include endoparasites and ectoparasites (Abdel-galil and Aboelhadid 2021). Endoparasites are microorganisms that live and multiply within the host, while those that cause externally infest the host are called ectoparasites. Zoonotic endoparasitic diseases, such as toxoplasmosis, cryptosporidiosis, and echinococcosis, are caused by protozoa and helminths that can affect animal and human health (Abo-EL-Sooud 2018).

The parasitic life cycles are complex depend on hosts and vectors, and exhibit different modes of transmission. Life cycles of these parasites are significantly affected by human activities (urbanization, deforestation, and climate change) which change their emerging and spreading pattern (Akhtar et al. 2012). In comparison, vectors such as ticks, mosquitoes, and fleas, are mainly involved in the causation and transmission of zoonotic ectoparasitic diseases. Lyme disease, one of the well-known zoonotic diseases, is caused by the bacterium *Borrelia burgdorferi* and transmitted by ticks. It affects the integumentary, skeletal, cardiac, and nervous systems, resulting in a multi-systemic disorder (Akhtar et al. 2012).

Fleas cause the transmission of the bacterium *Yersinia pestis* which results in the bubonic plague. Furthermore, global-health-threatening diseases such as malaria and West Nile Fever are caused by mosquitoes transmitting the plasmodium parasite and West Nile Virus (Al-Zanbagi 2009). Phytotherapeutics (herbal or traditional medicines) are herbs and plants that possess medicinal properties and are used to treat disease conditions in animals and humans. Throughout history, phytotherapeutics has been used to treat morbidities and infections, manage pain, and treat and control both endoparasites and exoparasites (Al-Zanbagi 2011). Using plants as therapy dates back to old times when ancient civilizations utilized their nature-related knowledge to cure pathological conditions. Phytotherapeutics have been regularly used in traditional healing practices by several cultures (Al-Zanbagi and Zelai 2008).

In recent years, there has been an increase in the concerns related to drug resistance, side effects of synthetic therapeutics, and the recognition of the medicinal potential of plants natural compounds, which resulted in a resurgence of interest in the use of phytotherapeutics.

Extensive use of synthetic anti-parasitic drugs has made the parasites resistant to them (Andreotti et al. 2013).

Several medicinal herbs possess exceptional anti-microbial and cytotoxic activities, and their use is beneficial in controlling both ectoparasites and endoparasites.

Biologically active compounds of these medicinal plants exhibit their anti-parasitic activity by targeting the parasite genome (DNA), damaging the cellular integrity, and interrupting the nervous system of the parasites (Annan-Prah et al. 2012).

Many plant extracts and their secondary metabolites show excellent anti-protozoal activity by hampering the growth of Plasmodium, Trypanosoma, Leishmania, Trichomonas, and intestinal helminths. Considering the extensive use of traditional therapeutics, the World Health Organization (WHO) has recognized the role of phytotherapeutics in the Alma-Ata Declaration 1978 of Health-for-All (Arab et al. 2006).

2. HISTORY OF PHYTOTHERAPY

Phytotherapy is an ancient healing practice that involves using plants and their extracts to treat various health conditions. This brief history of phytotherapy explores the origins and development of this traditional healing approach (Attisso 1979). The roots of phytotherapy can be traced back to prehistoric times when early humans relied on their knowledge of the natural world to identify plants with medicinal properties. Archaeological evidence and ancient writings from civilizations like Egypt, Mesopotamia, China, and India reveal the use of herbal remedies in their healing practices (Awais et al. 2011).

The classical Greek and Roman periods were instrumental in shaping phytotherapy as a formal medical discipline. Renowned figures such as Hippocrates and Dioscorides extensively documented the medicinal uses of plants, laying the groundwork for subsequent generations (Bauri et al. 2015). During the medieval and Renaissance eras, monasteries played a pivotal role in preserving and advancing herbal knowledge. The Age of Exploration further enriched phytotherapy with the discovery and exchange of medicinal plants from various regions across the globe (Beigh and Ganai 2017).

In modern times, the field of phytotherapy observed significant developments due to advancements in chemistry and pharmacology. While the rise of modern pharmaceuticals gained prominence, herbal medicine continued to be valued in traditional healing practices worldwide (Benoit-Vical et al. 2000). Today, phytotherapy remains an essential component of traditional medicine in many cultures and has found its place within complementary and alternative medicine (CAM) in Western societies. The integration of ancient herbal wisdom with modern scientific validation continues to drive its relevance and recognition in promoting health and well-being (Brown et al. 1998).

3. MODES OF ACTION OF PHYTOTHERAPEUTICS

The active compounds present in plants responsible for their medicinal properties are known as phytochemicals. These bioactive substances interact with the body's physiological processes to exert therapeutic effects (Casida 1980). Modes of action of phytotherapeutics in treating and controlling parasites include *1. Anthelmintic Properties*: Many phytotherapeutic compounds possess anthelmintic activity, meaning they can kill or expel parasitic worms (helminths) residing in the host's gastrointestinal tract or other organs. *2. Insecticidal and Acaricidal Properties:* Some phytochemicals act as natural insecticides and acaricides, effectively eliminating ectoparasites such as fleas, ticks, mites, and lice (Choi et al. 2008).

3. Immunomodulatory Effects: Certain phytotherapeutics can modulate the host's immune response, bolstering its defense mechanisms against parasites. *4. Antiprotozoal effects:* Phytochemicals can disrupt the membrane integrity of protozoa, interfere with their energy metabolism, and inhibit their ability to invade host cells. *5. Repellent Action:* Some plant extracts act as repellents, deterring parasites from infesting the host in the first place (Christenhusz and Byng 2016). Table 1 and 2 highlights the mode of action of antiparasitic plants against ectoparasites and endoparasites.

4. PHYTOTHERAPEUTICS FOR ENDOPARASITES

There are several herbal plants with properties to act as antiparasitic treatment, they include a) Wormwood (*A. absinthium*): it contains the compound artemisinin, which exhibits potent antiparasitic properties against various endoparasites (Gefu et al. 2000). It is particularly effective against intestinal worms such as roundworms and hookworms. It has a long history of use in traditional medicine for various purposes, including anti-parasitic medicine. b) Black Walnut (*J. nigra*) is a tree native to North

America, and its various parts, including the hulls, leaves, and bark, have been traditionally used for medicinal purposes (George et al. 2008). It is believed to possess antiparasitic properties, particularly against intestinal parasites. Its anthelmintic effects are due to the presence of certain active compounds, such as juglone, tannins, and flavonoids. c) Garlic (*A. sativum*) contains several bioactive compounds that contribute to its antiparasitic properties and are as follows: i) Allicin: a sulfur-containing compound that is formed when garlic is crushed or chopped and is one of the most potent and biologically active compounds and has a proven activity against a wide range of parasites, including protozoans and helminths ii) Diallyl Disulfide (DADS): another sulfur-containing compound of garlic exhibiting antiparasitic activity against intestinal parasites (protozoa and helminths) (Gouda et al. 2014) iii) Ajoene: a sulfur-containing compound, shown to have antiparasitic effects, particularly against the malaria parasite (*Plasmodium spp*.) and certain skin parasites like scabies mites (*Sarcoptes scabiei*). iv) S-Allyl Cysteine (SAC): a bioactive and water-soluble compound found in garlic, contributes to the overall antiparasitic properties of garlic (Hadimani and Gupta 2011). v) Sulfur compounds: and their collective presence contributes to the herb's overall antimicrobial and antiparasitic effects d) Papaya (*C. papaya*) contains i) Papain, a proteolytic enzyme found in the latex or milky sap of unripe papaya fruit and is known for its digestive properties and antiparasitic activity against intestinal parasites (Hammond et al. 1997). This enzyme helps break down the protective outer layer of parasites, making them more susceptible to the body's immune response and other treatments ii) Carpaine, an alkaloid found in papaya leaves has demonstrated antiparasitic properties iii) Flavonoids (quercetin and kaempferol) act as antimicrobial and antiparasitic iv) Tannins are polyphenolic compounds and contribute to the fruit's antimicrobial and antiparasitic effects v) Alkaloids exhibit antiparasitic properties vi) Cysteine Proteinases: contribute to antiparasitic activity (Hördegen et al. 2003).

Table 1: Mode of action of antiparasitic plant against ectoparasites**.**

No.	Plant	Constituents	Mode of Action	References
1	Neem (*Azadirachta indica*)	Azadirachtin, Nimbidin, Nimbin	Disruption of Reproduction and Growth	(Chungsamarnyart and Jansawan 2001)
		Neem oil	Disruption of feeding and digestion	(Cordeiro et al. 2005)
		Limonoids	Cell membrane damage	(Costa et al. 2006)
		Gedunin	Immune system modulation	(de Almeida et al. 2012)
		Neem oil	antimicrobial activity,	(Diaz Lira et al. 2005)
2	Eucalyptus (*Eucalyptus globulus*)	Eucalyptol 1,8-Cineole	Interfere with cell membrane integrity	(Ekanem et al. 2004)
		Limonene	Disrupt the growth and survival of various parasites	(Ekanem and Andi Brisibe 2010)
		Alpha-Pinene and Beta-Pinene	Interfere with cell membrane integrity	(Costa et al. 2006)
		Terpinen-4-ol	Disturb the growth	(Fajimi and Taiwo 2005)
3	Lavender (*Lavandula angustifolia*)	Linalool	Disrupt the cellular activities	(Fajimi et al. 2003)
		Linalyl acetate	Impairs the digestive function	(Fajimi et al. 2002)
		Camphors	Growth disruption	(Fernandes et al. 2008)

5. PHYTOTHERAPEUTICS FOR ECTOPARASITES

a) Neem (*A. indica*): It contains different bioactive compounds that contribute to its antiparasitic properties. The different parts of the neem tree, including the leaves, seeds, bark, and oil, contain these compounds such as: i) Azadirachtin: a primary bioactive compound found in neem seeds and acts as a potent insecticide and antiparasitic agent interferes with the development and growth of various insect larvae (mosquito larvae and agricultural pests) ii) Nimbin and Nimbidin: possess antifungal, antibacterial,

and antiparasitic properties, and are effective against various parasites and pathogens (Hoste et al. 2005) iii) Gedunin: a limonoid compound shown to have antimalarial activity iv) Salannin: another limonoid that exhibits antiparasitic activity against various pests and parasites v) Quercetin: a flavonoid that has demonstrated antimicrobial and antiparasitic properties (Hounzangbe-Adote et al. 2005) vi) Beta-Sitosterol: a phytosterol found in neem leaves and seeds, possesses antiparasitic effects against certain parasites vii) Azadirone and Azadiradione: These compounds are found in neem oil and have insecticidal and acaricidal (killing mites) properties viii) Neem Volatile Oil: This oil contains various volatile compounds contributing to its antiparasitic effects (Jang et al. 2007).

Table 2: Mode of action of anti-parasitic plant against Endo-parasites

No.	Plant	Constituents	Mode of Action	References
1	Wormwood (*Artemisia absinthium*)	Artemisinin	• Formation of free radicals • Disruption of membrane structure • Heme accumulation leads to toxicity • Inhibition of parasitic growth and development	(Costa et al. 2006)
2	Black Walnut (*Juglans nigra*)	Juglone	Disruption of parasites physiology and metabolism	(de Almeida et al. 2012)
		Tannins	Precipitation and inactivation of parasite cell proteins	(Diaz Lira et al. 2005)
		High ORAC value	Neutralizes free radicals. Immunomodulation.	(Ekanem et al. 2004).
3	Garlic (*Allium sativum*)	Allicin	• Interfering with the structure and function of parasitic cellular components • Disruption of the integrity of the cell membranes and metabolism	(Ekanem and Andi Brisibe 2010)
		Allyl Cysteine (SAC)	• Immunomodulatory properties. • Antioxidant activity.	(Costa et al. 2006)
4	Papaya (*Carica papaya*)	Chymopapain proteolytic enzymes	Degrade parasite proteins	(Ekanem and Andi Brisibe 2010)
		Immune modulation		(Costa et al. 2006)
		Carpaine	Antioxidant activity	(Fajimi and Taiwo 2005)
		Flavonoids	Antimicrobial properties	(Ekanem and Andi Brisibe 2010)

b) Eucalyptus (*E. globulus*) oil contains cineole, which acts as a natural insect repellent and can be used to control ectoparasites. Eucalyptus is a fast-growing evergreen tree native to Australia, but it is now cultivated in many parts of the world for its medicinal and aromatic properties (Jansawan et al. 1993). The essential oil extracted from it is particularly well-known for its antiparasitic and antimicrobial effects. The primary constituents of Eucalyptus essential oil are: i) Eucalyptol (1,8-Cineole): it is the major active compound typically comprising 60-80% of the oil. It is responsible for the characteristic aroma and many of the medicinal, antimicrobial, and antiparasitic properties ii) Alpha-Pinene and Beta-Pinene: These are monoterpenes and contribute to the oil's antimicrobial activity and can also help deter certain parasites iii) Limonene and Terpinen-4-ol: both are monoterpene with antiparasitic properties iv) Terpinen-4-ol and Alpha-Terpineol: these are alcohol that exhibits strong antimicrobial, antifungal, insecticidal, and antiparasitic properties v) Phenolic compounds: such as catechins and flavonoids possess antimicrobial and antiparasitic effects (Kaaya et al. 1995).

c) Lavender *(L. angustifolia),* a popular aromatic herb known for its calming and soothing properties. While lavender is primarily valued for its use in aromatherapy and relaxation, it also possesses certain

bioactive compounds that may exhibit antiparasitic properties against ticks and fleas (Kavitha et al. 2012). However, it's essential to understand that lavender's antiparasitic effects are relatively mild compared to other herbs specifically known for their antiparasitic activity. The constituents of lavender that may contribute to its antiparasitic properties include: i) Linalool: its significant amount is present in the oil and is known for its pleasant floral scent with demonstrated parasitic properties (Khan et al. 2008) ii) Linalyl Acetate and Camphor: which may contribute to the overall antiparasitic effects of lavender. Lavender may have some potential for supporting the body's natural defense against parasites due to its mild antimicrobial properties (Kiss et al. 2012).

d) Citronella (*Cymbopogon nardus*): Citronella oil is a well-known natural mosquito repellent that can be useful for controlling blood-sucking ectoparasites. The essential oil of citronella is composed of several constituents, and while some of them have shown antimicrobial activity, their direct antiparasitic effects against internal parasites have not been extensively studied (Kostadinovic et al. 2012). The main constituents of citronella essential oil include: i) Citronellal: a major component of the oil, responsible for its lemon-like scent. It exhibits insect-repelling properties and has some antimicrobial activity against bacteria and fungi ii) Geraniol and Citronellol: these have antimicrobial activity and are known for their insect-repelling properties iii) Geranyl Acetate: present in the oil and contributes to its aromatic profile (Lans et al. 2007).

6. INDIRECT METHOD TO COMBAT THE PARASITES

The use of Condensed Tannins (CT) affects the helminths in 2 ways:

6.1. INDIRECT EFFECT

The indirect effect includes feeding the animals with forages rich in tannin amount, resulting in CT release and formation of abomasum-degraded CT-Protein complex (Lee et al. 2008). This complex helps in combating protein loss caused by helminth infestation and supports more protein release to overcome parasite-generated losses.

6.2. DIRECT EFFECT

Direct effect includes the formation of CT-chillates with surface proteins of the parasite body, impairing the normal functioning of the vital organs of parasites (locomotory, digestive, and reproductive organs) (Macarenco et al. 2001). Table 3 enlists the plants used against ruminant endoparasites. Table 4 shows the medicinal plants used for the treatment of various parasitic infections.

7. MEDICINAL PLANTS USED FOR THE TREATMENT OF ARTHROPOD INFESTATION

In a study, tobacco leaves and steam extracts were shown to be completely efficacious against lice and kept repelled the parasite for 56 days in African goats. Neem skin cream showed excellent antiparasitic activity when mixed with shampoo foams. Table 5 shows the medicinal plants used against arthropod infection.

8. FUTURE PERSPECTIVES AND UPCOMING DIRECTIONS

There is an increase in interest in the role of phytotherapeutics in controlling zoonotic parasitic diseases in the field of both traditional and modern medicine (Sandoval-Castro et al. 2012). The

Table 3: Plants used for ruminants endoparasites

Animals	Scientific names of plants	English names of plants	Used parts	Parasite Types	References
Sheep	*Achellia millefolium L.*	Yarrow	Whole, Extract	GIT Nematodes	(Madzimure et al. 2011)
	Alnus glutinosa L.	Alder	Shoots	Trematodes	(Mandeel and Taha 2005).
	Artemisia absinthium L.	Wormwood	Aerial parts, Extract, Whole, Leaves	Roundworms including, *Toxocara vitulorum*, *Haemonchus contortus* and *Trichostrongylus colubriformis* Tapeworms, *Eimeria spp.*	(Matovu and Olila 2007)
	Artemisia campestris L.	Field wormwood	Leaves, Extract	Effective against roundworms especially *H. contortus*	(Michels et al. 2011)
	Artemisia maritime L.	Sea wormwood		Nematodes	(Min and Hart 2003)
	Artemisia vulgaris L.	Mugwort	Leaves, extract	It is effective against roundworms, especially *T. colubriformis*	(Min et al. 2005)
	Betula pubescens Ehrh.	Downy birch	Leaves, Bark	Nematodes, Trematodes & Cestodes	(Molan et al. 2009)
	Calluna vulgaris L.	Hill/Heater	Leaves, Bark	Flukes (Trematodes)	(Molan et al. 2000)
	Cichorium intybus L.	Chicory	Whole	It's effective against Gastrointestinal tract roundworms & lungworm infections	(Mothana et al. 2014)
	Dryopteris filix-mas L.	Male Fern	Roots	Roundworms including, *Trichostrongylus colubriformis* It is also effective against *Fasciola spp.* and *Dicrocoelium spp*. of class trematodes	(Mudi and Bukar 2011)
	Humulus lupulus L.	Hop	Whole, Roots	It is effective against helminths, especially tapeworms and flukes	(Mwangi et al. 1995)
	Juniperus communis L.	Juniper	Bark, Roots	It is effective against Trematodes, especially liver flukes	(Madzimure et al. 2011)
	Lepidium sativum L.	Garden cres	Whole, Seeds	Helminths especially trematodes	(Mandeel and Taha 2005)
	Nigella sativa L.	Garden fennel	Seeds, Extract	It's effective against gastrointestinal tract roundworms & tapeworms	(Matovu and Olila 2007)
	Pastinaca sativa L.	Wild parsnip	Aerial parts	Endoparasites	(Michels et al. 2011)
Sheep	*Pyrus communis L.*	Pear	Berries	Roundworms	(Min et al. 2005)
	Salix spp.	Willow	Bark, Leaves	It is effective against helminths, especially tapeworms & flukes	(Molan et al. 2009)
	Symphori-carpos albus L.	Snowberry	Leaves	Cestodes	(Molan et al. 2000)
	Tanacetum vulgare L.	Tansy	Aerial parts, Whole, Leaves, Seeds	Roundworms including, *Trichostrongylus colubriformis* Trematodes and Cestodes	(Mothana et al. 2014)
	Urtica dioica L.	Common nettle	Whole, Seeds	It is effective against helminths, especially flukes	(de Almeida et al. 2012)
	Valeriana officinalis	Common valerian	Roots	Roundworms including *T. colubriformis*	(Diaz Lira et al. 2005)

Goat	*Artemisia absinthium L.*	Wormwood	Aerial parts, Extract, Whole, Leaves	Roundworms including, *T. colubriformis, H. contortus, T. vitulorum.* Tapeworms *Eimeria protozoal spp*.	(Ekanem et al. 2004)
	Cichorium intybus L.	Chicory	Whole	It is effective against gastrointestinal roundworms and lungworms	(Ekanem and Andi Brisibe 2010)
	Artemisia campestris L.	Field wormwood	Leaves, Extract	Roundworms (*H. contortus*)	(Costa et al. 2006)
	Dryopteris filix-mas L.	Male-fern	Roots	Roundworms (*T. colubriformis*) Flukes (*Fasciola Spp.* and *Dicrocoelium spp.*)	(Naidoo et al. 2008)
	Juniperus communis L.	Juniper	Berries, Roots	It is good against flukes and is effective against liver flukes.	(Ndumu et al. 1999)
	Nigella sativa L.	Garden fennel	Extract, Seeds	Gastrointestinal tract (GIT) Roundworms, Tapeworm	(Niezen et al. 2002)
	Pastinaca sativa L.	Wild parsnip	Aerial parts	Endoparasites	(Nweze and Obiwulu 2009)
	Symphori-carpos albus L.	Snoeberry	Leaves	Cestodes	(Nwosu et al. 2011)
Cow	*Artemisia absinthium L*	Wormwood	Aerial parts, Extract, Whole, Leaves	Roundworms (*T. colubriformis, T. vitulorum and H. contortus*) Tapeworm, *Eimeria spp.*	(Nwude and Ibrahim 1980)
	Acorus calamus L.	Sweet-flag	Roots	It is effective against helminths.	(Orengo et al. 2012)
	Artemisia vulgaris L.	Mugwort	Leaves, Extract	Nematodes, *T. colubriformis*	(Paolini et al. 2004)
	Cichorium intybus	Chicory	Whole	GIT Nematodes, Lungworm,	(Papazahariadou et al. 2010)
	Dryopteris filix-mass L.	Male fern	Roots	Roundworms, *T. colubriformis*. Flukes, (*Dicrocoelium spp. Fasciola Spp.*)	(Patel et al. 2009)
	Iris Pseudocorus L.	Yellow iris	Roots	Helminths	(Ekanem et al. 2004)
	Juniperus communis L.	Juniper	Berries, Roots	It is effective against trematodes especially (liver fluke)	(Ekanem and Andi Brisibe 2010)
	Lotus corniculatus L.	Bird`s-foot-trefoil		Roundworms, (*Ostertagia ostertagi* and *Cooperia oncophora*) Lungworm (*Dictyocalus eckerti*)	(Costa et al. 2006)
	Pastinaca ssativa L.	Wild parsnip pear	Aerial parts	Endoparasites	(Ekanem and Andi Brisibe 2010)
	Quercus Robur L.	Pedunculate oak	Nuts	Helminths	(Costa et al. 2006)
	Salix spp	Willow	Bark, Leaves	It is effective against helminths, especially tapeworms and flukes	(Fajimi and Taiwo 2005)
	Senecio Vulgaris L.	Groundsel	Leaves	Cestodes	(Ekanem and Andi Brisibe 2010)
	Symphori- carpus albus	Snowberry	Leaves	Endoparasites	(Costa et al. 2006)

use of Phyto-medicines acts as a potential alternative approach to traditional antiparasitic drugs, and suggests several future perspectives and upcoming directions in this field:

8.1. PHYTOCHEMICAL RESEARCH

The objective of the ongoing research is to identify and isolate the active biological compounds of the plants that show anti-parasitic activity.
An in-depth understanding of the bioactive compounds of medicinal plants' is now possible by using advanced phytochemical analysis techniques (Mass spectrometry and Nuclear magnetic resonance) (Sathiyamoorthy et al. 1999).

8.2. MECHANISMS OF ACTION

Phytotherapeutics can be effectively used if their anti-parasitic modes of action are well understood. The understanding of the parasites-phytocompounds interaction at the molecular level can reveal more of plants antiparasitic characteristics.

8.3. SYNERGY AND COMBINATION THERAPY

Studies are being conducted to find what different combinations of plant extracts possess synergism that improve their antiparasitic activity (Smith-Schalkwijk 1999). Using phytotherapeutics in combination with conventional drugs may also result in enhancement of the therapeutic results and reduction in the development of parasitic resistance (Su and Mulla 1999).

8.4. CLINICAL TRIALS AND VALIDATION

While the use of several medicinal herbs in antiparasitic therapy has been documented by old civilization knowledge however extensive clinical studies are required for the validation of their efficacy and safety. More randomized controlled trials (RCTs) are being conducted to establish the evidence-based use of phytotherapeutics against zoonotic parasites.

8.5. FORMULATION DEVELOPMENT

Developing standardized and stable formulations of phytotherapeutics is crucial for their widespread use. This includes creating extracts, capsules, or topical formulations with consistent levels of active compounds to ensure reproducible outcomes (Tariq and Tantry 2012).

8.6. BIOAVAILABILITY AND PHARMACOKINETICS

Understanding the bioavailability and pharmacokinetic properties of plant compounds is crucial for optimizing dosing regimens and ensuring that therapeutic levels are achieved in the body.

8.7. PLANT BIOTECHNOLOGY

Advancements in plant biotechnology, such as genetic engineering and recombinant DNA technology, may facilitate the production of high-yield, standardized, and genetically modified plants with enhanced antiparasitic properties and targeted molecular drug delivery.

8.8. ETHNOPHARMACOLOGICAL STUDIES

Collaborations between traditional healers, Eastern medicine doctors, and medical scientists can lead to the discovery of novel plant-based medicines. This will improve our understanding of traditional medicine effectiveness, safety, bioavailability, and applications.

Table 4: Medicinal plants used for the treatment of various parasitic infections including *Toxoplasma gondii*

Plant Name	Parts Used	Extraction Method	Biological effect	References
Vernonia colorata	Stems and leaves	Air-dried, powdered, and ethanolic extract	It has the anti-toxoplasmic activity	(Pereira and Famadas 2006)
Zingiber officinale	Stems and Leaves	Air-dried, powdered, and ethanolic extract	It has the anti-toxoplasmic activity	(Pirali-Kheirabadi and da Silva 2010)
Sophora flavescens	Stems and Leaves	Air-dried, powdered, and ethanolic extract	It has the anti-toxoplasmic activity	(Poyares et al. 2005)
Torilis japonica	Stems and Leaves	Air-dried, powdered, and ethanolic extract	It has the anti-toxoplasmic activity	(Fajimi and Taiwo A 2005)
Euricoma longifolia	Roots	Air-dried, powdered, and methanolic extract	It has the anti-toxoplasmic activity	(Ekanem and Andi Brisibe 2010)
Callotropis procera	Leaf	Air-dried, grounded and ethanolic soak	It has an anti-malarial effect.	(Russo et al. 2009)
Pulicaria crispa	Leaf	Air-dried, powdered and methanolic extract	It has the anti-malarial and anti-cancer activity	(Niezen et al. 2002)
Euphorbia retusa	Leaf and stem	Dried at room temperature, powdered and methanolic extract	It has the Anti-bacterial activity	(Nweze and Obiwulu 2009)
Rumex spinose	Leaf	Air-dried chloroformic and methanolic extract	It has the anti-fungal (*Candida albicans*, *Alternaria alternate*, *Saccharomyces cerevicsiae*)	(Refahy 2011)
Ocradenus baccatus	Leaves and flower	Air-dried powdered and methanolic extract	It has anti-malarial, anti-leishmanial, anti-trypanosomal, and hypocholesterolemic effect	(Regassa 2000)
Lycium shwii	Leaves	Oven-dried grounded and methanolic extract	Hypoglycemic Anti-plasmodial and anti-trypanosomal effect	(Refahy 2011)
Curcuma longa	Stem and leaf	Air-dried water and ethanolic extract	It has the anti toxoplasmic activity	(Poyares et al. 2005)

Table 5: Medicinal plants used for the treatment of arthropods infestation

Plant	Part used	Active compound	Efficacy	Reference
Stemona collinsae	Root	Extract	*In vitro* and *in vivo* against *B. microplus* (Mortality of Nymph & Adult)	(Zeineldin et al. 2018)
Aganonerion polymorphum	Leaves and stem	Crude ethanolic extract	Mortality of *Boophilus microplus*	(Zaman et al. 2012)
Calotropis gigantean	Leaf and stem	Crude ethanolic extract	*Mortality of B. miroplus*	(Niezen et al. 2002)
Margaritaria discoidea	Leaf & stem (Bark is more acaricidal)	Hexane extract	Nymph mortality of *Rhipicephalus appendiculatus*	(Nweze and Obiwulu 2009)
Osimum suave	Aerial parts	Oil extracted by steam distillation	Larvae mortality of *R. appendiculatus*	(Youn et al. 2003)
Pimenta dioica	Leaf	Hexane extract / Essential oil	Mortality and inhibit oviposition in *B. microplus*	(Wink 2012)
Azadirachta indica	Seed	Oil extract	In vitro acaricidal against *Amblyoma variegatum* (Larvae mortality)	(Youn and Noh 2001)
Tamarindus indicus	Mature fruit	Aqueous & (10% Ethanol extract)	Mortality of *B. microplus (Engorged females)*	(Wichtl 2004)

Euphorbia obovalifolia	Aerial parts	Crude extract	Inhibitory effect on all stages of *Rhippicephalus decoloratus*	(Viegi et al. 2003)
Dahlstedtia pentaphyla	Root	Ethanol extract (terpenoids)	In vivo spray on bovines Adulticide against *B. microplus*	(Waller et al. 2001)
Copaifera reticulate	Stem & Leaf	Extract (Terpenoids)	Larvicidal against *B. microplus*	(Urban et al. 2008)
Tephrosia vogelii	Leaf	Methanol aqueous and other extracts	In vitro efficacy against various genra of *Ixodid ticks* Cidal (Nymph & Adult)	(Turolla and Nascimento 2006)
Hypericum polyanthimum	Aerial parts	Crude methanolic extracts	In vitro Larvicidal (100% @ high concern.) against *B. microplus*	(Uchegbu et al. 2011)
Magonia pubescens	Stem, Bark	Crude Ethanolic extracts	Larvicidal against *R. sanguineus*	(Trojan-Rodrigues et al. 2012)
Calea serrata	Leaf & stem	Hexane extract Precocene	Inhibit *B. microplus* egg hatching	(Thamsborg et al. 2001)
Aloe ferox & Ptaeroxylon oblicum	Fresh leaves (crushed)	Overnight soaked in water	High degree control of *B. microplus*)	(Tipu et al. 2002)
Pelargonitum Roseum & Ecucalyptus globulis	Aerial parts	Essential oil	Adulticidal effect on *B. annulatus*	(Singh et al. 2011)
Lavendula augustifolia	Leaf	Essential oil	Acaricidal effect on *B. microplus*	(Seely et al. 2008)
Tetradenia riperia	Leaf	Essential oil	In vivo & in vitro adulticide against *B. microplus*	(Schmahl et al. 2010)
Lippia javanica	Leaf	Aqueous extract (Phenolic glycosides, flavonoids)	In vivo Adulticid against *B. microplus*	(Chungsamarnyart and Jansawan 2001)
Nicotiana tabacum	Leaf	Essential oil & (precocene II) isolated from it	In vitro toxic to larvae of *B. microplus*	(de Almeida et al. 2012)
Calatropis procera	Flower	Aqueous extract	Effective against all developmental stages (Dose 7 time-dependent response) of *B. microplus*	(Fernandes et al. 2008)
Trachyspermum ammi	Seed	Essential oil	Reduced average weight of ticks, no of ticks & Larval viability reduced	(Tipu et al. 2002)
Strychnos spinosa & Solanum incanum	Fruit	Extracts	Cattle pen trial *in-vitro* & *In-vivo* with amitraz as reference control and effective on all stages. The efficacy of *S. incanum* fruit extract higher	(Singh et al. 2011)
Cymbopogon martini	Leaf	Essential oil & Precocene II isolate from it	Toxic to larvae of *B. microplus*	(Seely et al. 2008)

8.9. ONE-HEALTH APPROACH

Adopting a "One-Health" approach, which recognizes the interdisciplinary approach of human, animal, and environmental health, can help address zoonotic diseases more effectively. Phytotherapeutics may play a role in the transmission of zoonotic diseases to humans.

8.10. REGULATORY CONSIDERATIONS

Establishing appropriate regulations and quality control for phytotherapeutics is vital to ensure their safety, efficacy, storage, and applications.

REFERENCES

Abdel-galil MA and Aboelhadid SM, 2012. Trials for the control of trichodinosis and gyrodactylosis in hatchery-reared *Oreochromis niloticus* fries by using garlic. Veterinary Parasitology 185: 57-63.

Abo-EL-Sooud K, 2018. Ethnoveterinary perspectives and promising future. International Journal of Veterinary Science and Medicine 6: 1-7.

Akhtar M et al., 2012. Immunostimulatory and protective effects of Aloe vera against coccidiosis in industrial broiler chickens. Veterinary Parasitology 186: 170-177.

Akhtar M et al., 2012. Studies on wheat bran Arabinoxylan for its immunostimulatory and protective effects against avian coccidiosis. Carbohydrate Polymers 90: 333-339.

Al-Zanbagi NA, 2009. In vivo effect of some home spices extracts on the *Toxoplasma gondii* tachyzoites. Journal of Family & Community Medicine 16: 59.

Al-Zanbagi NA, 2011. Noticeable effect of *Juniperus rocera* as *Toxoplasma gondii* tachyzoites inhibitor in vivo. International Journal of Health, Wellness & Society 1: 2.

Al-Zanbagi NA and Zelai NT, 2008. Two methods for attenuating *Toxoplasma gondii* tachyzoites RH strain by using ethanol extract of Curcuma longa. Journal of the Egyptian Society of Parasitology 38: 965-976.

Andreotti R et al., 2013. Protective action of *Tagetes minuta* (Asteraceae) essential oil in the control of *Rhipicephalus microplus* (Acari: Ixodidae) in a cattle pen trial. Veterinary Parasitology 197: 341-345.

Annan-Prah A et al., 2012. Study of the potential of using the goat weed (*Ageratum conyzoides*) as an anticoccidia agent in chicken. Journal of Veterinary Advances 2: 292-297.

Arab HA et al., 2006. Determination of artemisinin in *Artemisia sieberi* and anticoccidial effects of the plant extract in broiler chickens. Tropical Animal Health and Production 38: 497-503.

Attisso M, 1979. As plantas medicinais voltam a florescer. O correio da UNESCO 7: 6-8.

Awais MM et al., 2011. Immunotherapeutic effects of some sugar cane (*Saccharum officinarum L.*) extracts against coccidiosis in industrial broiler chickens. Experimental Parasitology 128: 104-110.

Bauri RK et al., 2015. A review on use of medicinal plants to control parasites. Indian Journal of Natural Products and Resources (IJNPR) 6: 268-277.

Beigh YA and Ganai AM, 2017. Potential of wormwood (*Artemisia absinthium Linn.*) herb for use as additive in livestock feeding: A review. The Pharma Innovation 6: 176.

Benoit-Vical F et al., 2000. Anti-toxoplasma activity of vegetal extracts used in West African traditional medicine. Parasite 7: 3-7.

Brown HA et al., 1998. Biological activities of the extracts and constituents of pimento, *Pimenta dioica* L. against the southern cattle tick, *Boophilus microplus.* International Journal of Tropical Insect Science 18: 9-16.

Casida JE, 1980. Pyrethrum flowers and pyrethroid insecticides. Environmental Health Perspectives 34: 189-202.

Choi KM et al., 2008 Anti-*Toxoplasma gondii* RH strain activity of herbal extracts used in traditional medicine. International Journal of Antimicrobial Agents, 32: 360-362.

Christenhusz MJ and Byng JW, 2016. The number of known plants species in the world and its annual increase. Phytotaxa 261: 201-217.

Chungsamarnyart N and Jansawan W, 2001. Effect of *Tamarindus indicus* L. against the *Boophilus microplus*. Agriculture and Natural Resources, 35: 34-39.

Cordeiro CHG et al., 2005. Interações medicamentosas de fitoterápicos e fármacos: Hypericum perforatum e Piper methysticum. Revista Brasileira de Farmacognosia 15: 272-278.

Costa CTC et al., 2006. Anthelmintic activity of *Azadirachta indica A*. Juss against sheep gastrointestinal nematodes. Veterinary Parasitology 137: 306-310.

de Almeida GF et al., 2012. Use of *Artemisia annua* as a natural coccidiostat in free-range broilers and its effects on infection dynamics and performance. Veterinary Parasitology 186: 178-187.

Diaz Lira C et al., 2005. Controlling parasites in weaned lambs on browse blocks. New Zealand 31: 549.

Ekanem A et al., 2004. Effects of crude extracts of *Mucuna pruriens* (Fabaceae) and *Carica papaya* (Caricaceae) against the protozoan fish parasite *Ichthyophthirius multifiliis*. Parasitology Research 92: 361-366.

Ekanem AP and Andi Brisibe E, 2010. Effects of ethanol extract of *Artemisia annua L*. against monogenean parasites of *Heterobranchus longifilis*. Parasitology Research 106: 1135-1139.

Fajimi A and Taiwo A, 2005. Herbal remedies in animal parasitic diseases in Nigeria: a review. African Journal of Biotechnology 4: 303-307.

Fajimi A et al., 2003. studies on the anti-louse activity of aqueous tobacco extract and invermectin in heavily parasitized West African dwarf goats. Israel Journal of Veterinary Medicine 3: 118-122.

Fajimi A et al., 2002. Evaluation of shea butter plus salt against naturally acquired psoroptic mange in rabbits. Tropical Veterinarian 20: 11-16.

Fernandes FF et al., 2008. Toxicity of extract of *Magonia pubescens* (Sapindales: Sapindaceae) St. Hil. to control the brown dog tick, *Rhipicephalus sanguineus* (Latreille)(Acari: Ixodidae). Neotropical Entomology 37:205-208.

Gefu JO et al., 2000. Ethnovet. practices res. Dev. Proc. Of the workshop on ethnovet practices held 14-18 August 2000, Kaduna, Nig. Published by the National Animal Production Research Institute 34: 123-124.

George DR et al., 2008. Use of plant-derived products to control arthropods of veterinary importance: a review. Annals of the New York Academy of Sciences 1149: 23-26.

Gouda YG et al., 2014. Cytotoxic and antimicrobial activities of some composite plants growing in Taif area, Saudi Arabia. International Journal of Pharmaceutical Science Invention 3: 43-48.

Hadimani S and Gupta SK, 2011. Anticoccidial efficacy of *Carica papaya* and *Azadirachta indica* leaves and their effect on serum IgY levels in *Eimeria tenella* infected birds. Journal of Veterinary Parasitology 25: 67-71.

Hammond JA et al., 1997. Prospects for plant anthelmintics in tropical veterinary medicine. Veterinary Research Communications 21: 213-228.

Hördegen P et al., 2003. The anthelmintic efficacy of five plant products against gastrointestinal trichostrongylids in artificially infected lambs. Veterinary Parasitology 117: 51-60.

Hoste H et al., 2005. Consequences of the regular distribution of sainfoin hay on gastrointestinal parasitism with nematodes and milk production in dairy goats. Small Ruminant Research 59: 265-271.

Hounzangbe-Adote MS et al., 2005. In vitro effects of four tropical plants on three life-cycle stages of the parasitic nematode, *Haemonchus contortus*. Research in Veterinary Science 78: 155-160.

Jang SI et al., 2007. Anticoccidial effect of green tea-based diets against *Eimeria maxima*. Veterinary Parasitology 144: 172-175.

Jansawan WN et al., 1993. Effect of *Stemona collinsae* Extract against Cattle Ticks (*Boophilus microplus*). Agriculture and Natural Resources 27: 336-340.

Kaaya GP et al., 1995. Acaricidal activity of *Margaritaria discoidea* (Euphorbiaceae) plant extracts against the ticks *Rhipicephalus appendiculatus* and *Amblyomma variegatum* (Ixodidae). International Journal of Acarology 21: 123-129.

Kavitha N et al., 2012. In vitro anti-*Toxoplasma gondii* activity of root extract/fractions of *Eurycoma longifolia* Jack. BMC Complementary and Alternative Medicine 12: 1-8.

Khan MA et al., 2008. Comparative efficacy of some herbal and homeopathic preparations against coccidiosis in broilers. International Journal of Agriculture and Biology 10: 358-360.

Kiss T et al., 2012. Tick prevention at a crossroads: new and renewed solutions. Veterinary Parasitology 187: 357-366.

Kostadinovic L et al., 2012. Anticoccidial effects of the *Artemisia absinthium L*. extracts in broiler chickens. Archiva Zootechnica 15: 69.

Lans C et al., 2007. Ethnoveterinary medicines used for ruminants in British Columbia, Canada. Journal of Ethnobiology and Ethnomedicine 3: 1-22.

Lee SH et al., 2008. Immunomodulatory properties of dietary plum on coccidiosis. Comparative Immunology, Microbiology and Infectious Diseases 31: 389-402.

Macarenco RS et al., 2001. Study of the action of *Ginkgo biloba* extract and hypertonic hydroxyethyl starch in the attenuation of alterations resulting from ischemia and reperfusion of splanchnic organs in rats. Acta Cirurgica Brasileira 16: 139-145.

Madzimure J et al., 2011. Acaricidal efficacy against cattle ticks and acute oral toxicity of *Lippia javanica* (Burm F.) Spreng. Tropical Animal Health and Production, 43: 481-489.

Mandeel Q and Taha A, 2005. Assessment of in vitro. Antifungal activities of various extracts of indigenous bahraini medicinal plants. Pharmaceutical Biology 43: 164-172.

Matovu H and Olila D, 2007. Acaricidal Activity of *Tephrosia vogelii* Extracts on Nymph and Adult Ticks. International Journal of Tropical Medicine 32: 12-65.

Michels MG et al., 2011. Anticoccidial effects of coumestans from *Eclipta alba* for sustainable control of *Eimeria tenella* parasitosis in poultry production. Veterinary Parasitology 177: 55-60.

Min BR and Hart SP, 2003. Tannins for suppression of internal parasites. Journal of Animal Science 81: 102-109.

Min BR et al., 2005. The effect of grazing forage containing condensed tannins on gastrointestinal parasite infection and milk composition in Angora does. Veterinary Parasitology 130: 105-113.

Molan AL et al., 2009. Effect of pine bark *(Pious radiata*) extracts on sporulation of coccidian oocysts. Folia Parasitologica (Prague) 56:1.

Molan AL et al., 2000. The effect of condensed tannins from seven herbages on *Trichostrongylus colubriformis* larval migration in vitro. Folia Parasitologica 47: 39-44.

Mothana RA et al., 2014. Evaluation of the in vitro antiplasmodial, antileishmanial, and antitrypanosomal activity of medicinal plants used in Saudi and Yemeni traditional medicine. Evidence-Based Complementary and Alternative Medicine 23: 53.

Mudi SY and Bukar A, 2011. Anti-plasmodia activity of leaf extracts of *Calotropis procera Linn*. Biochemistry 23: 51.

Mwangi EN et al., 1995. Repellent and acaricidal properties of *Ocimum suave* against *Rhipicephalus appendiculatus* ticks. Experimental & Applied Acarology 19: 11-18.

Naidoo V et al., 2008. The value of plant extracts with antioxidant activity in attenuating coccidiosis in broiler chickens. Veterinary Parasitology 153: 214-219.

Ndumu PA et al. 1999. Toxicity of neem seed oil (*Azadiracta indica*) against the larvae of *Amblyomma variegatum* a three-host tick in cattle. Phytotherapy Research 13: 532-534.

Niezen JH et al., 2002. The effect of diet fed to lambs on subsequent development of *Trichostrongylus colubriformis* larvae in vitro and on pasture. Veterinary Parasitology 105: 269-283.

Nweze NE and Obiwulu IS, 2009. Anticoccidial effects of *Ageratum conyzoides*. Journal of Ethnopharmacology 122: 6-9.

Nwosu CO et al., 2011. Toxicity and anticoccidial efficacy of some plants used in the traditional treatment of avian coccidiosis in semi-arid northeastern Nigeria. Research Journal of Parasitology 6: 18-30.

Nwude N and Ibrahim M, 1980. Plants used in traditional veterinary medical practice in Nigeria. Journal of Veterinary Pharmacology and Therapeutics 3: 261-273.

Orengo J et al. 2012. Evaluating the efficacy of cinnamaldehyde and *Echinacea purpurea* plant extract in broilers against *Eimeria acervulina*. Veterinary Parasitology 185: 158-163.

Paolini V et al., 2004. In vitro effects of three woody plant and sainfoin extracts on 3rd-stage larvae and adult worms of three gastrointestinal nematodes. Parasitology 129: 69-77.

Papazahariadou M et al., 2010. Use of *Fraxinus ornus* as an alternative anti-coccidian in broilers experimentally infected with *Eimeria tenella*. Revue De Médecine Vétérinaire 161: 326-331.

Patel SS et al., 2009. *Passiflora incarnata Linn*: A phytopharmacological review. International Journal of Green Pharmacy (IJGP) 3: 4.

Pereira JR and Famadas KM, 2006. The efficiency of extracts of *Dahlstedtia pentaphylla* (Leguminosae, Papilionoidae, Millettiedae) on *Boophilus microplus* (Canestrini, 1887) in artificially infested bovines. Veterinary Parasitology 142: 192-195.

Pirali-Kheirabadi K and da Silva JAT, 2010. *Lavandula angustifolia* essential oil as a novel and promising natural candidate for tick (*Rhipicephalus (Boophilus) annulatus*) control. Experimental Parasitology 126: 184-186.

Poyares D et al., 2005. Hipnoindutores e insônia. Brazilian Journal of Psychiatry 27: 2-7.

Refahy LAG, 2011. Study on flavonoids and triterpenoids content of some Euphorbiaceae plants. Journal of Life Sciences 5: 100-107.

Regassa A, 2000. The use of herbal preparations for tick control in western Ethiopia. Journal of the South African Veterinary Association 71: 240-243.

Russo R et al., 2009. Pharmaco-toxicological aspects of herbal drugs used in domestic animals. Natural Product Communications 4: 1777-84.

Sandoval-Castro CA et al., 2012. Using plant bioactive materials to control gastrointestinal tract helminths in livestock. Animal Feed Science and Technology 176: 192-201.

Sathiyamoorthy P et al., 1999. Screening for cytotoxic and antimalarial activities in desert plants of the Negev and Bedouin market plant products. Pharmaceutical Biology 37: 188-195.

Schmahl G et al., 2010. The efficacy of neem seed extracts (Tre-san®, MiteStop®) on a broad spectrum of pests and parasites. Parasitology Research 107: 261-269.

Seely D et al., 2008. Safety and efficacy of Panax ginseng during pregnancy and lactation. Journal of Population Therapeutics and Clinical Pharmacology 15: 23.

Singh Bal et al., 2011. Antiparasitic additive effect of *Leucaena leucocephala* (Subabul) seed extract in broiler chicken. Indian Veterinary Journal 88: 49.

Smith-Schalkwijk MJ, 1999. Veterinary phytotherapy: an overview. The Canadian Veterinary Journal 40: 891.

Su M and Mulla MS, 1999. Activity and biological effects of neem products against arthropods of medical and veterinary importance. Journal of the American Mosquito Control Association 15: 133-152.

Tariq KA and Tantry MA, 2012. Preliminary studies on plants with anthelmintic properties in Kashmir—the north-west temperate Himalayan Region of India. Chinese Medicine 3: 106-112.

Thamsborg S et al., 2001. Sainfoin reduces the establishment of nematode infections in grazing lambs. Speech at: The 18th International Conference of the World Association for the Advancement of Veterinary Parasitology: Promoting Advancement, Preserving Tradition 3: 26-30.

Tipu MA et al., 2002. Comparative efficacy of salinomycin sodium and neem fruit (*Azadirachta indica*) as feed additive anticoccidials in broilers. International Journal of Poultry Science 1: 91-93.

Trojan-Rodrigues M et al., 2012. Plants used as antidiabetics in popular medicine in Rio Grande do Sul, southern Brazil. Journal of Ethnopharmacology 139: 155-163.

Turolla MSDR and Nascimento EDS, 2006. Informações toxicológicas de alguns fitoterápicos utilizados no Brasil. Revista Brasileira de Ciências Farmacêuticas 42: 289-306.

Uchegbu M et al., 2011. The growing importance of neem (Azadirachta indica A. Juss) in agriculture, industry, medicine and environment: A review. Research Journal of Medicinal Plant 5: 230-245.

Urban J et al., 2008. In vitro anthelmintic effects of medicinal plants used in Czech Republic. Pharmaceutical Biology 46: 808-813.

Viegi L et al., 2003. A review of plants used in folk veterinary medicine in Italy as basis for a databank. Journal of Ethnopharmacology 89: 221-244.

Waller PJ et al., 2001. Plants as de-worming agents of livestock in the Nordic countries: historical perspective, popular beliefs and prospects for the future. Acta Veterinaria Scandinavica 42: 1-14.

Wichtl M, 2004. Herbal drugs and phytopharmaceuticals: a handbook for practice on a scientific basis, Medpharm GmbH Scientific Publishers 76:12-13

Wink M, 2012. Medicinal plants: a source of anti-parasitic secondary metabolites. Molecules 17: 12771-12791.

Youn HJ and Noh JW, 2001. Screening of the anticoccidial effects of herb extracts against *Eimeria tenella*. Veterinary Parasitology 96: 257-263.

Youn HJ et al., 2003. Anti-protozoal efficacy of medicinal herb extracts against *Toxoplasma gondii* and *Neospora caninum*. Veterinary Parasitology 116: 7-14.

Zaman MA et al., 2012. In vitro and in vivo acaricidal activity of a herbal extract. Veterinary Parasitology, 186: 431-436.

Zeineldin M et al., 2018. A Review: Herbal Medicine as an Effective Therapeutic Approach for Treating Digestive Disorders in Small Ruminants. Alexandria Journal for Veterinary Sciences 56: 3-6.