REVISTA OWL (*OWL Journal*)
www.revistaowl.com.br – ISSN: 2965-2634

NATURAL PRODUCTS AND THE LIFE CYCLE OF *TOXOPLASMA GONDII*

NATURAL PRODUCTS AND THE LIFE CYCLE OF TOXOPLASMA GONDII

DOI: 10.5281/zenodo.19894928

Marcia Cristina Braga Nunes Varricchio[1]
Iracema Forni Vieira[2]
Daniel Figueiredo Vanzan[3]
Simone da Silva[4]
Paulo Sergio Torres Brioso[5]
Edson Pablo da Silva[6]
Hilton Antonio Mata-Santos[7]
Alexandre dos Santos Pyrrho[8]

1 PhD in Sciences (Plant Biology and Biotechnology) from the Postgraduate Program in Plant Biotechnology (PPGBV - UFRJ). Environmental Health, Parasitology, Bioethics Project of the Laboratory of Immunoparasitology and Toxicological Analysis of the Faculty of Pharmacy of the Federal University of Rio de Janeiro (SAPB-LIPAT/FF/UFRJ). E-mail: varichio2@gmail.com
2 Master in Parasitic Biology from Fundação Instituto Oswaldo Cruz (MSc, FIOCRUZ). MINISTRY OF HEALTH – Infectious Diseases at the Hospital Federal Servidores do Estado. E-mail: ifornivieira@gmail.com
3 Master of Science in Pharmaceutical Sciences from UFRJ (Federal University of Rio de Janeiro). PhD student in Pharmaceutical Sciences at UFRJ. Laboratory of Pharmaceutical Technology of the Faculty of Pharmacy (UFRJ). E-mail: danielfvanzan@gmail.com
4 Post-Doctorate in Biodiversity and Biotechnology from Federal University of Amazonas (UFAM). PhD in Sciences (Plant Biology and Biotechnology) from the Postgraduate Program in Plant Biotechnology (PPGBV - UFRJ). Amazon Biobusiness Center (CBA) & Institute of Technology and Education Galileo da Amazônia (ITEGAM). E-mail: simonydasilva@gmail.com
5 Graduated in agronomic engineering. PhD in Sciences – Genetics. Federal Rural University of Rio de Janeiro. Official Laboratory of Phytosanitary Diagnosis – Phytopathology. E-mail: brioso@bighost.com.br
6 Graduation in Biology. PhD in Sciences dos Alimentos - UFLA Lavras - MG - Brasil/IATA/CSIC - Valência - Espanha. Instituto Nacional de Pesquisas da Amazônia (INPA). E-mail: edsonpablosi@gmail.com
7 Associate Professor at the Faculty of Pharmacy of UFRJ (Federal University of Rio de Janeiro). PhD in Pharmaceutical Sciences from UFRJ. Laboratory of Immunoparasitology and Toxicological Analysis of the Faculty of Pharmacy (UFRJ). Email: hiltonufrj@gmail.com

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

ABSTRACT

The World Health Organization recognizes Toxoplasmosis as a major foodborne disease worldwide prevalence. The illness is a zoonosis occurring in areas of greater social vulnerability due to a lack of knowledge about the life cycle of the agent, the protozoan *Toxoplasma gondii*, when it contaminates soil, water, and consequently, food. The present study revision summarized evidence on natural compounds with anti-*T. gondii* activity, identified gaps, and proposed priorities for research in plant biotechnology, as several plant assays were communicated around the world, reinforcing the activity upon its life cycle. The authors sought to present the importance of Toxoplasmosis from a broad perspective, addressing aspects such as the impact upon host immunity, and the significance of refined studies evaluating natural products that may assist in controlling, or at least reducing, the harmful effects of this important parasitic infection. Besides the plant biotechnological research potential upon life cycle of *Toxoplasma gondii.* Finally, it was presented a booklet to health promotion through health education.

Keywords: *Toxoplasma gondii*, life cycle, natural products, biotechnological potential, health education.

RESUMO

A Organização Mundial da Saúde reconhece a toxoplasmose como uma importante doença transmitida por alimentos, com prevalência mundial. A doença é uma zoonose que ocorre em áreas de maior vulnerabilidade social devido à falta de conhecimento sobre o ciclo de vida do agente causador, o protozoário Toxoplasma gondii, quando este contamina o solo, a água e, consequentemente, os alimentos. O presente estudo de revisão resume as evidências sobre compostos naturais com atividade anti-T. gondii, identifica lacunas e propõe prioridades para pesquisas em biotecnologia vegetal, visto que diversos ensaios com plantas foram divulgados em todo o mundo, reforçando a atividade sobre o ciclo de vida do protozoário. Os autores buscaram apresentar a importância da toxoplasmose sob uma perspectiva ampla, abordando aspectos como o impacto na imunidade do hospedeiro e a relevância de estudos mais aprofundados que avaliem produtos naturais que possam auxiliar no controle, ou pelo menos na redução, dos efeitos nocivos dessa importante infecção parasitária. Além disso, abordam o potencial da pesquisa em biotecnologia vegetal sobre o ciclo de vida do Toxoplasma gondii. Por fim, é apresentado um livreto sobre promoção da saúde por meio da educação em saúde.

Palavras-chave: *Toxoplasma gondii*, ciclo de vida, produtos naturais, potencial biotecnológico, educação em saúde.

8 PhD in Sciences (Biophysics) from the Federal University of Rio de Janeiro (UFRJ). Laboratory of Immunoparasitology and Toxicological Analysis of the Faculty of Pharmacy (UFRJ). E-mail: pyrrho@farmacia.ufrj.br

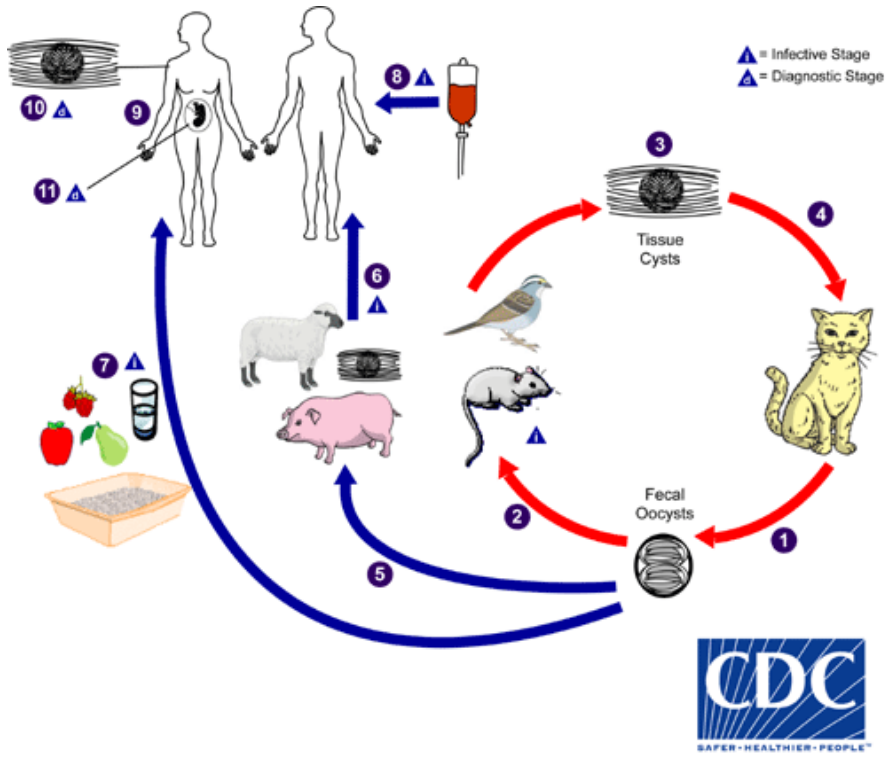
A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

BACKGROUND

The World Health Organization recognizes Toxoplasmosis as a major foodborne disease worldwide, but does not include it in the global list of neglected diseases (US-FDA In WHO, 2025). Toxoplasmosis is a zoonosis with a worldwide prevalence, occurring in areas of greater social vulnerability due to a lack of knowledge about the life cycle of the agent, the protozoan *Toxoplasma gondii*, when it contaminates soil, water, and consequently, food (Attias et al., 2020).

Regarding the life cycle, shown in Figure 1, *T. gondii* has three main infective forms: tachyzoite (acute multiplication phase), bradyzoite (tissue cysts, latent form), and sporozoite within oocysts excreted in feline feces and capable of contaminating soil/water/food (Attias et al., 2020).

Figure 1. Life cycle of *Toxoplasma gondii*.

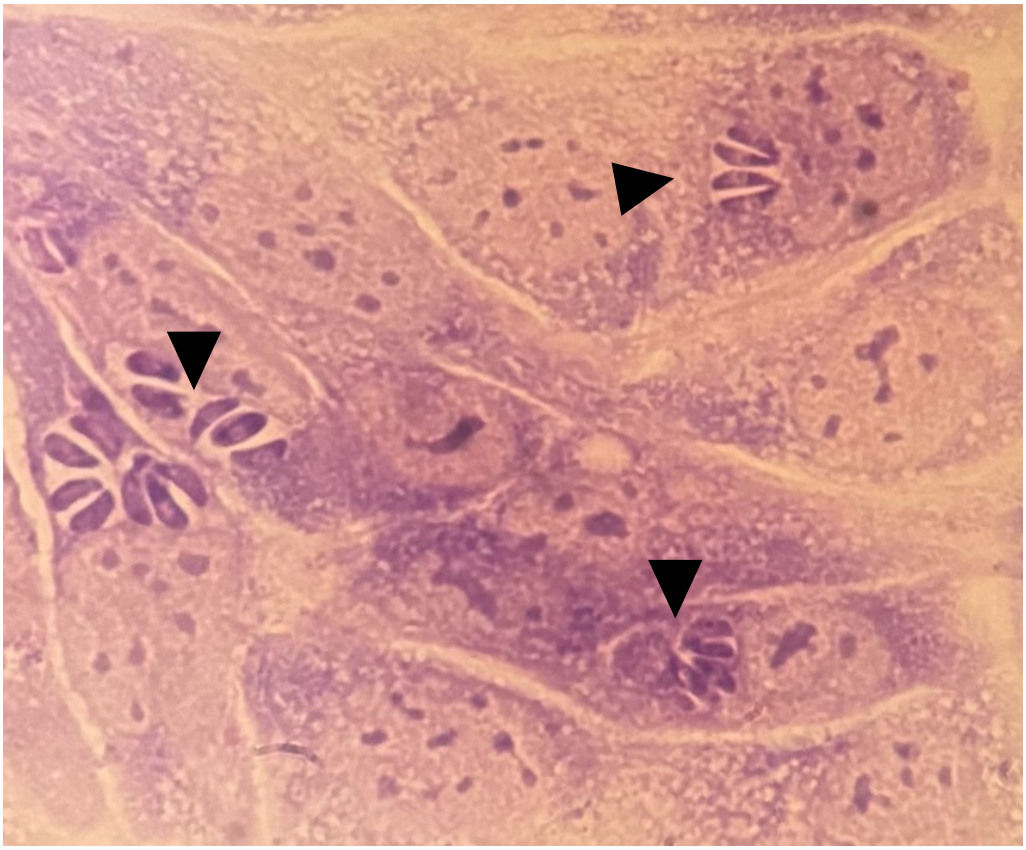


Source: CDC (Center of Diseases Control and Prevention – USA)

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

Humans become infected primarily by ingesting meat containing bradyzoites or food/water/soil contaminated with oocysts; after ingestion, bradyzoites/sporozoites convert into tachyzoites (Attias et al., 2020). Figure 2 below shows the presence of infective forms (tachyzoites) in tissue after accidental food ingestion.

Figure 2. Cells infected with tachyzoite forms of *Toxoplasma gondii* identified by the arrowheads.



Source: *The Authors.*

The life cycle of *Toxoplasma gondii* is heteroxenic, with felines, particularly domestic cats, as definitive hosts and virtually any bird or mammal as intermediate hosts. Humans can become infected in several ways: ingestion of sporulated oocysts eliminated by felines; ingestion of undercooked poultry or mammalian meat; congenital transmission if the pregnant woman is in the acute phase of toxoplasmosis; and, more rarely, through whole blood transfusion or organ transplantation (Hébraud et al., 2008; Campistol; Moreno, 2011;

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

Fernández-Sabé et al., 2012; Filloy, Garcia-Garcia, Fernández-Lorente, 2013; Blume, Seeber, 2018; Robert-Gangneux et al., 2018; Gay et al., 2019; Abbas et al., 2020; Adekunle et al., 2020; 2021; Sanchez; Besteiro, 2021; Francí et al., 2023; Ka, Salibindla, Kendler, 2024; Centers for Disease Control and Prevention – USA, 2024, a, b).

Among such clinical repercussion and maintain prevalence, arises a question: Is there any research on natural products that could interfere with the life cycle of *T. gondii*?

AIMS

To summarize evidence on natural compounds with anti-*T. gondii* activity, identify gaps, and propose priorities for research in plant biotechnology.

METHODS

A bibliographic review study was performed based on natural compounds with anti-*T. gondii* activity.

RESULTS

Natural products do not replace antiparasitic therapy prescribed by a physician (e.g., pyrimethamine + sulfadiazine + leucovorin) (CDC, 2024). However, the control of this zoonosis may be achieved through chemical classes of natural products capable of acting on different stages of the *T. gondii* cycle.

Research on natural products with anti-*Toxoplasma gondii* activity.

Most data on natural products (of plant, animal, and marine origin) comes from in vitro and in vivo studies in animals. Therefore, they do not replace antiparasitic therapy prescribed by a physician (e.g., pyrimethamine + sulfadiazine + leucovorin) (CDC, 2024). Main compounds have been scientifically investigated.

Curcumin extracted from Curcuma longa has undergone several *in vitro* and animal model studies showing a reduction in parasite load. It is also associated with anti-inflammatory and antioxidant effects; recent systematic reviews on the anti-Toxoplasma

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

activity of curcumin and formulations (e.g., nanocurcumin) suggest promising preclinical evidence (Kalani et al., 2023).

Resveratrol has also been shown to have direct activity against tachyzoites in cell cultures, along with a reduction in inflammatory damage in animal models; the proposed mechanisms include effects on stress/epigenetic pathways and immune modulation (Chein et al., 2019).

Artemisinin derivatives, such as dihydroartemisinin (DHA), are antimalarial compounds with activity against *T. gondii* in laboratory studies; some studies show that they affect calcium homeostasis and other pathways; currently, there are studies on combinations and resistance (Nagamune, Beatty, Sibley, 2007).

Essential oils and terpenes (e.g., turmeric oils and other extracts) through in vitro studies in murine models indicate a reduction in parasitism with improvement in inflammatory indices through various mechanisms (oxidative stress, membrane destruction, immune modulation) (Ezzatkhah; Mahmoudvand; Raziani, 2023).

At revision study, it was found that Eutirucallin is a lectin isolated from the latex of *Euphorbia tirucalli*, a plant known for its medical properties. There were investigated various characteristics of Eutirucallin including stability, cytotoxicity against tumor cells, antimicrobial and antiparasitic activities. Eutirucallin was stable from 2 to 40 days at 4°C, maintained hemagglutinating activity within a restricted range, and showed optimal activity at pH 7.0–8.0 (Palharini et al., 2017).

Indeed, Eutirucallin showed to be effective when tested directly against *Toxoplasma gondii* infection *in vitro*. Therefore, this study shed perspectives for pharmacological applications of Eutirucallin (Palharini et al., 2017).

Several natural compounds with leishmanial and trypanossomial and insecticidal activities, also possess anti-*Toxoplasma gondii* activity. As showed, also *Euphorbia* species. *Euphorbia resinifera* Berg is an important traditional medicinal species used by the Moroccan population against different disorders, as antimicrobial, antileishmanial, antitrypanosomal and insecticide activities. Stems of *E. resinifera* did not show any anti-*Toxoplasma* effect in experimental conditions (data not shown - Elkoraichi et al. (2025), but roots weren't investigated yet.

Thus, several biological activities of interest were shown at Table 1 below.

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

Table 1: Antimicrobial, antileishmanial, antitrypanosomal, insecticide and anti-*Toxoplasma gondii* activities of plants.

Parts and Prepares of Plants	**Biological Effect Investigated**	**Actions evidenced**	**Authors/Year**
Resin and raw latex of *E. resinifera (E.r.)*	Irritant activity in vivo on the ear of a mouse		Hergenhahn, 1984
12 semisynthetic terpenoid derivatives obtained by several chemical modifications of major compounds of *E. resinifera*	Antileishmanial activities	Triterpenes inhibited L. infantum promastigotes because they can interfere with sterol metabolism.	Mazoir et al., 2011
12 semisynthetic terpenoid derivatives obtained by several chemical modifications of major compounds of *E. resinifera*	Antitrypanosomal Activity	*In vitro*activity on *Trypanosoma cruzi* epimastigotes because triterpenes used can interfere with sterol metabolism.	Mazoir et al., 2011
E. resinifera total extract	Antifungal Activity	*Aspergillus flavus* mycelial growth inhibition rates ranged from 64.14% to 85.51% and *Penicillium expansum* from 60.14% to 85.51%.	Benmehdi et al., 2013
04 semi-synthesized triterpenes derivatives from latex of *E. resinifera*	Insecticide Activity	The four semi-synthesized triterpenes completely inhibited sprouting.The tomato seeds germinated in the presence of four triterpenes derivatives induced resistance to Verticillium wilt caused by *Verticillium dahliae*.	Smaili et al., 2018
Roots of *E. resinifera*	Antibacterial effect	*Escherichia coli*, *Staphylococcus aureus* and *S. epidermidis*, *S. typhimurium*, *B. subtilis*	Bendjamaa et al.,2020
Extracts of *E. resinifera*	Antibacterial effect	*Pseudomonas aeruginosa*	Bendjamaa et al.,2020
E. resinifera 37 samples honeys	Antibacterial effect	*S. aureus* and *E. coli*	Bendjamaa et al.,2020
Stems of *E. resinifera*	No activity	*T. gondii*	Elkoraichi et al.,

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

			2025
Methanolic extracts of *Euphorbia retusa*	Antitoxoplasmic activity	*T. gondii*	Khan et al., 2021
*Moringa oleifera*seeds	Increased apoptotic, necrotic effects	*T. gondii* subpopulations	Hmidouche etal.,2023
Betulone triterpene of *Alnus glutinosa*	Inhibited *in vitro* growth	*T. gondii*	Hmidouche et al., 2023
Hydro-ethanol extract of tea bark of *Tectona grandis*	phenols, tannins and flavonoids with different selectivity indices	*T. gondii*	Hmidouche et al., 2023
Copaifera multijuga-derivedoleoresin	Sesquiterpenes,diterpenes and β-caryophyllene reduced proliferation in human trophoblastic cell lines	*T. gondii*	Hmidouche et al., 2023
Ethanol extractof *Ammi visnaga* seeds	Saponinsinduced apoptosis-like intachyzoites	*T. gondii*	Elkoraichi et al., 2025
Aqueous extract of *A. visnaga* seeds	Coumarinsand Sterols direct killing effect	*T. gondii*	Elkoraichi et al., 2025
E. guineensis metabolites	Possible candidates to obtain lead compounds against	*T. gondii*	Elkoraichi et al., 2025
Aqueous extracts of *Syzygium aromaticum* flower buds	Phenols induced apoptosis-like intachyzoites	*T. gondii*	Elkoraichi et al., 2025
Aqueous extracts of *Punica granatum* peel	Gallictanninsinduced apoptosis-like intachyzoites	*T. gondii*	Elkoraichi et al., 2025

Source: *Prepared by the Authors.*

Regarding the investigation of other natural compounds, reviews list a number of alkaloids, flavonoids, quinones, fungal compounds, and plant extracts with anti-*T. gondii* activity in the laboratory. Several of these compounds are "starting points" for drug development (Sepulveda-Arias; Veloza; Mantilla-Muriel, 2014).

Punica granatum peel show promise as potential preclinical candidates for the Toxoplasmosis treatment, warranting further investigation into its potential for safe and effective therapeutic use Congenital Toxoplasmosis in several countries, remains challenging

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

due to high cost and potential toxicity of existing treatment, limiting their widespread application.

Dign of worth, a hydro-methanolic extract of P. granatum peel was as effective as ivermectin and albendazole in eliminating parasitic gastroenteritis eggs in faeces of different ruminant species after 2 oral treatments at 200 mg/kg (Elkoraichi et al., 2025).

DISCUSSION

It is observed that outbreaks of severe toxoplasmosis apparently occur, which may be related to acute infections from the ingestion of contaminated food (contaminated vegetables and raw or undercooked meats) as well as exposure during work in contaminated soils and groundwater. However, other causes of severe immunosuppression capable of leading to death from toxoplasmosis in unusual circumstances (Renoult et al., 1997; Hébraud et al., 2008), neurotoxoplasmosis and disseminated toxoplasmosis involve underlying diseases such as malignant neoplasms, acquired immunodeficiency syndrome, chemical dependency, in addition to treatment with immunosuppressants (Gay et al., 2019; Ka; Salibindla; Kendler, 2024).

However, although it is rare, there is a group of immunosuppressed patients who are closely monitored due to the high risk of developing severe forms of toxoplasmosis (either through reactivation, dissemination or even contamination): Kidney transplant recipients (Renoult et al., 1997; Robert-Gangneux et al., 2018).

Due to the difficulty in clinically monitoring these severely ill patients undergoing immunosuppression to prevent rejection, they require careful and highly complex management. In this sense, biotechnological plant research into interfering with the *Toxoplasma gondii* life cycle in nature becomes understandable. It seems to be a better, simpler, more effective, and cheaper option, capable of modifying outcomes not only in immunosuppressed individuals but, perhaps, also in others hosts, through reducing exposure.

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

Research on natural products with anti-*Toxoplasma gondii* activity

Several studies have evaluated the potential of medicinal plant extracts in controlling *T. gondii* infection, identifying compounds with promising activity (such as those from *Copaifera spp*., *Euphorbia retusa* and others (Khan et al., 2021), however *Euphorbia resinifera* has not been specifically tested in this context for this parasite, but because of this abroad of activities, it is very promissor (Giorgi et al., 2026).

The level of evidence for the effectiveness of natural products on the T. gondii life cycle is relevant and of interest in research, since in vitro (cell culture): many compounds tested (curcumin, resveratrol, artemisinins, terpenes, etc.) show inhibitory activity on tachyzoites (Chen et al., 2019), as shown in Table 2:

Table 2: Natural products with anti-*Toxoplasma gondii* activity.

Product / compound	**Type of study**	**Main results reported**	**Limitations / safety**	**Main references**
Useful Plants of West Africa	Ethnobothanical	Inhibition of cycle	Not known yet	Burkill,1985
Useful Plants of West Tropical Africa	Ethnobothanical	Inhibition of cycle	Not known yet	Burkill, 1997
Vegetable extracts used in West African traditional medicine	*In vitro* study	Inhibition of cycle	Not known yet	Benoit-Vical et al., 2000. DOI:10.1051/parasite/2000071003
Artemisinins / Dihydroartemisin (DHA)	In vitro and animal model studies; combination studies with conventional drugs.	Demonstration of antiparasitic activity; possible action on calcium homeostasis and pathways leading to parasite death; effect in reducing the growth of *T. gondii.*	Compounds used clinically for malaria have known toxicity and pharmacology, but their use for toxoplasmosis is not approved; there is a risk of resistance in apicomplexans.	Experimental studies (e.g., Huang 2022; Nagamune 2007 on the mechanism).PubMed+1 https:// pubmed.ncbi.nlm.nih.gov/ 36613672/? utm_source=chatgpt.com
Eutirucallin (*Euphorbia tirucalli*)	*In vitro* study	Effective when tested directly against *Toxoplasma gondii* infection	Toxicity not defined.	Palharini et al., 2017.
Triterpenoids of *Quercus crispula*	*In vitro* study	Structure–activity relationship of anti-toxoplasma	Toxicity not defined.	Endo et al., 2019
Omega-3 polyunsaturated fatty acids	*In vitro* study	Prevent infection by inducing autophagy via AMPK activation	Toxicity not defined.	Choiet al., 2019

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

Product / compound	Type of study	Main results reported	Limitations / safety	Main references
Euphorbia retusa and *Pulicaria undulata*	*In vitro* study	Effective when tested directly against Toxoplasma gondii infection	Toxicity not defined.	Khan et al., 2021
Essential oils and terpenes from *Origanum vulgare*, Dracocephalum spp.	*In vitro* studies; some tests in animal models; identification of active components.	Inhibition of tachyzoite growth in vitro, reduction of cell invasion; morphological alterations in tachyzoites; potential anti-Toxoplasma activity in essential extracts.	Large variation in chemical composition; potential toxicity at high doses; lack of standardization and clinical trials.	Yao 2021 (Origanum); Khamesipour 2022 (Dracocephalum).Frontiers+1 https://www.frontiersin.org/journals/cellular-and-infection-microbiology/articles/10.3389/fcimb.2021.793089/full?utm_source=chatgpt.com
Curcumin (*Curcuma longa*)	Systematic reviews, in vitro and animal model studies; nano formulations (nanocurcumin) tested.	Reduction of parasite load in animal models, modulation of pro-inflammatory cytokines, antioxidant effects; potential to reduce neurological/affective damage in chronic models.	No clinical evidence in humans; low bioavailability without formulations; possible drug interactions. Not a substitute for medical treatment.	Kalani 2023 (systematic review); Housing 2023.PubMed+1 https://pubmed.ncbi.nlm.nih.gov/35996237/?utm_source=chatgpt.com
Pleopeltis crassinervata active subfractions	*In vitro*	Efficacy, cytotoxicity, and GC/MS profile	Not known yet	Anacleto-Santos et al., 2023
Resveratrol (polyphenol)	*In vitro* studies and experimental models (cells, mice); mechanistic studies.	It inhibits tachyzoite proliferation in vitro; modulates the inflammatory response (e.g., NF-κB); reduces lung damage in an animal model; and alters redox homeostasis and epigenetic markers.	Main preclinical evidence; possible drug interactions (e.g., anticoagulants, P450 enzymes). Lack of clinical studies.	Various: experimental studies and reviews; PMC articles on direct effects.PMC+2PubMed+2 https://pmc.ncbi.nlm.nih.gov/articles/PMC6395936/?utm_source=chatgpt.com https://pubmed.ncbi.nlm.nih.gov/35996237/?utm_source=chatgpt.com
Other alkaloids, flavonoids, quinones (various extracts)	Reviews and screening studies (2000–2023)	Many compounds show activity *in vitro*, serving as "leads" for pharmacological development.	The vast majority remain in the pre-clinical phase; variability and lack of clinical data.	Systematic review / 20-year research (ResearchGate summary 2024).ResearchGate https://www.researchgate.net/publication/381914641_The_Search_for_Drugs_Derived_from_Natural_Products_for_Toxoplasma_gondii_Infection_Treatment_in_the_Last

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

Product / compound	Type of study	Main results reported	Limitations / safety	Main references
				_20_Years_-_A_Systematic_Review?utm_source=chatgpt.com
New plant extracts (e.g., *Elaeis guineensis* leaves - 2025)	Recent *in vitro* screening (2024–2025); isolation of new compounds with activity.	Some extracts showed significant inhibition of parasite growth in screenings; identification of nor-sesquiterpenes and glycosides with activity.	Initial studies; validation in animal models and toxicity assessment are required.	Ouattara 2025 (screening).ScienceDirect https://www.sciencedirect.com/science/article/pii/S0031942225000652?utm_source=chatgpt.com

Source: *Prepared by the Authors.*

De Souza and colleagues (2021) demonstrated that cyclooxygenase 2 modulates T. gondii infection, immune response, and the formation of lipid droplets in human trophoblastic cells and villous explants.

Besides, animal models (rats) have shown a reduction in parasitism and improvement in inflammatory parameters and survival reported for some extracts and compounds (Yao et al., 2021).

The compounds of interest justify their research due to:

- Artemisinins / DHA: compounds already used clinically (malaria) with activity against apicomplexans; possible clear pathways of action (calcium homeostasis). Priority: evaluate synergies with conventional therapies and risk of resistance (Huang et al., 2022).
- Curcumin: Demonstrates good anti-parasitic activity in models; exhibits anti-inflammatory and antioxidant properties that may reduce tissue damage in chronic infections. Problem: low bioavailability; potential solution: nanoparticulate formulations (nanocurcumin). Priority: pharmacokinetic studies and preclinical dose/safety trials before phase I (Kalani et al., 2023; Moradi et al., 2023).
- Resveratrol: proven in vitro activity and inflammation-modulating effects; mechanism suggests redox damage to the parasite and epigenetic modulation. Priority: dose modeling in rodents and toxicological studies (Chen et al., 2019).

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

- Essential oils / terpenes: useful as sources of molecules with membrane-lytic/antiparasitic activity; prioritize isolation of active principles and toxicity assessment (Yao et al., 2021).
- Eutirucallin from *Euphorbia tirucalli* inhibited 62.5% of *Escherichia coli* growth (Palharini et al., 2017), also had been discussioned its potential ability to freatic and soil recover (Rebelo et al., 2025) and mechanical action stopping vectors movements (Wendling da Silva et al., 2025).

These results indicate that the activity of the plant is not only dependent on the type of extract, but also on the target species (Ebong, P.E.; Owu, D.U.; Isong, 1999; Annan et al., 2012; Soundararajan; Sreenivasan, 2012; Abubacker; Deepalakshmi, 2013; De Carvalho; Caramujo, 2018; Tepongning et al., 2018; Bisht; Bankoti; Bharti, 2021; Tow et al., 2021; Ouattara et al., 2025).

The natural products shown are capable of interfering with the *T. gondii* cycle. Once again, the actions of plant species originating from the African and Asian continents are observed, which may not only be due to the active substances produced but also to investment in research with natural products by various countries on these continents (Burkill, 1985; 1997).

E. tirucalli species belong its origin from African-Asian continents and it is spread around the world. Many researches are made from informations about its traditional use. While developed countries biotechnological research, as Japan, China, India, among others, go on verifying its antitumoral action, we aimed to discuss its plant biotechnological potential applied to environmental health for example: mosquitoes and vectors of parasitary illnesses (Gomes et al., 2023, a), to environmental technology (Rebelo et al., 2025), to environmental immunology (Varricchio et al., 2025) and also to environmental engineering through plant biotechnology (Varricchio et al. 2025a).

Indeed, Eutirucallin also has evidenced antiproliferative activity for HeLa (Epithelial adenocarcinoma of the cervix), PC3 (human prostate cancer with high metastatic potential),

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

MDA-MB-231 (Human breast adenocarcinoma, triple-negative subtype) and MCF-7 (Human breast adenocarcinoma, Luminal A subtype - ER Positive) tumor cells but was not cytotoxic for non-tumorigenic cells such as macrophages and fibroblasts. Eutirucallin inhibited the Ehrlich ascites carcinoma *in vivo* (Palharini et al., 2017).

Indeed, *Euphorbia* genus has been reported to have antitrypanosomal activity due to its wide variety of terpenoids. The mechanism by which these compounds exhibited their cytotoxic activity was not fully understood and the authors suggested that the triterpenes used can interfere with sterol metabolism. Further studies are needed with natural triterpenes of the Euphorbia genus in order to discover new bioactive drugs against Chagas disease (Mazoir and coworkers, 2011 In Hmidouche et al., 2023).

Mazoir et al. (2011) verified triterpenes at different concentrations, extracted from the latex with methanol of *Euphorbia resinifera*, showed significant antiparasitic effects on *Leishmania infantum* were the most cytotoxic to *L. infantum* with less cytotoxic effect to mammalian Chinese hamster ovary cells. So, it was suggested that the triterpenes used can interfere with sterol metabolism (Hmidouche et al., 2023), what is promissor to interfere in *T. gondii* metabolism.

Besides insecticide activity, the tomato seeds germinated in the presence of four triterpenes derivatives which induced resistance to Verticillium wilt caused by *Verticillium dahliae*. Concentrations as low as 10 mg/mL were effective in reducing the external symptoms of wilt of *Verticillium* manifested by leaf lesion and growth restriction, as well as internal symptoms such as vascular discoloration (Hmidouche et al., 2023).

Echinacea purpurea has been investigated as a promising therapeutic alternative for the treatment of Toxoplasmosis, acting primarily as an immunomodulatory and anti-inflammatory agent, especially in cases of chronic infection. Echinacea stimulates the immune system, particularly natural killer (NK) cells, which help fight intracellular parasites such as *T. gondii* (Pastre, 2022).

Studies in animal models (Wistar rats) have shown that treatment with *E. purpurea* can regulate the myeloperoxidase (MPO) enzyme in the ileum, reducing intestinal damage caused

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

by chronic infection. Research indicates that it may help modulate the immune response during the chronic phase of the disease, when tissue cysts persist in the host. Therefore, it is considered a complementary therapy for the patient, but its use should be avoided in immunosuppressed patients, pregnant women (without guidance), or those with autoimmune diseases (Pastre, 2022).

Therefore, Echinacea genus is of great interess to biotechnological research, because of this immune modulatory effect to host, in general, an imunestimulant effect with toxicity and dosages are well defined, also being considered functional food (Hansel-Martins et al., 2025; Coutinho et al., 2026).

Finally, it is known that natural products are not indicated for adjuvant treatment of Toxoplasmosis, as they may exhibit drug interactions: Resveratrol may interact with anticoagulants, p450; Curcumin in high doses has gastrointestinal effects and potential drug interactions. They should never be used as substitutes for conventional prescribed treatment, especially in pregnant women, immunosuppressed individuals (post-transplant patients), and immunosuppressed patients with toxoplasmic encephalitis (CDC, 2024b).

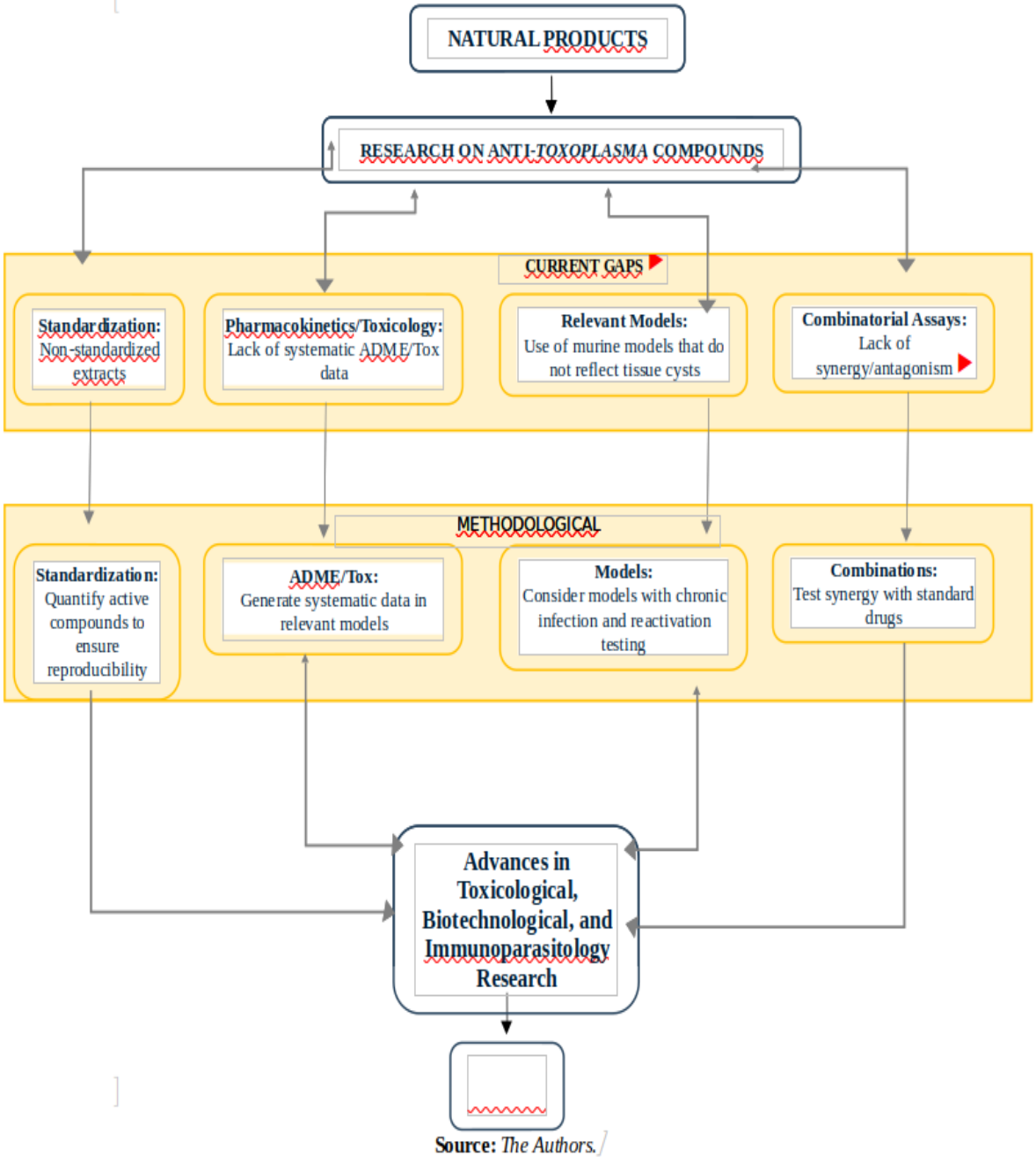
Natural products are a promising source of "lead" compounds (Bentes Lopes et al., 2024; Marques-Santos et al., 2024; Cazumbá et al., 2025; Mao et al., 2025) in general, but they should not be used in isolation to treat patients with proven toxoplasmosis. Prioritize robust translational research (standardization, toxicology, PK/PD, assays in chronicity models). The ethical evaluation of translational use should involve pharmacologists, parasitologists, and toxicologists in the design of the assays (CDC, 2024b).

There is an urgent demand for affordable, safe and accessible alternatives. Plants used in traditional medicine are of interests of using plant extracts containing several active compounds acting in synergy (Elkoraichi et al., 2025).

Finally, the synthesis of this review study relating to natural products with potential action on the parasitic cycle is shown in Figure 3 below:

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

Figure 3: Research on compounds derived from natural products that act on the *Toxoplasma gondii*.



Source: *The Authors.*

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

Gaps in research and methodological recommendations:

• Standardization: many extracts are not standardized; without quantification of the concentration of active ingredients, it becomes difficult to reproduce results.
• Pharmacokinetics/toxicology: lack of systematic ADME/Tox data for most compounds in relevant models.
• Relevant models: in addition to mice, consider models that better reflect the biology of tissue cysts, such as models with chronicity and reactivation tests.
• Combinatorial assays: test combinations with standard drugs to check for synergy or antagonism (e.g., DHA with pyrimethamine/sulfadiazine). PubMed https://pubmed.ncbi.nlm.nih.gov/36613672/?utm_source=chatgpt.com

LIMITS

Although a comprehensive approach was adopted, several clinical, immunological, and epidemiological aspects were undoubtedly not emphasized.

CONTRIBUTIONS

The authors sought to present the importance of Toxoplasmosis from a broad perspective, addressing aspects such as the impact upon host immunity, and the significance of refined studies evaluating natural products that may assist in controlling, or at least reducing, the harmful effects of this important parasitic infection. Besides the plant biotechnological potential upon life cycle of *Toxoplasma gondii*.

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

PRODUCT

BOOKLET: Proven practical preventive measures for the general population to avoid contamination, based on health agencies (CDC, US-FDA), with strong practical evidence for reducing the risk of infection (Gayer, 2025).

CONCLUSION

Here is a long-standing diagnosis in adults that still deserves contemporary consideration: Toxoplasmosis.

Authors declare no conflicts of interest.

REFERENCES

ABBAS, A.; ZHENG, C.; PANNERDEN, C.; NEWSHOLME, W.; HILTON, R. (2020). **Primary toxoplasmosis complicated by possible IRIS 15 years after renal transplantation,** 100021. https://doi.org/10.1016/j.clinpr.2020.100021

ABUBACKER, M.N.; DEEPALAKSHMI, T. ***In vitro*** **antifungal potentials of bioactive compound methyl ester of hexadecanoic acid isolated from *Annona muricata* Linn. (Annonaceae) leaves.** Biosci Biotechnol Res Asia, 10 (2013), pp. 879-884, 10.13005/bbra/1211

ADEKUNLE, R.; SHERMAN, A.; SPICER, J.; MESSINA, J.; STEINBRINK, J.; SEXTON, M.; LYON, G.; MEHTA, A.; PHADKE, V.; WOODWORTH, M. (2019). 2693. **Clinical Presentation of Toxoplasmosis and 30-Day Mortality in Transplant Recipients at Two Academic Medical Centers.** Open Forum Infectious Diseases, 6, S946 - S947. https://doi.org/10.1093/ofid/ofz360.2370

ADEKUNLE, R.; SHERMAN, A.; SPICER, J.; MESSINA, J.; STEINBRINK, J.; SEXTON, M.; LYON, G.; MEHTA, A.; PHADKE, V.; WOODWORTH, M. (2021). **Clinical**

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

characteristics and outcomes of toxoplasmosis among transplant recipients at two US academic medical centers. Transplant Infectious Disease, 23. https://doi.org/10.1111/tid.13636

AGÊNCIA FIOCRUZ DE NOTÍCIAS. **Neglected Diseases.** 2022. Available at: https://agencia.fiocruz.br/doencas-negligenciadas#:~:text=As%20doen%C3%A7as%20negligenciadas%20s%C3%A3o%20aquelas,medicamentos%20e%20em%20seu%20controle.

ANACLETO-SANTOS, J.; CALZADA, F.; LÓPEZ-CAMACHO, P.Y.; LÓPEZ-PÉREZ, T. DE J.; CARRASCO-RAMÍREZ, E.; CASARRUBIAS-TABAREZ, B.; FORTOUL, T.I.; ROJAS-LEMUS, M.; LÓPEZ-VALDÉS, N.; RIVERA-FERNÁNDEZ, N. **Evaluation of the anti-*Toxoplasma gondii* efficacy, cytotoxicity, and GC/MS profile of *Pleopeltis crassinervata* active subfractions.** Antibiotics, 12 (5) (2023), p. 889, DOI: 10.3390/antibiotics12050889.

ANNAN, K.; SARPONG, K.; ASARE, C.; DICKSON, R.; K.I. AMPONSAH, K.I.; GYAN, B.; OFORI, M.; GBEDEMA, S.Y. ***In vitro* anti-plasmodial activity of three herbal remedies for malaria in Ghana : *Adenia cissampeloides* (Planch.) Harms., *Termina liaivorensis* A. Chev, and *Elaeis guineensis* Jacq.** Pharmacogn. Res., 4 (4) (2012), pp. 225-229, 10.4103/0974-8490.102270

ANVARI, D., SHARIF, M., SARVI, S., AGHAYAN, S., GHOLAMI, S., PAGHEH, A., HOSSEINI, S., SABERI, R., NAYERI, T., HOSSEININEJAD, Z.; DARYANI, A. (2019). **Seroprevalence of *Toxoplasma gondii* infection in cancer patients: A systematic review and meta-analysis.** *Microbial pathogenesis*, 129, 30-42. https://doi.org/10.1016/j.micpath.2019.01.040

ATTIAS, M.; TEIXEIRA, D.E.; BENCHIMOL, M.; VOMMARO, R.C.; CREPALDI, P.H.; DE SOUZA, W. **The life-cycle of *Toxoplasma gondii* reviewed using animations.** Parasites & Vectors. V. 13, Article number: 588 (2020) Link at : https://parasitesandvectors.biomedcentral.com/articles/10.1186/s13071-020-04445-z?utm_source=chatgpt.com

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

BENOIT-VICAL, F.; SANTILLANA-HAYAT, M.; KONE-BAMBA, D.; MALLIE, M.; DEROUIN, F. **Anti- *Toxoplasma* activity of vegetal extracts used in West African traditional medicine.** Parasite, 7 (1) (2000), pp. 3-7, 10.1051/parasite/2000071003

BENTES LOPES, J., GASPAR, S. A., GOMES, N. B. DE N., IABRUDI, R. C., CRUZ FILHO, F. C., GAYER, D. DE S., EZEQUIEL, T. D. G., BOLOGNANI, F. DE A., MALFACINI, S. DA S., GORINI, C. C., DE FREITAS, J. V. M., VIEIRA, I. F., KUSTER, R. M., LAGE, C. L. S., DA SILVA, S., BRIOSO, P. S. T., ALEXANDRE DOS SANTOS PYRRHO, A. DOS S.; VARRICCHIO, M. C. B. N. (2024). **Environmental potential of plant use: Resource management in the face of climate uncertainty.** Latin American Economy Observatory, 22(4), 1–33. https://doi.org/10.55905/oelv22n4-019.

BISHT, B.S.; BANKOTI, H.; BHARTI, T. **A review on therapeutic uses of terpenoids.** J. Drug Deliv. Therapeut., 11 (2021), pp. 182-185, 10.22270/jddt.v11i1-s.4523

BLUME, M.; SEEBER, F. (2018). **Metabolic interactions between *Toxoplasma gondii* and its host.** *F1000Research*, 7. https://doi.org/10.12688/f1000research.16021.1

BURKILL, H.M. **The Useful Plants of West Africa.** (second ed.), Royal Botanic Garden (1985), pp. 458-459.

BURKILL, H.M. **The Useful Plants of West Tropical Africa.** (second ed.), vol. 3, Royal Botanic Gardens, Kew-London (1997). Families J–L

CAZUMBÁ, A. DA S.; CÉZAR DA SILVA, G.V.; REBELO, R. DE M.; HAMMES, R. S. S.; GASPAR, S.A.; GOMES, N. B. DE N.; VARRICCHIO, M. C. B. N.; DA SILVA, S.; CASTELO BRANCO, M. T. L.; PYRRHO, A. DOS S. (2025) **NEGLECTED DISEASES: Leishmaniasis and Natural Products (Actualization Review).** INFO_SAPB. Revista de suporte ao Projeto Saúde Ambiental, Parasitologia, Bioética do Laboratório de Imunoparasitologia e Análises Toxicológicas (Projeto SAPB-LIPAT) da Faculdade de Farmácia da UFRJ. V9 - n2 - Out 2025. Available at: https://sites.google.com/view/lipat/sapb-revista_info-sapb?authuser=0#h.oceiqv3p0z55.

CDC. CENTER FOR DISEASES CONTROL. **About Toxoplasmosis (prevention and hygien).** 2024. Link at: https://www.cdc.gov/toxoplasmosis/about/index.html?utm_source=chatgpt.com

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

CDC. CENTER FOR DISEASES CONTROL. **Toxoplasmosis: An Important Message for Cat Owners** (PDF). 2024a. Link at: https://www.cdc.gov/parasites/toxoplasmosis/resources/printresources/catowners.pdf?utm_source=chatgpt.com

CDC. CENTER FOR DISEASES CONTROL. Clinical Care of Toxoplasmosis. 2024b. Link at:https://www.cdc.gov/toxoplasmosis/hcp/clinical-care/index.html?utm_source=chatgpt.com

CHEN, Q-W.; DONG, K.; QIN, H-X.; YANG, Y-K.; HE, J-L.; LI, J.; ZHENG, Z-W.; CHEN, D-L.; CHEN, J-P. **Direct and Indirect Inhibition Effects of Resveratrol against *Toxoplasma gondii* Tachyzoites *In Vitro*.** Antimicrobial Agents and Chemotherapy. Washington, Feb 26; 63(3): e01233-18. 2019. DOI: 10.1128/AAC.01233-18. Available at: https://pmc.ncbi.nlm.nih.gov/articles/PMC6395936/. Access in: Apr, 8. 2026. https://pmc.ncbi.nlm.nih.gov/articles/PMC6395936/

CHEN, J., LIAO, W.; PENG, H. (2022). ***Toxoplasma gondii* infection possibly reverses host immunosuppression to restrain tumor growth.** *Frontiers in Cellular and Infection Microbiology*, 12. https://doi.org/10.3389/fcimb.2022.959300

CHEN, M.; YANG, P.; XIN, Z.; CHEN, J.; ZOU, W.; ZHOU, L.; YANG, L.; PENG, J.; PENG, H. (2023). ***Toxoplasma gondii* gra5 deletion mutant protects hosts against *Toxoplasma gondii* infection and breast tumors.** *Frontiers in Immunology*, 14. https://doi.org/10.3389/fimmu.2023.1173379

CHOI, J.-W.; LEE, J.; LEE, J.-H.; PARK, B.-J.; LEE, E.J.; SHIN, S.; CHA, G.-H.; LEE, Y.-H.; LIM, K.; YUK, J.-M. **Omega-3 polyunsaturated fatty acids prevent *Toxoplasma gondii* infection by inducing autophagy *via* AMPK activation.** Nutrients, 11 (2019), p. 2137, 10.3390/nu11092137

CONG, W.; LIU, G.; MENG, Q.; DONG, W.; QIN, S.; ZHANG, F.; ZHANG, X.; WANG, X.; QIAN, A.; ZHU, X. (2015). ***Toxoplasma gondii* infection in cancer patients: prevalence, risk factors, genotypes and association with clinical diagnosis.** *Cancer letters*, 359 2, 307-13. https://doi.org/10.1016/j.canlet.2015.01.036

CONSENSUS AI. **AI-powered search engine for research** at https://consensus.app

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

Link at https://consensus.app/search/ha-muitos-relatos-de-casos-de-toxoplasmose-em-paci/0bVZif4iRyqOe_kslpQdrw/?utm_source=share&utm_medium=clipboard

COUTINHO, B.; ROMAGNOLI, L.; FERNANDES, AC; RIBEIRO, CMM; LEIRA, MF; BOLOGNANI, F. DE A.; GIORGI, J. DOS SJ; VARRICCHIO, MCBN. **Pharmaceutical preparations from Echinacea: immunomodulatory potential in cancer.** Brazilian Journal of Development, v.12, n.2, 2026. ISSN 2525-8761. DOI: https://doi.org/10.34117/bjdv12n2-088. Available at: https://ojs.brazilianjournals.com.br/ojs/index.php/BRJD/issue/view/316.
DE CARVALHO, C.C.C.R.; CARAMUJO, M.J. **The various roles of fatty acids.** Molecules, 23 (2018), p. 2583, 10.3390/molecules23102583

DE SOUZA, G.; SILVA, R.J.; MILIÁN, I.C.B.; ROSINI, A.M.; DE ARAÚJO, T.E.; TEIXEIRA, S.C.; OLIVEIRA, M.C.; FRANCO, P.S.; DA SILVA, C.V.; MINEO, J.R. *et al.* **Cyclooxygenase (COX)-2 modulates *Toxoplasma gondii* infection, immune response and lipid droplets formation in human trophoblast cells and villous explants.** Sci. Rep., 11 (2021), Article 12709, DOI: 10.1038/s41598-021-92120-3.

DUPONT, D.; ROBERT, M.; BRENIER-PINCHART, M.; LEFEVRE, A.; WALLON, M.; PELLOUX, H. (2023). ***Toxoplasma gondii*, a plea for a thorough investigation of its oncogenic potential.** *Heliyon*, 9. https://doi.org/10.1016/j.heliyon.2023.e22147

EBONG, P.E.; OWU, D.U.; ISONG, E.U. **Influence of palm oil (*Elaesis guineensis*) on health.** Plant Foods Hum. Nutr., 53 (3) (1999), pp. 209-222, 10.1023/A:1008089715153

ELKORAICHI, I.; MOIRÉ, N.; RAIS, S.; DIMIER-POISSON, I. ;DAOUDI, F., DEBIERRE-GROCKIEGO, F. Extracts of food and medicinal plants sold in Moroccan markets induce apoptosis-like in *Toxoplasma gondii* tachyzoites *in vitro.* Scientific African. V. 27, March 2025, e02529.

ENDO, M.; SHIGETOMI, K.; MITSUHASHI, S.; IGARASHI, M.; UBUKATA, M. **Isolation, structure determination and structure–activity relationship of anti-toxoplasma triterpenoids from *Quercus crispula* Blume outer bark.** J. Wood Sci., 65 (1) (2019), p. 3, 10.1186/s10086-019-1782-8.

EZZATKHAH, F.; MAHMOUDVAND, H.; RAZIANI, Y. **The role of *Curcuma longa* essential oil in controlling acute toxoplasmosis by improving the immune system**

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

and reducing inflammation and oxidative stress. Front. Cell. Infect. Microbiol., Sec. Parasite and Host. 26 April 2023. V.13. DOI: https://doi.org/10.3389/fcimb.2023.1161133

FERNÁNDEZ-SABÉ, N., CERVERA, C., FARIÑAS, M., BODRO, M., MUÑOZ, P., GURGUÍ, M., TORRE-CISNEROS, J., MARTÍN-DÁVILA,P., NOBLEJAS, A., LEN, Ò., GARCIA-REYNE, A., DEL POZO, J.; CARRATALÁ, J. (2012). **Risk factors, clinical features, and outcomes of toxoplasmosis in solid-organ transplant recipients: a matched case-control study.** Clinical infectious diseases : an official publication of the Infectious Diseases Society of America, 54 3, 355-61.https://doi.org/10.1093/cid/cir806 https://academic.oup.com/cid/article-abstract/54/3/355/303016?redirectedFrom=fulltext

FILLOY, A.; GARCIA-GARCIA, O.; FERNÁNDEZ-LORENTE, L. (2013). **Chorioretinitis as the First Sign of Acquired Toxoplasmosis Transmitted from Donor following Kidney Transplantation: Case Report and Review of the Literature.** Ocular Immunology and Inflammation, 21, 34 - 35. https://doi.org/10.3109/09273948.2012.726390

FRANCÍ, E.; ADEKUNLE, R.; NUCCI, M.; POUCH, S. (2023). **Complex considerations – Fever and pancytopenia after solid organ transplantation.** Transplant Infectious Disease, 25. https://doi.org/10.1111/tid.14079

GAY, J.; GENDRON, N.; VERNEY, C.; JOSTE, V.; DARDÉ, M.; LOHÉAC, C.; VRTOVSNIK, F.; ARGY, N.; HOUZÉ, S. (2019). **Disseminated toxoplasmosis associated with hemophagocytic syndrome after kidney transplantation: A case reportand review.** Transplant Infectious Disease, 21. https://doi.org/10.1111/tid.13154

GAYER, D. **Preventive measures against Toxoplasmosis**. Booklet, 2025. Link available at: https://sites.google.com/view/lipat/sapb-artigos?authuser=0#h.5k94zyaj8avd. Access in 2026, January 13.

GIORGI, J. DOS S.J.; COUTINHO, B.; LEIRA, M.F.; BOLOGNANI, F. DE A.; GIORGI, M.S.; PYRRHO, A. DOS S.; CASTELO BRANCO, MTL.; VARRICCHIO, MCBN. **Euphorbium (*Euphorbia resinifera*): a revision study.** PROJEÇÃO E DOCÊNCIA, v.17, n.1, de 2026. Curitiba. ISSN 2178-6275. DOI: https://doi.org/10.54899.rpd.v17n1-2561. Available at: https://projecaociencia.com.br/index.php/Projecao3/issue/view/190.

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

GOMES, N. B. DE N.; IABRUDI, R.C.; MACEDO REBELO, R. DE; GASPAR, S. A.; VARRICCHIO, M. C. B. N.; BRIOSO, P. S. T.; DA SILVA, S.; PYRRHO, A. DOS S. **Leishmaniose, produtos naturais, bioeconomia e desenvolvimento sustentável.** Brazilian Journal of Development. 2023. Disponível em: - https://ojs.brazilianjournals.com.br/ojs/index.php/BRJD/article/view/62510/44980

GOMES, N. B. DE N.; FREIRE SOUZA SILVA, F.; WASIM, N.; IABRUDI, R.C.; DA SILVA, S.; BRIOSO, P. S. T.; VARRICCHIO, M.C.B.N.; PYRRHO, A. DOS S. **Esquistossomose e o potencial bioeconômico brasileiro.** Brazilian Journal of Development. Curitiba, v.9, n.10, p. 28700-28711, oct., 2023a. Disponível em: https://ojs.brazilianjournals.com.br/ojs/index.php/BRJD/issue/view/220.

HANSEL-MARTINS, C.; VARRICCHIO, M.C.B.N.; PYRRHO,A. DOS S.; DA SILVA, J.; SILVA,E.P.; DA SILVA, S.; CASTELO BRANCO, M.T.L. **Post-COVID-19 syndrome: neurobehavioral disorders and the potential of functional foods for symptom relief.** Caderno Pedagógico, 2025, v.22, n.13. ISSN 1983-0882. DOI: https://doi.org/10.54033/cadpedv22n13-036. Link at: https://ojs.studiespublicacoes.com.br/ojs/index.php/cadped/issue/view/163

HÉBRAUD, B., KAMAR, N., BORDE, J., BESSIÈRES, M., GALINIER, M. ; ROSTAING, L. (2008). **Unusual presentation of primary toxoplasmosis infection in a kidney-transplant patient complicated by an acute left-ventricular failure.** NDT Plus, 1,429 - 432. Link at: https://doi.org/10.1093/ndtplus/sfn1593

HMIDOUCHE, O.; BOUFTINI, K.; CHAFIK, A.; KHOURI, S.; RCHID, H.; RAHIMI, A.; MIMOUNI, M.; MAAROUF, E.; ZAAKOUR, F.; NMILA, R.; KHOUCHLAA, A. **Ethnomedicinal Use, Phytochemistry, Pharmacology, and Toxicology of *Euphorbia resinifera* O. Berg. (B): A Review.** J. Zool. Bot. Gard. 2023, 4, 364–395. https://doi.org/10.3390/jzbg4020029.

HODGE, J., COGHILL, A., KIM, Y., BENDER, N., SMITH-WARNER, S., GAPSTUR, S., TERAS, L., GRIMSRUD, T., WATERBOER, T.; EGAN, K. (2021). ***Toxoplasma gondii* infection and the risk of adult glioma in two prospective studies.** *International Journal of Cancer*, 148, 2449 - 2456. https://doi.org/10.1002/ijc.33443

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

HUANG, M.; CAO, X.; JIANG, Y.; SHI, Y.; MA, Y.; HU, D.; SONG, X. **Evaluation of the Combined Effect of Artemisinin and Ferroptosis Inducer RSL3 against *Toxoplasma gondii.*** Int J Mol Sci. 2022, Dec 23; 24(1): 229. DOI: 10.3390/ijms24010229.

KA, F.; SALIBINDLA, D.; KENDLER, A. (2024). **Disseminated Toxoplasma Gondii Infection in a Deceased Donor Kidney Transplant Recipient: A Fatal Case Report.** American Journal of Clinical Pathology.162. DOI: https://doi.org/10.1093/ajcp/aqae129.007

KALANI, H.; SHAKIB, P.; FARIDNIA, R.; HO, J.; MARDANSHAH, O.; DOLATSHAH, M.; SEPAHVAND, A.; CHERAGHIPOUR, K.; ZIVDARIA, M. **Anti- *Toxoplasma gondii* Activity of Curcumin: A Systematic Review of Pre-clinical Studies. Infect Disord Drug Targets.** 2023; 23(2): e200822207821. DOI: 10.2174/1871526522666220820185637.

KALANTARI, N., GORGANI-FIROUZJAEE, T., HASSANI, S., CHEHRAZI, M.; GHAFFARI, S. (2020). **Association between *Toxoplasma gondii* exposure and hematological malignancies: A systematic review and meta-analysis.** *Microbial pathogenesis*, 104440. https://doi.org/10.1016/j.micpath.2020.104440

KHAN, T.A.; AL NASR, I.S.; MUJAWAH, A.H.; KOKO, W.S. **Assessment of *Euphorbia retusa* and *Pulicaria undulata* activity against *Leishmania major* and *Toxoplasma gondii*.** Tropical Biomedicine 38(1): 135-141 (2021) https://doi.org/10.47665/tb.38.1.023.

LIU, Q., WANG, Z., HUANG, S., ZHU, X. (2015). **Diagnosis of toxoplasmosis and typing of *Toxoplasma gondii*.** *Parasites & Vectors*, 8. https://doi.org/10.1186/s13071-015-0902-6

LIU, L.; WANG, P.; XU, J.; XIA, C. (2019). **Increased risk of *Toxoplasma gondii* infection in cancer patients: A meta-analysis of current evidence based on case-control study.** *Acta tropica*, 192, 30-40. https://doi.org/10.1016/j.actatropica.2019.01.010

MAO, E.Y.; PAGE, S.W.; SLEEBS, B.E.; GANCHEVA, M.R.; WILSON, D.W. **A review of natural products as a source of next-generation drugs against apicomplexan parasites.** npj Antimicrobials and Resistance, London, v. 3, n. 1, art. 51, 2025. DOI: 10.1038/s44259-025-00119-x. Disponível em: https://www.nature.com/articles/s44259-025-00119-x. Acesso em: 8 abr. 2026. https://www.nature.com/articles/s44259-025-00119-x

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

MARQUES-SANTOS, L. et al. **The search for drugs derived from natural products for *Toxoplasma gondii* infection treatment in the last 20 years: a systematic review.** Current Topics in Medicinal Chemistry, Sharjah, v. 24, n. 22, p. 1960-2000, 2024. DOI: 10.2174/0115680266294509240617064335. Available at: https://www.researchgate.net/publication/381914641_The_Search_for_Drugs_Derived_from_Natural_Products_for_Toxoplasma_gondii_Infection_Treatment_in_the_Last_20_Years_-_A_Systematic_Review. Accessed in: 2026, Apr 8.

MARTINA, M., CERVERA, C., ESFORZADO, N., LINARES, L., TORREGROSA, V., SANCLEMENTE, G., HOYO, I., COFÁN, F., OPPENHEIMER, F., MIRÓ, J., CAMPISTOL, J.; MORENO, A. (2011). ***Toxoplasma gondii* primary infection in renal transplant recipients. Two case reports and literature review.** Transplant International, 24. DOI: https://doi.org/10.1111/j.1432-2277.2010.01173.x https://onlinelibrary.wiley.com/doi/10.1111/j.1432-2277.2010.01173.x

MORADI, F.; DASHTI, N.; BAHADORAM, F.; NOURI, F. B.; FATEMI, A.; ZAHMATKESH, M. **Curcumin ameliorates chronic *Toxoplasma gondii* infection-induced affective disorders through modulation of proinflammatory cytokines and oxidative stress.** Iranian Journal of Basic Medical Sciences, Mashhad, v. 26, n. 4, p. 428-437, 2023. DOI: 10.22038/IJBMS.2023.68487.14937. Disponível em: https://pmc.ncbi.nlm.nih.gov/articles/PMC10008396/. Acesso em: 8 abr. 2026. https://pubmed.ncbi.nlm.nih.gov/37009013/

NAGAMUNE, K.; BEATTY, W.L.; SIBLEY, L.D. **Artemisinin Induces Calcium-Dependent Protein Secretion in the Protozoan Parasite *Toxoplasma gondii.*** ASM Journals/Eukaryotic Cell. 2007. Vol. 6, No. 11. DOI: https://doi.org/10.1128/ec.00262-07

OUATTARA, N.; ISSOUFOU-TINY, M.; MAGID, A.A.; ESCOTTE-BINET, S.; YAO-KOUASSI, P.A.; VILLENA, I.; VOUTQUENNE-NAZABADIOKO, L. Anti-*Toxoplasma gondii* screening of eight species used in Côte d'Ivoire, and bio-guided isolation of three previously undescribed nor-sesquiterpenoids and one benzyl glycoside from *Elaeis guineensis* leaves. Phytochemistry. V. 234, June 2025, 114442. https://www.sciencedirect.com/science/article/pii/S0031942225000652

PALHARINI, JG; RICHTER, AC; SILVA, MF; FERREIRA, FB; PIROVANI, CP; NAVES, KSC; GOULART, VA; MINEO, TWP; SILVA, MJB; SANTIAGO, FM. **Eutirucallin: A**

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

Lectin with Antitumor and Antimicrobial Properties. Frontiers in Cellular and Infection Microbiology. 2017 Apr 25;7:136. doi: 10.3389/fcimb.2017.00136 https://doi.org/10.3389/fcimb.2017.00136

PASTRE, M.J. **Jejunal response to *Toxoplasma gondii* infection in rats with different strains: an exploratory study of the serotonergic response to acute infection and the effects of immunostimulation by *Echinacea purpurea* in chronic infection.** 2022. 139 p. Thesis (Doctorate in Biosciences and Physiopathology) - State University of Maringá, 2022, Maringá, PR.

REBELO, R. DE M.; HAMMES, R. S. S.; CAVALCANTI, L. C.; GAYER, D. S.; VARRICCHIO, M.T.; VARRICCHIO, M.C.B.N.; DA SILVA, J.; PYRRHO, A. DOS S.; LAGE, C.L.S.; CASTELO BRANCO, M.T.L. **Environmental Pollution, Smoking and Public Health: Environmental Technology Resources.** Individual chapter in Sustainability and environmental management [e-book/livro eletrônico] Organização Dariane Cristina Catapan. -- 1. ed. -- Curitiba, PR: Editora Foco, 2025. ISBN: 978-65-83117-16-8. DOI: 10.54033/stebook.978-65-83117-16-8_4.

RENOULT, É., GEORGES, E., BIAVA, M., HULIN, C., FRIMAT, L., HESTIN, D.; KESSLER, M. (1997). **Toxoplasmosis in kidney transplant recipients: report of six cases and review.** Clinical infectious diseases: an official publication of theInfectious Diseases Society of America, 2 4 4, 625-34. https://doi.org/10.1093/clind/24.4.625

ROBERT-GANGNEUX, F. *et al.* Toxoplasmosis in transplant recipients, Europe, 2010–2014. **Emerging Infectious Diseases**, Atlanta, v. 24, n. 8, p. 1497-1504, 2018. DOI: 10.3201/eid2408.180045. Disponível em: https://pubmed.ncbi.nlm.nih.gov/30014843/.

SANCHEZ, S.; BESTEIRO, S. (2021). **The pathogenicity and virulence of *Toxoplasma gondii*.** *Virulence*, 12, 3095 - 3114. https://doi.org/10.1080/21505594.2021.2012346

SAPB-LIPAT PROJECT, Pharmacy Faculty of Federal University of Rio de Janeiro: **Toxoplasmosis, Refugées, Spiritual and Environmental Health Event**, 2018. Available at: https://sites.google.com/view/lipat/sapb-eventos_sapb?authuser=0#h.67d9h2wossw0. Acess in: 2026, January, 13.

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

SEPULVEDA-ARIAS, J.C.; VELOZA, L.A.; MANTILLA-MURIEL, L.E. **Anti-Toxoplasma activity of natural products: a review.** Recent Pat Anti infect Drug Discov. 2015; 9(3):186-94. DOI: 10.2174/1574891x10666150410120321.

SHIHAB, R., SULAIMAN, E.; ABDEEN, A. (2025). **The Relationship Between Toxoplasmosis and Prostate Cancer Patients.** *Indonesian Journal on Health Science and Medicine*. https://doi.org/10.21070/ijhsm.v2i1.58

SONG, Y., YUAN, H., YANG, X., YANG, Z., REN, Z., QI, S., HE, H., ZHANG, X., JIANG, T., YUAN, Z. (2024). **The opposing effect of acute and chronic *Toxoplasma gondii* infection on tumor development.** *Parasites & Vectors*, 17. https://doi.org/10.1186/s13071-024-06240-6

SOUNDARARAJAN, V.; SREENIVASAN, S. **Antioxidant activity of *Elaeis guineensis* leaf extract: an alternative nutraceutical approach in impeding aging.** APCBEE Procedia, 2 (2012), pp. 153-159, 10.1016/j.apcbee.2012.06.028.

TOW, W.K.; GOH, A.P.; SUNDRALINGAM, U.; PALANISAMY, U.D.; SIVASOTHY, Y. **Flavonoid composition and pharmacological properties of *Elaeis guineensis* Jacq. leaf extracts: a systematic review.** Pharmaceuticals, 24 (10) (2021), p. 961, 10.3390/ph1410096114

TEPONGNING, R.N.; MBAH, J.N.; AVOULOU, F.L.; JERME, M.M.; NDANGA, E.K.; FEKAM, F.B. **Hydroethanolic extracts of *Erigeron floribundus* and *Azadirachta indica* reduced *Plasmodium berghei* parasitemia in BALB/c mice.** Evid Based Complement Alternat Med, 21 (2018), Article 5156710, 10.1155/2018/5156710

US-FDA. U.S. FOOD AND DRUG ADMINISTRATION. **Foodborne illness – Toxoplasmosis.** Link at: https://www.fda.gov/food/people-risk-foodborne-illness/toxoplasma-prevention-you-become-pregnant-food-safety-moms-be?utm_source=chatgpt.com

VARRICCHIO, MCBN, NAGAMATSU, D.; BOLOGNANI, F. DE A.; GIORGI, MS.; BENTES LOPES, J.; PYRRHO, A DOS S.; DA SILVA, S.; CASTELO BRANCO, M.T.L.; DE FREITAS, F.J. ***Euphorbia tirucalli* dynamized and cancerinic state: reflections and evidences after 25 years of studies.** Caderno Pedagógico. v.22, n.12, 2025a. ISSN 1983-

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)

0882. DOI: https://doi.org/10.54033/cadpedv22n12-044. Available at: https://ojs.studiespublicacoes.com.br/ojs/index.php/cadped/issue/view/160.

WENDLING DA SILVA, AV; WASIM, N.; NAGAMATSU, D.; GASPAR, S.A.; VARRICCHIO, MCBN.; PYRRHO, A. DOS S.; DA SILVA, S. ***EUPHORBIA tirucalli,* Acupuncture and Biotechnological Potential of Latex: Preliminary Qualitative Evaluation and Perspectives.** Individual Chapter In Expanded Science: Innovation and Research. Pg. 555 – 573. ISBN: 978-65-6109-190-9. DOI: 10.56238/sevened2025.029-. 2025-07-01. Link at: https://sevenpubl.com.br/editora/issue/view/228

WORLD HEALTH ORGANIZATION. ***Toxoplasma gondii:* background document for the WHO Guidelines for drinking-water quality and the WHO Guidelines on sanitation and health.** Geneva: WHO, 2025. 17 p. Disponível em: https://iris.who.int/server/api/core/bitstreams/16951c0b-7865-4a79-890e-6e2da6206509/content. Acesso em: 31 mar. 2026.

XIAO, J.; YOLKEN, R. (2015). **Strain hypothesis of *Toxoplasma gondii* infection on the outcome of human diseases.** *Acta Physiologica*, 213. https://doi.org/10.1111/apha.12458

YANG, X., SONG, Y., YUAN, H., MAHMMOD, Y., YANG, Z., TAN, J., LIU, R., YANG, J., ZHANG, X., YUAN, Z. (2022). **Mechanism of Interaction Between Acute and Chronic *Toxoplasma gondii* Infection and Lung Cancer.** *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4208338

YAO, N.; XU, Q.; HE, J-K.; PAN, M.; HOU, Z-F.; LIU, D-D.; TAO, J-P.; HUANG, S-Y. **Evaluation of *Origanum vulgare* Essential Oil and Its Active Ingredients as Potential Drugs for the Treatment of Toxoplasmosis.** Front. Cell. Infect. Microbiol. Sec. Clinical and Diagnostic Microbiology and Immunology. 2021, November, 21. V. 11. Link at: https://doi.org/10.3389/fcimb.2021.793089

Recebido em: 09/04/2026
Aprovado em: 18/04/2026
Publicado em: 29/04/2026

A Revista OWL Journal está licenciada com uma Licença Creative Commons Atribuição (CC BY)