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# Efficacy of Botanicals against *Toxoplasma gondii* in Felines: Prevention Strategies for Zoonotic Animal Diseases

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**ABSTRACT**

*Toxoplasma gondii* is a parasitic protozoan of significant veterinary and general human health significance that is obligatory and intracellular in nature, with felines as definitive hosts that cause environmental contamination of oocysts. In cats, conventional treatment methods are constrained by the inability to achieve parasite clearance, toxicity, and failure to inhibit the shedding of oocysts. The growing antimicrobial resistance and fear of drug residues have necessitated the need to look into plant-derived compounds as an alternative or complementary measure. The antiparasitic, immunomodulatory, and antioxidant effects of botanicals containing bioactive phytochemicals (polyphenols, flavonoids, saponins, tannins, and terpenoids) have the potential to interfere with parasite replication and transmission. This review critically assesses the pathogenesis, epidemiology, and current control interventions of toxoplasmosis in felines, in addition to identifying the possibility of botanical compounds as sustainable interventions. Combining phytotherapeutics and current management can improve the health of cats and minimize the risk of zoonosis, contributing to One Health management of toxoplasmosis.

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## INTRODUCTION

*Toxoplasma gondii* is a protozoan parasite that is able to infect virtually any warm-blooded animal including human beings and is distributed all over the world (Adem and Ame 2023). The parasite is apicomplexan belonging to the phylum and has intricate life cycle encompassing sexual and asexual phases (Delgado et al. 2022; Farhab et al. 2025). A key role in the sexual life cycle is played by felids, especially domestic cats, which are definite hosts in which sexual reproduction takes place in the intestinal epithelium to produce environmentally resistant oocysts (Dixit et al. 2024). These oocysts infect soil, water and food and are effective in the transmission of infection to intermediate hosts, which include livestock, wildlife and human beings (Javed and Alkheraije 2023). Toxoplasmosis is more than a veterinary issue, as it is a potential zoonotic infection (Pal and Tolawak 2023). Transmission to humans normally happens by consuming under cooked meat with tissue cysts or by coming in contact with oocyst-contaminated environments (Hasan et al. 2024). This is especially susceptible to immunocompromised patients and pregnant women, where the risks are encephalitis, congenital defects and fetal loss (Jash and Sharma 2022). It follows that the infection in felines should be controlled to minimize environmental contamination and subsequent exposure to humans. In cats, infection can be subclinical, but clinical toxoplasmosis can be seen, particularly in young or immunocompromised cats (Farhab et al. 2025). Clinical presentation may involve respiratory distress, neurological, eye lesions, and systemic disease (Taha et al. 2022). Although the role of felines in the life cycle of the parasite

is essential, there are few effective methods of controlling oocyst shedding (Zhu et al. 2022). Traditional pharmacological therapy using clindamycin and pyrimethamine is aimed at eliminating the tachyzoite stage but with limited effect on tissue cysts and not always preventing shedding (Abaza 2025).

Recent developments in parasitology and pharmacognosy have shown that plant-derived compounds have the potential to be used as alternative or complementary therapies (Jamil et al. 2022). Broad-spectrum antimicrobial activities have been documented in botanicals used in traditional medicine systems in the past (Abdallah et al. 2023). Such compounds tend to have more than one mechanism of action, such as interference with parasite membranes, replication, host immune response, and oxidative stress (Pawłowska et al. 2023). The increasing popularity of botanical interventions can be attributed to several factors. To begin with, a safer and more environmentally friendly therapeutic option with reduced side effects compared to synthetic drugs is needed (Chaachouay and Zidane 2024). Drug resistance in protozoan parasites has necessitated the exploration of new compounds with different modes of action (Tarannum et al. 2023). Plant-based compounds tend to be more affordable and available, especially in low-resource environments (Viroli et al. 2023).

Phytochemicals (polyphenols, flavonoids, saponins, tannins, and terpenoids) have shown excellent antiparasitic effects in laboratory experiments (Ranasinghe et al. 2023; Abbas et al. 2025). These chemicals have the potential to disrupt key biological functions of *T. gondii*, such as invasion, replication, and survival within host cells. Additionally, most botanicals have immunomodulatory effects that optimize the host response to infection (Marques-Santos et al. 2024). The development of botanical-based therapies for the management of toxoplasmosis represents the One Health concept, which is based on the interdependence of human, animal, and environmental health (Yates et al. 2022). Botanical interventions can minimize the shedding of oocysts in cats, thereby reducing environmental contamination and the risk of infection in cats and other animals (Štrbac et al. 2023).

This review aims to briefly discuss the effectiveness and mechanisms of action of botanical compounds in the treatment of *T. gondii* in cats. This review discusses the epidemiology and public health implications of the parasite, its pathogenesis in cats, the limitations of conventional treatments, and the promise of plant-derived compounds as alternative measures to control the parasite. This article summarizes the existing scientific information and outlines how botanicals can be used to enhance the health of cats and reduce the risk of zoonotic diseases caused by T. gondii.

## Pathogenesis of *T. gondii* in Felines

*Toxoplasma gondii* in cats develops both asexually and sexually, unlike other hosts, making cats unique in the life cycle of the parasite (Warschkau and Seeber 2023). The disease is mainly transmitted by the ingestion of tissue cysts in infected prey or raw meat (Gabriël et al. 2022). After ingestion, bradyzoites are released in the intestine and enter epithelial cells where they reproduce sexually (Wiser 2024). The result of this process is the production of oocysts which are released in feces (Zhao et al. 2024). The duration of prepatent in cats is three to ten days, depending on the stage of the ingested parasite (Pal and Tolawak 2023). The rapid multiplication of intestine cells takes place during this period resulting in the generation of millions of oocysts (Ahmed 2023). These oocysts are shed and then sporulate in the environment making them very infectious (Davenport et al. 2024). Notably, cats tend to shed oocysts once in their lifetime, but reinfection and reshedding may take place under some circumstances (Zhu et al. 2022).

In addition to the intestinal stage, tachyzoites spread to the rest of the body via the bloodstream and lymphatic systems (Ghazy et al. 2025). These rapidly multiplying shapes infect different tissues, including the lungs, liver, central nervous system, and eyes (Rani et al. 2024). The host immune system ultimately causes the parasite to enter a latent phase, where it develops into bradyzoites, which have tissue cysts mainly in the muscle and neural tissues (Jamil Al-Obaidi and Desa 2024). Cats can develop clinical disease, although it is uncommon and typically occurs in cases with inadequate immune responses (Hofmann-Lehmann et al. 2022). Pathological alterations include necrosis and inflammation of the affected organs (Gusev and Zhuravleva 2022). Pulmonary toxoplasmosis can cause dyspnea and interstitial pneumonia, and neurological dysfunction may manifest as ataxia, seizures, and behavioral changes. They also often have ocular lesions, such as uveitis (Akins et al. 2024).

The immune response in felines includes both adaptive and innate aspects (Faenza and Blalock 2022). Cell-mediated immunity, that is, the participation of T lymphocytes and interferon gamma, is important in the regulation of the replication of the parasites (Lekki-Jóźwiak and Bąska 2023). Nevertheless, *T. gondii* has developed the ability to avoid immune surveillance and survive in host cells, leading to chronic infection (Khan and Moretto 2022). It is critical to understand the pathogenesis in felines and develop specific interventions to decrease oocyst shedding and control systemic infections (Zhu et al. 2022).

## Epidemiology and Public Health Significance

*Toxoplasma gondii* is among the most prevalent zoonotic parasites, and there is a great variation in seroprevalence according to location based on environmental, climatic, and socioeconomic conditions (Ahaduzzaman and Hasan 2022). Domestic and wild felines are the major sources of environmental contamination through oocyst shedding (Zhu et al. 2023). One infected cat can produce millions of oocysts, which can survive in soil and water for a long period (Pal and Tolawak 2023). It is transmitted to humans primarily by ingesting contaminated water and food, eating undercooked meat, or accidentally ingesting oocysts in the environment (Shaltout 2024). Occupational exposure of veterinarians, farmers, and persons dealing with soil or cat litter (Crawford et al. 2025). Mother-to-fetus transmission is a serious area of concern, and in most cases, there are serious congenital abnormalities (Megli and Coyne 2022). In livestock, infection leads to economic losses through abortion, stillbirth, and low productivity (Bose and Siva Kumar 2025). Toxoplasmosis is a significant problem in animal husbandry, especially in sheep and goats (Holec-Gąsior and Sołowińska 2023). Transmission among farm

animals is enhanced by the contamination of pastures and feed with feline fecal oocysts (Celi et al. 2022).

Humidity and temperature are environmental factors and affect the survival and spread of oocysts (Wang et al. 2023). Warm and wet climates are more likely to be prevalent in regions (McKay et al. 2024). The problem of urbanization and growing numbers of stray cats adds to the pollution of the environment (Candela et al. 2022). The hygiene, good preparation of meat and control of cats are stressed in the public health strategies (Vecchiato et al. 2022). But the process of oocyst shedding in cats is very important but difficult to control as an important part of prevention (Helmy and Hafez 2022). Epidemiology patterns need to be understood better to come up with integrated measures to control the health of animals and humans (Singh et al. 2024).

**Conventional Therapies and their Limitations**

The antimicrobial agents most commonly used in the treatment of toxoplasmosis in felines include clindamycin, pyrimethamine, and sulfonamides (Reinhart and Prescott 2024). Clindamycin is a popular choice because of its efficacy in treating tachyzoites and its relatively favorable safety profile (Armengol Alvarez et al. 2022). Pyrimethamine and sulfonamides work together by blocking folic acid production in the parasite, thus replicating it (Kumar and Mahato 2024). Although effective, these drugs have several limitations (Akombaetwa et al. 2023). Their failure to destroy tissue cysts is one of the greatest disadvantages, leaving them with latent infections (Yuan et al. 2023). Therefore, the treated animals can still be carriers of the parasite and can be a source of infection (Khan and Witola 2023). Moreover, these drugs fail to reliably prevent oocyst shedding, which is the main cause of environmental contamination to the environment (Ali et al. 2024).

Another consideration is adverse effects; pyrimethamine may suppress the bone marrow; hence, close follow-ups and folinic acid are important (Gomes Ferrari Strang et al. 2023). GIT upsets are frequent with clindamycin, which may compromise compliance in cats. The length of treatment is another complication (Guo et al. 2025). Resistance to drugs is not well reported in *T. gondii*, but it may pose a risk, especially when traditional treatment is widely and sustainably used (Arrighi et al. 2023). In addition, these drugs may not be available in resource-strained environments (Santomartino et al. 2023).

Another weakness is the lack of effective cat vaccines (Egberink et al. 2022). Experimental vaccines have potential, but none of them have been commercially produced and used commonly (Matić and Šantak 2022). This highlights the necessity of other methods that can be used to supplement current therapies (Alaoui Mdarhri et al. 2022). Considering these difficulties, there is increased interest in searching for natural compounds that exhibit antiparasitic effects (Shang et al. 2025). The potential of botanicals to provide alternative mechanisms of action and their low toxicity make them a promising avenue (Ullah et al. 2022).

**Botanical Compounds as Alternative Control Strategy**

Botanical compounds could be a valuable adjunctive therapy against *Toxoplasma gondii* infection in cats (Marques-Santos et al. 2024). Bioactive molecules found in plants have shown strong antiparasitic effects both in vitro and in vivo (Asghari et al. 2022). These compounds may inhibit various phases of the parasite life cycle, such as invasion, multiplication, and survival in host cells (Lian et al. 2023). Moreover, most botanicals have antioxidant and immunomodulatory effects that improve host defense against infection (Alanazi et al. 2023). Phytochemicals tend to be associated with lower toxicity levels and lower chances of resistance development than conventional drugs (Table 1) (Suganya et al. 2022). The use of botanical interventions in the management of felines can be used to minimize the shedding of oocysts and contamination of the environment, which plays a role in the prevention of zoonotic transmission (Štrbac et al. 2023).

**Polyphenols**

Polyphenols refer to a group of heterogeneous plant secondary metabolites that are well known to have antioxidant and antimicrobial effects (Rudrapal et al. 2024). They are usually found in green tea, grapes, berries, and other medicinal herbs (Cladis et al. 2022). Polyphenols have been observed to prevent parasite growth in different ways in the context of *Toxoplasma gondii* (Tan et al. 2022). Among the main mechanisms, a violation of the oxidative balance in the parasite can be identified (Pawłowska et al. 2023). Polyphenols may cause the production of reactive oxygen species, which cause oxidative stress and damage cells, including lipids, proteins, and DNA (Jomova et al. 2023). This oxidative damage compromises the viability of parasites and their replication (Li et al. 2025). The polyphenols also disrupt the process of invading the host cells by the parasite (Palomo-Ligas et al. 2022). Research has shown that some compounds have the capacity to prevent the release of microneme proteins that are necessary in host cell attachment and invasion (Cova et al. 2022). Polyphenols inhibit these processes, which decrease the effectiveness of infection (Davidova et al. 2024).

Another significant effect is host immune response modulation (Pal et al. 2022). Polyphenols promote the synthesis of interferon gamma, which is instrumental in controlling *T. gondii* (Alanazi and Alnomasy 2023). They also aid in the activation of macrophages, whereby the parasite is killed intracellularly (Camaya et al. 2023). In addition, polyphenols can prevent major enzymes of the metabolism of the parasite, interfering with the energy generation and biosynthesis pathways (Rudrapal et al. 2024). This polypharmacic mechanism of action decreases the chances of resistance development (Lafferty et al. 2022). Polyphenols are an important group of compounds with great potential in the management of toxoplasmosis because of their direct antiparasitic properties and ability to increase host defence (Marques-Santos et al. 2024).

**Flavonoids**

Flavonoids are polyphenols that belong to a subclass that is prevalent in fruits, vegetables, and medicinal plants (Roy et al. 2022). They are characterized by strong biological actions, such as anti-inflammatory, antioxidant, and antiparasitic activities (Islam et al. 2022). *Toxoplasma gondii* In terms of *Toxoplasma gondii* Flavonoids have been the most extensively studied for inhibiting T. gondii growth and replication is concerned (Marques-Santos et al.

2024). Inhibition of nucleic acid production is considered one of the main mechanisms of action (Zhang et al. 2024). Flavonoids can disrupt enzymatic activities involved in DNA and RNA replication, thus inhibiting the growth of parasites (Soto-Sánchez 2022). This is especially effective when compared to the tachyzoite stage, which is rapidly dividing (Wang et al. 2022). Flavonoids also interfere with mitochondrial function in parasites (Memariani et al. 2024). They weaken the capacity of the parasite to maintain its metabolic functions necessary for survival by inhibiting electron transport and energy production (Pawłowska et al. 2023). This causes low viability and subsequent death of the parasites (Ranasinghe et al. 2023).

The other major mechanism is the suppression of protein kinases that control the parasite signaling pathways (Wen et al. 2022). These kinases play crucial roles in cell division and differentiation (Pang et al. 2022). Flavonoids inhibit parasite growth by targeting these pathways (Ramaroson et al. 2022). Flavonoids also boost host immune functions by promoting the synthesis of pro-inflammatory cytokines and the activity of natural killer cells and macrophages (Han et al. 2022). This immunomodulatory activity enhances the host's ability to contain the infection (Alanazi et al. 2023). Moreover, flavonoids have membrane-stabilizing effects, which may disrupt parasite membranes, resulting in cellular leakage (Faleye et al. 2023). They are potential agents for combined control against toxoplasmosis because of their various modes of action (Huffman et al. 2022).

**Saponins**

Saponins are glycosidic compounds present in most plants, and their foaming properties are their characteristic feature (Oakenfull and Sidhu 2023). They possess good antimicrobial and antiparasitic properties; thus, they can be used as candidates for the control of *Toxoplasma gondii* infection (Arrighi et al. 2023). The main action of saponins is their contact with cell membranes (Pikhtirova et al. 2023). Saponins attach to the sterols in the parasite membrane, making it permeable and ultimately lysing it (Oakenfull and Sidhu 2023). This direct impact has the potential to substantially reduce the parasite load of parasites (Sures and Nachev 2022).

Saponins also mediate the adhesion and invasion of parasites, causing changes in membrane properties, making tachyzoites unable to attach to and penetrate host cells (Koger-Pease et al. 2023). This decreases the establishment of infection and further growth. Another significant property of saponin activity is its immunostimulatory effect (Alghirani et al. 2022). Saponins reportedly boost humoral and cell-mediated immunity. They activate cytokine synthesis and immune cell activation in macrophages and dendritic cells (Shen et al. 2023). This boosts immunity to help improve parasite (Sayyaf Dezfuli et al. 2023).

In addition, saponins can cause apoptosis of the infected host cells, thereby reducing the proliferation of the parasite (Lian et al. 2023). They also possess antioxidant properties, which are used to decrease tissue destruction related to infection (Fadilah et al. 2023). Saponins present a promising natural solution for the management of toxoplasmosis owing to their various mechanisms (Marques-Santos et al. 2024). However, their possible toxicity at high doses requires close consideration for feline use (De Santis et al. 2022).

**Tannins**

Tannins are polyphenols commonly present in plants, such as legumes, tree barks, and fruits (Oluwole et al. 2022). Their astringent properties are known, and they have shown great antiparasitic action against different protozoa, such as *Toxoplasma gondii* (Alawfi 2025). Protein binding is a key mechanism of tannins. Tannins can attach to proteins on the parasite surface and enzymes in the parasite, causing functional impairment (Huang et al. 2024). This contact interferes with important biological processes that ensure the survival and reproduction of the parasites (Binning et al. 2022). Interaction with lipid bilayers leads to structural damage and increased permeability, which is another mechanism of action of tannins on membrane integrity (Huang et al. 2024). This causes cellular content leakage and subsequent parasite (Barisch et al. 2023).

The other mechanism is enzyme inhibition (Mao et al. 2022). Key metabolic enzymes can be inhibited by tannins to reduce the viability of parasites by inhibiting their energy production and biosynthesis (Rodríguez-Hernández et al. 2023). They also disrupt DNA production, causing further restriction of replication (Epum and Haber 2022). In addition to their direct antiparasitic effects, tannins are antioxidants that alleviate oxidative stress in the host (Elghandour et al. 2023). Their other effects include the regulation of immune responses through the increase in immune cell activity and cytokine production of cytokines (Morris et al. 2022). Tannins also have the potential to decrease the accessibility of nutrients needed by parasites because of their ability to bind proteins and minerals (Besharati et al. 2022). This indirect action also promotes antiparasitic activity (Dziduch et al. 2022). Tannins are versatile compounds with great potential for managing toxoplasmosis via direct and indirect pathways (Huang et al. 2024).

**Terpenoids**

Isoprenoids or terpenoids are a diverse group of natural compounds formed by five-carbon isoprene units (Mohammadi-Cheraghabadi and Hazrati 2023). They are found abundantly in essential oils and as medicinal plants and have a wide range of biological activities, including antiparasitic (De Sousa et al. 2023). Terpenoids have been shown to interfere with the membrane structure and function of the parasite *Toxoplasma gondii* (Menezes and Tasca 2023). Many terpenoids are lipophilic, which means that they can be incorporated into lipid bilayers and modify the permeability of membranes (Monteiro et al. 2022). This causes the loss of essential cellular elements and the death of parasites (Sayyaf Dezfuli et al. 2023). Intracellular signaling pathways necessary for the survival of parasites are also disturbed by terpenoids (Jiang et al. 2023). They can also prevent the enzymes involved in the biosynthesis of isoprenoids, without which membrane formation and protein prenylation of the parasite cannot occur (Henkel et al. 2022). Another important mechanism is the induction of oxidative stress (Vo et al. 2024). Terpenoids can augment the generation of reactive oxygen species in parasites, leading to damage to cell components and retarding replication (Virendra et al. 2022). Moreover, mitochondrial inhibition by terpenoids has been demonstrated to slow energy production, causing a decrease in parasite viability (Guo et al. 2024). $Ca2+$ homeostasis, which is important

**Table 1:** Mechanisms of Botanical Compounds against *Toxoplasma gondii*

| Sr. No. | Class of Compound | Specific Compound | Plant Source | Part Used | Mechanism of Action against *T. gondii* | Target Parasite Stage | Type of Study | Key Findings | Advantages | Limitations | Potential Application in Felines | Reference (with Link) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Polyphenols | Resveratrol | *Vitis vinifera* | Skin/Seeds | Induces oxidative stress, inhibits replication | Tachyzoite | In vitro | Reduced proliferation | Antioxidant, multi-target | Low bioavailability | Adjunct therapy | (Wang et al. 2017) |
| 2. | Polyphenols | EGCG | *Camellia sinensis* | Leaves | Mitochondrial disruption, inhibits invasion | Tachyzoite | In vitro | Suppressed growth | Safe, natural | High dose needed | Dietary supplement | (Fakae et al. 2023) |
| 3. | Polyphenols | Curcumin | *Curcuma longa* | Rhizome | Alters calcium signaling, induces apoptosis | Tachyzoite/Bradyzoite | In vitro & in vivo | Reduced parasite burden | Anti-inflammatory | Poor absorption | Oral adjunct | (Saltykova et al. 2017) |
| 4. | Flavonoids | Quercetin | *Allium cepa* | Bulb | Inhibits DNA synthesis | Tachyzoite | In vitro | Reduced replication | Low toxicity | Limited in vivo data | Preventive use | (Alfredsson et al. 2015) |
| 5. | Flavonoids | Kaempferol | *Brassica oleracea* | Leaves | Inhibits protein kinases | Tachyzoite | In vitro | Moderate inhibition | Anti-inflammatory | Low bioavailability | Combination therapy | (Rasheed et al. 2026) |
| 6. | Flavonoids | Luteolin | *Apium graveolens* | Leaves | Mitochondrial dysfunction | Tachyzoite | In vitro | Inhibited intracellular growth | Antioxidant | Stability issues | Nutraceutical | (Domingos et al. 2008) |
| 7. | Saponins | Diosgenin | *Dioscorea spp.* | Tuber | Membrane disruption | Tachyzoite | In vitro | Reduced viability | Strong activity | Toxic at high dose | Controlled therapy | (Heinrich and Teoh 2004) |
| 8. | Saponins | Quillaja saponins | *Quillaja saponaria* | Bark | Immune stimulation, membrane disruption | Tachyzoite | In vivo | Enhanced clearance | Immunostimulant | Hemolysis risk | Vaccine adjuvant | (Fleck et al. 2019) |
| 9. | Saponins | Glycyrrhizin | *Glycyrrhiza glabra* | Root | Inhibits growth, anti-inflammatory | Tachyzoite | In vitro | Reduced replication | Safe | Mild potency | Support therapy | (Gondwe et al. 2008) |
| 10. | Tannins | Ellagic acid | *Punica granatum* | Peel | Enzyme inhibition, DNA interference | Tachyzoite | In vitro | Growth inhibition | Antioxidant | Limited feline data | Feed additive | (Ahmed et al. 2020) |
| 11. | Tannins | Tannic acid | Various | Bark/Leaves | Protein binding, enzyme inhibition | Tachyzoite | In vitro | Reduced viability | Broad activity | May affect nutrition | Controlled use | (Dunky 2021) |
| 12. | Tannins | Catechins | *Camellia sinensis* | Leaves | Membrane and enzyme disruption | Tachyzoite | In vitro | Decreased infection | Natural | Dose dependent | Preventive strategy | (Wan et al. 2007) |
| 13. | Terpenoids | Artemisinin | *Artemisia annua* | Leaves | ROS generation, parasite damage | Tachyzoite | In vitro & in vivo | Strong inhibition | Fast acting | Resistance risk | Therapeutic agent | (Morua et al. 2025) |
| 14. | Terpenoids | Thymol | *Thymus vulgaris* | Leaves | Membrane disruption | Tachyzoite | In vitro | Reduced survival | Natural antimicrobial | Volatile | Feed additive | (Naccarato et al. 2016) |
| 15. | Terpenoids | Carvacrol | *Origanum vulgare* | Leaves | Alters permeability | Tachyzoite | In vitro | Growth inhibition | Safe | Limited clinical data | Supplement | (Bradley et al. 2008) |
| 16. | Terpenoids | Limonene | Citrus spp. | Peel | Oxidative stress induction | Tachyzoite | In vitro | Moderate effect | Safe | Low potency | Supportive use | (Wong et al. 2007) |

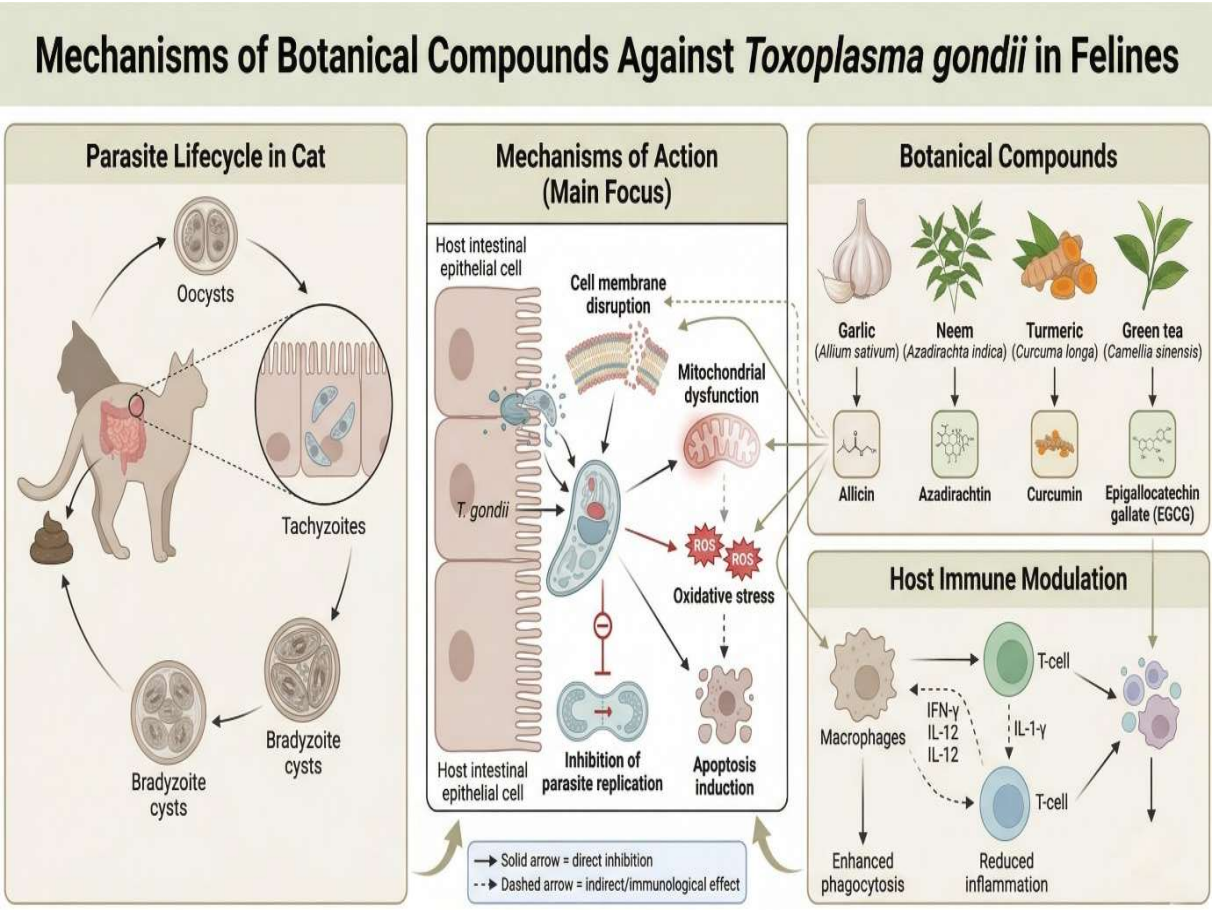


**Fig. 1:** Mechanisms of botanical compounds against *T. gondii* in felines.

for parasite motility and invasion, is also affected by some compounds (Gupta et al. 2022).

Terpenoids also have immunomodulatory properties, such as increasing host immune response, including macrophage activation and cytokine production (Hooda et al. 2024). The dual effect of direct antiparasitic activity and immunomodulation makes them attractive candidates for controlling toxoplasmosis (Sana et al. 2022).

**Future Perspectives**

Future studies on botanical compounds to control *Toxoplasma gondii* in cats should be directed toward translating experimental results into practice. Despite evidence of the antiparasitic benefits of phytochemicals in many in vitro and animal studies, no well-designed clinical trials have been conducted in cats. To guarantee the efficacy and safety of their use, standardization of plant extracts, identification of active compounds, and determination of optimum dosages are necessary. Advances in nanotechnology and drug delivery systems may improve the bioavailability and targeted action of botanical compounds. Phytochemical encapsulation into nanoparticles can enhance stability and release control, which improves therapeutic efficacy. The other field is the exploration of the synergy between botanical compounds and conventional drugs. The integration of these methods can decrease the number of drug-resistant strains and the dosage of drugs, as well as decrease drug side effects. Genomic and proteomic research can provide insights into the molecular targets of phytochemicals, facilitating the development of more specific and effective therapies. Moreover, the application of botanical strategies to the management practices of herds and populations at the population level will help decrease environmental contamination. In general, interdisciplinary research involving veterinary science, pharmacology, and plant science is necessary to develop the use of botanicals in the control of toxoplasmosis and improve One Health outcomes.

**Conclusions**

*Toxoplasma gondii* continues to be a major zoonotic parasite with far-reaching implications for animal and human health. Felines are important targets of control measures because they are relevant to the transmission of infection by shedding oocysts. Although conventional therapies are effective in the treatment of active parasite stages, they have drawbacks, such as their inability to fully clear the infection, possible toxicity, and the impossibility of preventing environmental pollution. The use of botanical compounds is a potential alternative, as they have a variety of mechanisms of action, such as direct antiparasitic action, stimulation of the host immune response, and antioxidant effects. Phytochemicals such as polyphenols, flavonoids, saponins, tannins, and terpenoids have shown considerable potential in inhibiting parasite growth and preventing the

severity of the infection. Although these benefits have been realized, additional studies are needed to confirm their effectiveness in cats and develop uniform treatment regimens. The combination of botanical and standard treatment and management methods can offer a better and more sustainable measure to manage toxoplasmosis. This type of integrated approach fits the One Health paradigm, which stresses the interdependence of animal, human, and environmental health. Zoonotic transmission can be minimized by reducing the infection rate in cats, and overall public health outcomes will improve.

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