Continental Vet J, 2024, 4(1): 62-75

Continental Veterinary Journal
Journal homepage: www.cvetj.com

Review Article

Phytomedicine efficacy and prospects in poultry; a new insight to old anthelmintic resistance

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ARTICLE INFO

ARTICLE HISTORY: CVJ-24-0104

Received 10 January 2024
Revised 15 April 2024
Accepted 05 May 2024
Published online 30 June 2023

Keywords:
Resistance
Phytomedicine
Poultry
Herbal plants

ABSTRACT

With the advancing population, poultry has attained a valuable food and economic position. It has become a necessary business, from scavenging backyard poultry to the $7.87 billion net worth of JBS poultry. Any kind of minor disturbance may cause a high strain on poultry production and parasitic infections are impacting the poultry industry in terms of production and management. As directly concerned with the gastrointestinal tract, parasitic infections hamper the feed conversion ratio, which is the base of poultry farming. Drugs used to treat these parasitic infections are losing their sensitivity because of various factors, including unchecked and repetitive use. Veterinary ethnopharmacology is adapting towards the use of botanicals, essential oils, and natural remedies to treat these parasitic infections. Recent studies have proved the efficacy of these products. This review aims to provide a brief comparison of these herbal products with anthelmintics, their efficacy, and their future in ethnopharmacology.

To Cite This Article: Rashid S, F Hafeez, R Ashraf, A Shoukat, A Nawaz and K Hassan, 2024. Phytomedicine efficacy and prospects in poultry; a new insight to old anthelmintic resistance. Continental Vet J, 4(1):62-75.

Introduction

Food animals have always been a source of greater attention, as they are concerned with public health, consumer demand, and the metabolic kinetics of consumers. With the elevating population, an increase in demand for food is natural. To meet this increasing food demand, there has been an increase in the animal population especially in tropic and sub-tropic areas (Osti et al. 2017). Poultry has been used as a source of food since the evolution of humankind, as it is an at-hand source of protein available (Khan 2018). To fulfill the required poultry production, especially broiler production is expected to meet the critical storage of animal protein need (Hatab et al., 2019; Kpomasse et al. 2021).

Poultry is the second largest industry in Pakistan and 11th largest industry in the world (Rehan et al. 2019). According to FAO statistics (2012-2022), poultry egg and meat demand is the highest among all the meat types (Desier et al. 2018). Various production systems have been introduced in poultry, i.e. cage system systems, free range, backyard poultry, etc. (Karcher and Mench, 2018). In all these systems, the process of disinfection, medication, vaccination, environmental control, manpower involvement, the progress of the disease, worm infestation, and all these factors are variable. The course of the disease is quite low in production systems, where an all-in-all-out system is applied (Zhou et al. 2020) and the feeding is controlled. When dealing with poultry, worm infestation is a major issue causing economic, commercial, and health losses. This worm infestation is observed highly in organic poultry and backyard poultry. It is because of their higher exposure to the environment. Economically, parasitic infections are of high importance (Blake et al. 2020). Moreover, the chances of parasitic infections in deep litter poultry systems and other production systems have also been reported (Singh et al. 2021). As parasites directly interact with the gastrointestinal tract of poultry, serious impacts are posed on the feed conversion ratio (FCR) and performance, which in turn impacts the economics of poultry farming (Ahmad et al. 2022). Effects on Feed conversion ratio (FCR) and performance mean production losses and production losses refer to less egg production in layers and poor weight gain in broilers. The probability of helminth infection varies from system to system (Sharma et al. 2019). However, the occurrence of parasitic infection is quite high in organic poultry and free-range systems (McMullin 2022). Because of free access to the environment and open fields, this type of poultry is more likely to have worm infestation. According to some reports, Even the eggs of *Taenia solium* have also been reported in the eggs of organic poultry (Dixon et al. 2020). The probability of *Ascardia galli* is the highest in backyard poultry and free-range systems (Tomza-Marciniak et al. 2014). Anthelmintic drugs are widely used and prepared in veterinary medicine because of this huge concern for parasitic infection (Castagna et al. 2021). But their consequences have also become a source of interest. Poultry parasites have become resistant to these anthelmintic drugs. This means parasites do not show any sensitivity or response to these drugs when used (Sharma et al. 2019). Many factors are involved in the development of anthelmintic drug resistance. The genes of nematodes can change, with less or incorrect concentration of drug dose, specific causes, experimental use of drugs, efficacy of drug, etc. Some studies have also revealed the toxic impacts of anthelmintics as their residues were found in poultry (Zirintunda et al. 2022). All these things demand an alternative to be used efficiently as anthelmintic. Ethnoveterinary practices have always been there in our field. Essential oils and medicinal plants are used as anthelmintics (Ramdani et al. 2023). Plants have strong antioxidant impacts that not only trigger the life status of animals but also have astringent properties (Quideau et al. 2011). Plants have secondary metabolites like polyphenols, tannins, and alkaloids that exhibit medicinal properties of plants. Many plants have been successfully used as anthelmintic without even knowing the specific metabolite or active ingredient responsible for their anthelmintic action (Oliveira et al. 2021). This review aims to review the anthelmintic activity of plants used as anthelmintic, their mode of action, pros and cons, and efficacy against parasites.

Helminthes infections in poultry

While raising poultry, external or internal parasites pose serious impacts on the quality as well as quantity of production (Gržinić et al. 2023). Internal parasites of helminths predilection sites are mostly in the gastrointestinal tract (Jilo et al. 2022). While raising poultry, production cost and FCR are two major points to be considered for successful and efficient production (Muhammad et al. 2023). Major economic losses are caused by *Ascardia galli, Heterakis gallinarum,* and *Eimeria* species of parasites. The most important infection of poultry is coccidiosis which is caused by *Eimeria* species having a mortality rate of 50%. Moreover, coccidiosis also promotes certain other infections and provides an environment for *Clostridium perferingens* (Abd El-Hack et al. 2022). Blackhead, a disease of the lower digestive tract is also caused by *Histomonas meleagridis*. Acaridiasis is caused by *Ascardia galli* which is a nematode. It is also a disease of high economic importance. It impacts egg production loss and reduced growth rate as in the presence of *Ascardia galli* in the intestine, nutrient absorbance is at its lowest (Abon 2021). Some important helminths of poultry are mentioned in Table 1.

Commonly used anthelmintics in poultry

While considering the mortality rates and economic losses, certain types of anthelmintic are used (Kadykalo et al. 2018). The efficacy of these anthelmintics has been analyzed *in vitro* and *in vivo*, by induced infections or natural infections (Bazh and El-Bahy 2013). The infective stages, time of anthelmintic administration, and dosage were checked against commonly present helminths (Williams et al. 2014).

The parameters for determining the potential of anthelmintics are necropsy findings, fecal and cecal egg count, worm burden, and number of larvae (Nielsen et al. 2022). The compounds for helminthiasis approved by the USA are given in Table 2.

Mechanism of action of anthelmintic

The activity of anthelmintic depends upon the specific anthelmintic used. The mode of action varies from compound to compound. The major site of target in anthelminthic is the cellular integrity and neuromuscular degeneration of the parasite (Holden-Dye and Walker 2014). Whereas the specific site of action may vary. The process by which cellular integrity is affected is explained in Fig. 1.

Macrocyclic lactones: These drugs work by binding the glutamate-gated chloride channels present in the nerve cells (Wolstenholme et al. 2016). This binding causes the channel to allow an agonistic activity towards worm muscle receptors i.e. L-subtype nicotinic acetylcholine receptors (Weeks et al. 2018).

Monepantel: It is the amino-acetonitrile derivative, it is the agonist of mptl-1 channel of the DEG-3 family of acetylcholine receptors (Baur et al. 2015). These receptors are present in nematodes only and lead to muscle depolarization and irreversible paralysis.

Derquantel: It is like piperazine causes flaccid paralysis in nematodes. But in the case of derquantel, it happens by inhibiting 45-pS channels (Tuck et al. 2016).

Piperazine: Another anthelmintic that works by hyperpolarizing the nerve membranes, thus breaking neuromuscular links and causing flaccid paralysis (Puttachary 2012)

Table 1: Common helminths of poultry, site of predilection, mortality rate and prepotency period

Parasite	Life Cycle	Predilection Site	Pathogenicity	Mortality Rate (%)	Prepatency period (Days)
Nematodes					
Amidostomum anseri	Direct	Gizzard	Severe	Up to 100	14-25 days
Ascaridia galli	Direct	Small intestine	Moderate	40	45 days
Eucoleus annulata	Earthworm	Esophagus, crop	Moderate to severe	>10	3-4 weeks
Eucoleus contortus	None or earthworm	Mouth, esophagus, crop	Severe	31	3-4 weeks
Baruscapillaria obsignata	Direct	Small intestine, ceca	Severe	30-35	19-22 days
Cyrnea colini	Cockroach	Proventriculus	mild	<1	5-6 weeks
Heterakis gallinarum	Direct	Ceca	Mild, but transmit histomoniasis	10	7-12 days
Heterakis isolonche	Direct	Ceca	Severe	50	24-30 days
Strongyloides avium	Direct	Ceca	Moderate	60	10 days
Trichostrongylus tenuis	Direct	Ceca	Severe	44	5-10 days
Cestodes					
Choanotaenia infundibulum	House flies	Upper intestine	Moderate	40.67	2-4 weeks
Raillietina cesticillus	Beetles	Duodenum, jejunum	Mild	52.6	28 days
Raillietina tetragona	Ants	Lower intestine	Severe	45	13 days
Davainea proglottina	Snails	Duodenum	Severe	37	2-3 weeks
Trematodes					
Postharmostomum commutatum	Unknown	Caecum	Moderate to severe	10	14 days
Zygocotyl lunata	Snails	Caecum	Severe	20	60 days
Hypoderaeum conideum	Snails, fishes	Posterior small intestine	Mild	30	3 weeks

a great influx of chloride ions. These chloride ions accumulate at different sites with different sensitivities. As a result, the effect of macrocyclic compounds varies. The pharynx is paralyzed, so the mobility of the digestive tract is lost. And even if the paralysis recovers due to lower sensitivity of chloride ions, the feeding intake not regained due to pharynx paralysis that contributes to helminths death.

Emodepside: These drugs act by the stimulation of latrophilin-like receptors, which are present at the neuromuscular junction synapse (Holden-Dye et al. 2012). These receptors transduce signals to Gqproteins and phospholipase C, due to which internal calcium and diacylglycerol levels are increased and calcium-activated potassium channel slo-1 is targeted. Binding to the latrophilin receptor and the slo-1 ion channel leads to inhibition of pharyngeal pumping, paralysis and death.

Development of Resistance

Resistance against anthelminthic can be described in the terms that helminths lose sensitivity to a specific chemical used against it (Fissiha and Kinde 2021). Resistance is one of the most common issues faced while dealing with the helminths in poultry. Resistance develops due to various causes. It is due to incorrect dosage and administration (Kaye and Pogue 2015). Most of the helminths are shed in feces of poultry. In backyard poultry, it is a common practice for poultry to peck other feces. This repeated exposure to helminths and anthelminthic causes the resistance to develop (Shalaby 2013). Low potent drugs, and incorrect knowledge of the specific helminths is also contributing towards resistance. certain helminths are resistant to certain anthelminthics, e.g. fenbendazole is resistant against *Ascaridia dissimilis,* and *Heterakis gallinarum, Histomonas meleagridis* (Patel et al. 2018). Another important contributing factor is the unavailability of any diagnostic test or instruments for checking resistant. Sometimes resistance develops because of mutations in bgenes(Raza genes (Raza et al. 2016). Moreover, as with macrolide compounds, the sensitivity of chlorine receptors varies, and the concentration of chlorine ion influx causes varying concentrations at various sites. This unknown accumulation may also lead to resistance.

Phytomedicine

The use of plants and plant products in medicine for the treatment of various infections either parasitic, bacterial, or viral is phytomedicine. It is one of the most explored research areas nowadays because of its high efficacy, proficiency, and availability. Herbal products are believed to cause very little harmful effects on the health of animals. The residues of botanicals in the meat and other products of food animals are very uncommon. Botanicals are now being used in various diseases widely, including parasitic diseases. Many of the parasites of poultry have become resistant to previously used anthelmintics because of multiple unattended causes. Concerning the economic importance of poultry, efforts are quite noticeable in dealing with the anthelminthic resistance (Wolstenholme 2011). As anthelminthic resistance can pose serious impacts on commercial meat production and meat quality. Several medicinal plants have been tested against resistant helminths infections *in vitro* and *in vivo* (Romero-Benavides et al. 2017). Beyond less cost, medicinal plants are more effective, highly potent, have no toxicity, and have fewer residues in meat. This may pose long term effects on the economy of poultry farmers specifically in developing countries (Conan et al. 2012).

Phytomedicine and Helminthiasis

Anthelminths have characteristics like cost effectiveness, single-dose cure and spectrum broad-spectrum activity (Panic et al. 2014). Botanicals used in helminthiasis have active ingredients such as Polyphenols, saponins, tannins, alkaloids, isoquinoline, maloinic acid, Proanthocyanidin, gallic acid, ellagic acid, flavonoids (Jamil et al. 2022). These compounds have their specific mode of action against specific anthelminticsa. Mostly ant anthelmintics work by disrupting the neuromuscular activity of larvae, as anthelmintic resistance passes in genes so disrupting the worm infestation at a very early stage is required to overcome helminthiasis (Shalaby 2013).

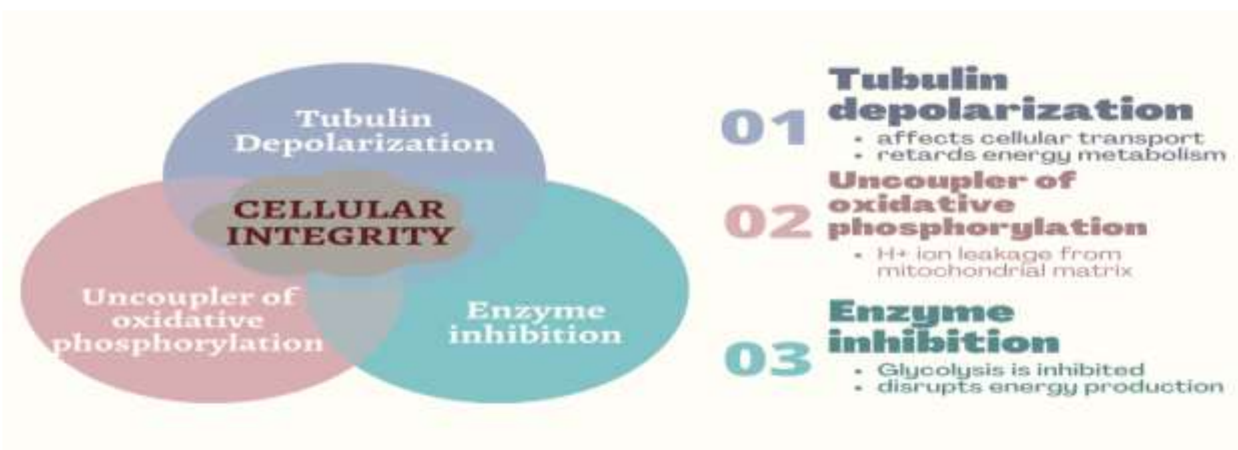

Fig. 1: Mode of action of anthelmintics in cellular integrity impairment

Saponins-based herbal anthelminthics

Saponins include steroids, ginsenosides, allium saponins, triterpenoids, and glycoalkaloid saponins (Soetan et al. 2014). There are 11 classes of saponins usually present on plants. Plant saponins which are used as anthelminthes are found in Aloeceae, Amaranthaceae, Zygophyllaceae, Rosaceae, Fabaceae, Apiaceae, and Verbenaceae (Oakenfull and Sidhu 2023.) Saponins are used in fingal, parasitic, and bacterial infections. Saponins that have anthelmintic properties listed in Table 3 work by disrupting the mitochondrial action resulting in low cellular energy (Faixová et al. 2021), and inability to move, which causes the death of helminths (Fig. 2). Some saponins work by increasing the permeability of the helminth cell membrane (Singla and Kaur 2021), allowing the passage of certain undesirable compounds which cause helminth to die (Fig. 2).

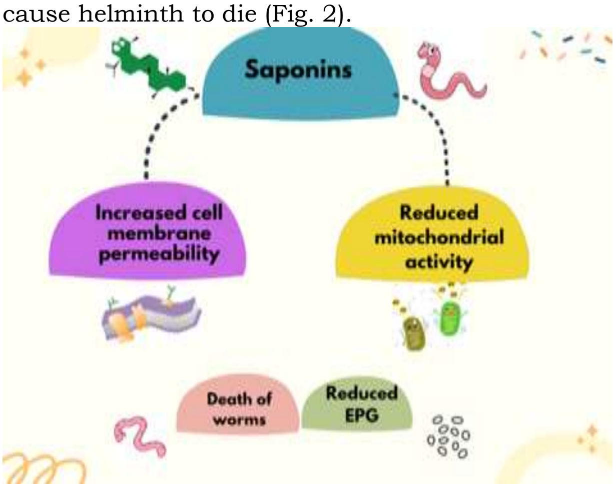

Fig. 2: Mechanism of action of saponins based saponins

Terpenoids

Terpenoids include monoterpenes, diterpenes, triterpenes, sesterpenes and sesquterpenes (Perveen 2021). It is made up of repeating units of carbon. The major source of terpenes is from the leaves of eucalyptus tree. Digoxin, lupeol, ursolic acid, oleanolic, atrastyloside cicutoxin, atractyloside, and betulinic acid, are the different types of terpenoids (Surbhi et al. 2023). All these types interfere with helminths infestation in different ways, by muscle contraction (varsha et al. 2017), increasing calcium ion absorption, blocks oxidative phosphorylation (Mbaveng et al. 2014), decreasing antioxidant enzymes, inhibiting ATP synthesis (Baliga et al. 2019), increasing cytochrome C by mitochondria (Dev et al. 2017) and lowering glucose levels of helminths (Fig. 3). The most common terpenoids listed in table 4 used for their anthelminthic properties are those from camphor and methanol (Mukherjee et al. 2016). Terpenoids interfere with the neurotransmission, leading to paralysis of helminth and ultimate death (Mukherjee et al. 2016). Terpenes are known to be effective against albendazole-resistant helminths (Mirza et al. 2020).

Flavonoids-based anthelminthics

Flavonoids are polyphenolic compounds that have enzymatic activity such as phosphodiesterase and Ca2+ ATPase (Al-sanafi 2020). Flavonoids are known for their synergistic action with botanical anthelmintics such as tannins and other anthelmintics like praziquantel (lateef et al. 2013). Flavonoids are known for their anticancer, inflammatory, and antioxidant effects (Liu et al. 2020). Flavonoids are known for reducing the EPG, juvenile and adult worms' survival rate.

Tannins and alkaloids-based anthelmintics

Tannins are polyphenols with many medicinal properties (sahakyan et al. 2020). Tannins also work as anthelmintics and paralyze the worm's causing death. Condensed tannins are usually known as anthelmintics. They need to be administered with care as they are antinutritional. Tannins are environmentally stable and degrade at very high temperatures (Jindal and Nikhanj 2023). Alkaloids are used as cardio protectors, anesthetics, and anti-inflammatory agents. Alkaloids are the neurotoxin anthelmintics, mostly work by breaking the cell walls, protein, and lipid content of worms (Molan 2014). Usually, the most common alkaloid anthelminthic is steroidal glycoside solamargine from plants. Glucosinolates interact with the DNA integrity of cells, acacia oxyphylla cause flaccid paralysis (Ade-Ademilua and okpoma 2018).

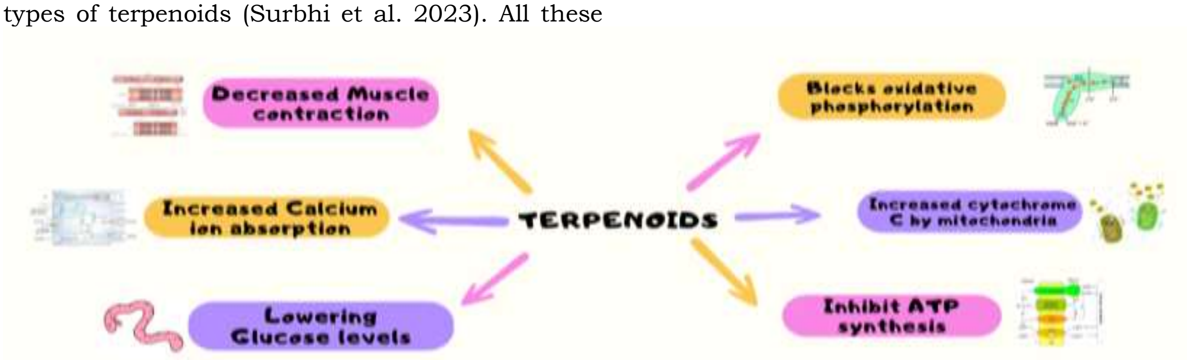

Fig. 3: Possible mechanisms of actions of terpenoids on helminths

Efficacy of botanical anthelminthic

Demand for anthelmintic alternatives is increasing rapidly due to certain causes like resistance, high-cost products, and less availability (Sepulveda-Crespo et al. 2020). At least studies have been conducted on the pharmacokinetics and pharmacodynamics of plants. Their efficacy can only be measured by conducting studies on the pharmacological impact of these plants. But their availability, less cost, need for alternative is making them highly susceptible in developing countries, specifically Asian countries (Nelson et al. 2019). The efficacy of anthelmintic drugs and their chemotherapy has always been a problem, due to several species, genetic variation in helminths species, developing resistance, toxic effects, and residues in meat and eggs. So, the need for alternatives that can cover all these impacts is quite important. Unfortunately, phytomedicines have given much less importance in research, as compared to their need

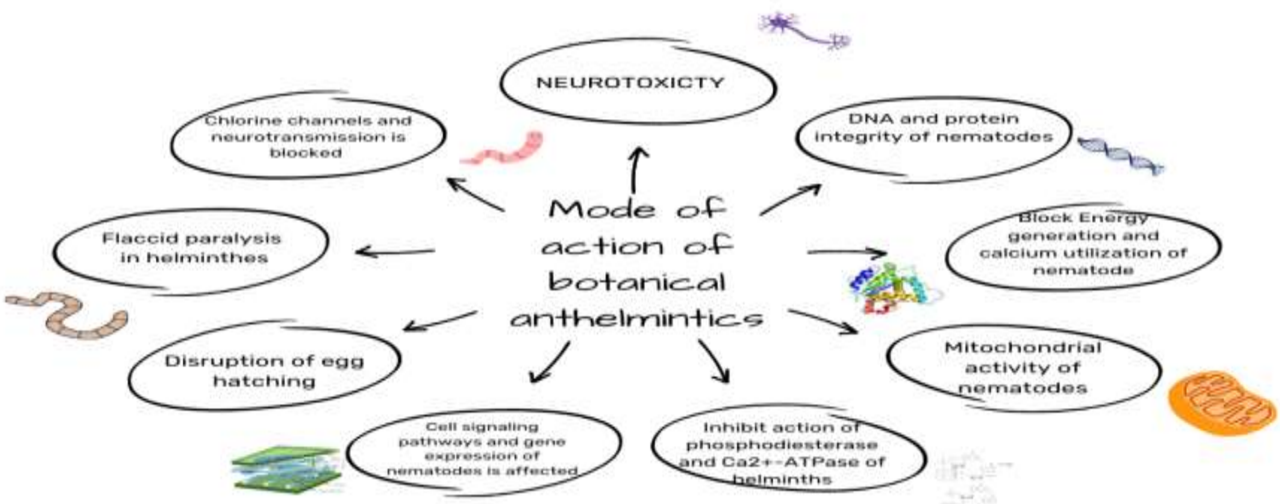

Fig. 4: Mechanisms of actions of commonly used anthelmintic drugs

Future prospectives

If proper pharmacological research is carried out on the impact of botanicals use as anthelmintic. In the upcoming years botanicals will completely replace anthelmintic drugs. Using these nonresistant anthelmintics can save the economic losses occurring from nematode infections yearly. Coccidiosis was able to cause 3 billion US dollar losses every year. Similarly, ascardiasis in poultry causes 10-40%loss in egg production. These all can be efficiently controlled by using botanicals. Moreover, residues in the meat or poultry after using anthelmintic drugs are also a major loss in broilers. Being considering poultry as a huge industry, its economics is taken seriously and that is improved by using quality nonresistant botanical anthelmintic.

Funding

No funds were provided by any national or international funding agencies.

Ethical statement

No Ethical permissions were required for this article.

Availability of data and material

The data can be obtained from the corresponding author on a reasonable request.

Acknowledgement

We acknowledge the technical support of the Department of Zoology, The Islamia University, Bahawalpur, for publication of this article.

Consent to participate

All the authors gave their consent for equal participation.

Consent for publication

All the authors gave their consent for publication.

Competing Interest

The authors declare that they have no relevant financial or non-financial interests to disclose.

Author Contribution

MR, AA, and BES wrote the manuscript NA, YM, and GM managed references, tables, and figure, TS and MF revised the article.

Table 4: Terpenoids used as anthelmintics in plants, their composition, MOA and Method of extraction

Medicinal plant	**Common name**	**Part of plant used**	**Active compound**	**MOA**	**Composition**	**Method of preparation**	**References**
Artemisia afra	African wormwood	Leaves	Flavonids	Block the neuromuscular transmission in a parasite by depolarizing nerve impulse conduction	Terpenoids, essential oils, coumarins, caffeoylquinic acid	Hexane extraction	(Symeonidou et al. 2018)
Dryopteris filix-mas Schott	Male fern	Leaves, stems	Quercetin	Multi target mechanism.	Terpenoids	Maceration with aqueous ethanol.	(Ramlal et al. 2023)
Momordica corantia L	Bitter melon	Fruit	Charantin, vicine.	Slow down the process of gluconeogenesis (Ramlal at al. 2023).	Sterols, terpenoids.	Filtration and evaporation in reduced pressure.	(Liu et al. 2020)
Menthe longifloia	Wild mint	Leaves	Pulegone	Inhibit the NF-kB signaling pathway	Menthol, cineole, menthone	Hydro distillation technique using Soxhlet apparatus.	(Lateef et al. 2023)
Curcuma longa	Turmeric rhizome	Rhizome extract	Curcumin	Interfere with Nf-kB (Ramlal et al. 2023)	Curcumin, demethoxycurcmin, bisdemethoxycurcumin	Hexane based extraction, hydro distillation.	(Manjusa and Pradeep 2022)
Cucurbita moschanta duchesne	Pumpkin	Seeds	Cucurbitin	Disrupt the neurotransmission and disruption of helminths egg	Carbohydrates, proteins, lipids, fiber	Organic solvent assisted extraction	(Lateef et al. 2013)

Table 2. Commonly used anthelmintic in poultry, target specie, mode of action, and percentage efficacy

Anthelminthic	**Commonly infected species**	**Dosage**	**Withdrawal Time**	**Percentage efficacy (%)**	**Mechanism of Action**
Piperazine compounds	*Ascaridia* spp.	Chickens: Single dose, 50 mg/bird (< 6 weeks old), 100 mg/bird (≥6 weeks old), in the feed at 0.2%–0.4% or in the drinking water at 0.1%–0.2% Turkeys: Single dose 100 mg/bird (< 12 weeks old) or 200 mg/bird (≥12 weeks old) Because only the piperazine moiety is efficacious, doses should be calculated based on mg of active piperazine/bird. Treatment can be repeated after 14 days.	14 days (meat); not approved in the USA for birds producing eggs for human consumption.	99-10	It binds with gamma butyric acid receptor subunit beta-3 which causes hyperpolarization of nerve endings and paralyzes the worm by this live worm s excluded from the body.
Fenbendazole	*Ascaridia* spp, *Heterakis gallinarum*	Growing turkeys: 14.5 g/ton of feed (16 ppm), fed continually as the sole ration for 6 days.	None for turkeys Not approved for other poultry.	More than 80	It binds with the tubulin protein of parasites thus inhibit the production of microtubules and poses negative impact on the transport system of parasite.
Hygromycin B	*Ascaridia* spp, *Heterakis gallinarum*, *Capillaria* spp.	8–12 g/ton in feed	3 days for meat	0-100	Inhibit Protein synthesis, growth rate, affect 30S ribosomes
Coumaphos	*Capillaria* spp.	Replacement pullets: 0.004% in feed for 10–14 days Layers: 0.003% in feed for 14. In birds maintained on contaminated litter or exposed to infected birds, the medication regimen should be repeated using the same dosages as the first. There should be at least 3 weeks between the first and second course of treatment.	Unknown	88.6	Immobilize nervous system of parasite
Thiabendazole	*Syngamus trachea*	Pheasants: 0.05% in feed for 14 days	21 days for meat	0-9	Inhibit the helminth specific enzyme fumarate reductase flavoprotein subunit

Table 3: Saponins used as anthelminthic in plants, their composition, MOA and Method of extraction

Medicinal plant	Common name	Part of the plant used	Active compound	MOA	Composition	Method of preparation	References
Cyamopsis tetragonoloba Taub	Guar bean	Flowers oil	Saponins	Saponins lyse the oocyst of helminths.	Ethyl acetate and methanolic acid	Grinding of endosperm portion	(Abo-EL-Sooud 2018)
Helichrysum splendidum less	Mulberry pines	Leaves, flowers	saponins	Inhibit the gene expression of NO (Lateef et al. 2013)	Phellandrene, cadinene, germacerene, cineole.	Microwave extraction technique	(Veerakumari 2015)
Sena occidentalis	Coffee sienna	Leaves	Saponosides	Hyperpolarizing of the nerve membrane, which leads to flaccid paralysis in helminths (Symeonidou et al. 2018)	Galactomannan, polysaccharides, glycosides	Ethanol-based leaf extraction	(Saeed and Alkheraije 2023)
Tehrosia Vogelli Hook.f	Fish poison bean	Leaves, stems	Deguelin	Inhibit larval development and motility.	saponins, alkaloids, phenols.	Hexane and ethanol-based extraction.	(Veerakumari 2015)
Momordica corantia L	Bitter melon	Fruit	Charantin, vicine.	Slow down the process of gluconeogenesis ((Ramlal et al. 2023).	Sterols, terpenoids, saponins	Filtration and evaporation in reduced pressure.	(Liu et al. 2020)
Morinda lucida	Brimstone tree	Leaf and bark extract	Alkaloids	Reduce nitric oxide and E-2 levels	Saponins, polyphenols, reducing sugars,	Methanol based maceration	(Saeed and Alkheraije 2023)
Echinacea purpurea Moench	Coneflower	Root, leaves and flowers	Chloric Acid	Activate phagocytosis andincreased respiratory activity	Polysaccharides, lipoproteins, saponins, betaine	Supercritical carbon dioxide extraction	(Abo-EL-Sooud 2018)
Carica papaya L	Paw paw	Seeds	alkaloids, saponins	Activation of caspase-3/7 pathway, increase peripheral glucose, NF-kB attenuation	BITC, carbohydrates, proteins, proteolytic enzymes	Boiling and shaking	(Lateef et al. 2013)

Table 5: Flavonoids used as anthelminthic in plants, their composition, MOA, and Method of extraction

Medicinal plant	**Common name**	**Part of plant used**	**Active compound**	**MOA**	**Composition**	**Method of preparation**	**References**
S. flavescens	Shrubby sophora	Root extract	Sophorae Radix	Induce apoptosis and autophagy by MCF-7 cells (Kostadinovi, et al. 2015)	Alkaloids and flavonoids	Ethanol purification followed by ion exchanger resin absorption	(Veerakumari 2015)
Allium staivum	garlic	cloves	Organosulfur compounds	Modulate the expression of Nf-kB transcription factors	Flavonoids, alliin, ajoenes, allicin	Boiling with ethanol extracts	(Liu et al. 2020)
Moringa oleifera	Drumstick tree	Seed extract	Flavanol Rutin	Inhibit the formation and mobility of larvae.	Carbohydrate, protein, fat, fiber	Superficial extraction with CO2 and ethanol.	(Lateef et al. 2013)
Punica Granatum L.	Pomegranate	peels	Ellagic acid	Disrupt the neurotransmission leading to paralysis of larvae	Anthocyanins, flavonoids, fructose, sucrose, organic sugars	High pressure nonpolar extraction	(Manjusa and Pradeep 2022)
Flemingia vestita L	Sohphlang	Root tuber	Genistein	Alters the glycolytic enzymes of cestodes (Jamil et al. 2022)	*Genistein, pseudobaptigenin, daidzein.*	Ethanol extraction	(Liu et al. 2020)
Vitis vinifera	Grape seed	Fruit	Proanthocyanidin	Act on the IL-8 promoter activity	Tannins, proteins, cellulose, lignin, hemicellulose	Maceration and elevated temperature extraction	(Liu et al. 2020)
Camellia sinensis kuntze	Green tea	leaves	polyphenols	Inhibition of intracellular enzymes, cell wall and cell membrane disruption	Tannin, Epigallocatechin-2, Gallate.	Ethanol extract	Bora and Bora (2021)

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