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(REVIEW ARTICLE)

The anti-parasitic activity of *Thymus vulgaris* (Thyme): A literature review

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Abstract

Thyme (*Thymus vulgaris)* is an enduring herb belonging to the mint family, *Lamiaceae*. It originates from the Mediterranean region and is characterized by its small, aromatic leaves, and sturdy stem. Appreciated for its robust and delightful scent, thyme is widely embraced as a culinary herb. However, its significance extends far beyond the kitchen, as it has been utilized medicinally for centuries. This is owing to the occurrence of active compounds like thymol and carvacrol, which possess noteworthy antibacterial, antioxidant, and anti-inflammatory attributes. Throughout history, thyme has been employed in the treatment of respiratory disorders, digestive ailments, and other diseases. The main objective of this study was to conduct an extensive review of the thyme plant, encompassing its classification, historical background, geographical distribution, chemical composition, and both economic and medicinal applications, particularly emphasizing its antiparasitic properties. In conclusion, apart from its well-known culinary and medicinal uses, scientific research has indicated that thyme exhibits promising effectiveness against diverse parasites. Notably, research has shown that thyme exhibited antiprotozoal activity against protozoan parasites such as *Giardia lamblia*, *Trichomonas vaginalis*, *Toxoplasma gondii*, *Entamoeba histolytica*, and others. Specific thyme extract components have shown great activity against these parasites. Thyme also has larvicidal properties, meaning that it can kill larvae. This includes *Anisakis* larvae, which can cause anisakiasis in humans. Thyme essential oil has been shown to effectively eliminate these larvae, suggesting that it could be used to prevent anisakiasis. Furthermore, it has also been studied for its potential to treat hepatic coccidiosis in rabbits. Research has shown that thyme oil, along with *Moringa oleifera* oil, can effectively reduce the number of oocysts shed by infected rabbits and improve the clinical signs of the infection. This suggests that thyme oil may be a promising therapeutic agent for tackling hepatic coccidiosis.

Keywords: Thyme; *Thymus vulgaris*; *Lamiaceae*; Anti-Parasitic; Medicinal use; Chemical constituents

1. Introduction

Thymus vulgaris (thyme) is a medicinal perennial botanical herb that belongs to the mint family, the *Lamiaceae* family, which is one of the largest flowering plant families in general, with approximately 220 genera and 4,000 species worldwide. It is also referred to as common thyme (Al-Rawi and Chakravarty, 1988; Preedy, 2015). Furthermore, *T. vulgaris L.*, also known as "garden thyme," is a flowering, aromatic plant; additionally, the word "*thymus*" may have derived from the Greek word thuô, which means fumigation, or from thio, which means perfume; on the other hand, "*vulgaris*" is the Latin word for "common" (Novak and Blüthner, 2020). Moreover, others claim that genus the *Thymus* includes more than 350 species found all over the world, including numerous taxa such as satureja, oregano, and thymus

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(Al-Fatimi et al., 2010). Thyme is an intriguing herb that has been recognized for thousands of years, having been utilized by ancient civilizations such as the Greeks, Sumerians (3500 BC), and Egyptians. Although *T. capitatus* is believed to be the most probable species, it was the Romans who introduced thyme to Northern Europe. Later on, European settlers transported it to North America around the 16th century (Amouretti and Comet, 1993). Notably, the Romans played a significant role in spreading thyme across Europe, where they employed it to cleanse and perfume their rooms. They also used it as a flavorful addition to cheese and alcoholic beverages. The Romans held the belief that the combination of thyme and water in bathing contributed to energy transmission. Furthermore, Pliny, the Roman scientist and philosopher, recommended burning dried thyme to eliminate harmful organisms in the surrounding area (Grieve, 1931; Hanrahan and Odle, 2005). Furthermore, thyme is widely distributed worldwide, regardless of its original location, whether it is in southern Europe or any other region (Hosseinzadeh et al., 2015). Several factors contribute to its extensive spread. Firstly, thyme is a plant that thrives in arid and harsh environments, particularly in dry and unshaded soil. It favors constant exposure to sunlight and coarse, mountainous terrain with well-drained soil. Interestingly, these conditions are not suitable for the growth of many other plant species, giving thyme a competitive advantage in its propagation (Javed et al., 2013; Kuete, 2017). Garden or common thyme, scientifically known as *T. vulgaris*, is an herbaceous plant known for its delightful aroma. Moreover, its flowers, leaves, and oil are frequently utilized to add flavor to various dishes and possess medicinal properties. It contains natural compounds that have the potential to assist in the treatment of bacterial and fungal infections. In addition, it is also known for its effectiveness in alleviating coughs and its antioxidant properties. Throughout history, thyme has been employed to address an array of health concerns, including coughs, alopecia areata (patchy hair loss), dementia, and various other ailments (Büechi et al., 2005; Conrad and Kemmerich, 2006). With a rich history in traditional medicine, thyme has been utilized for centuries to address various health conditions, particularly respiratory disorders. In addition, it has emerged as a versatile herb with numerous potential health benefits that have long been acknowledged. Over time, it has transitioned from a folk remedy to a credible choice in scientific phytotherapy, supported by scientific evidence demonstrating its effectiveness in treating diverse diseases. Also, thyme shows promise for enhancing cognitive function and memory retention. It serves as an excellent complement to any diet and can be easily incorporated into meals or taken as a supplement to maximize its health benefits (Abd El Kader and Mohamed, 2012; Dauqan and Abdullah, 2017).

2. Scientific classification and Morphology

Thyme belongs to the extensive plant family Labiatae (*Lamiaceae*), which accounts for the abundance of thyme species. The exact number of species is a topic of debate, with one claim suggesting 928 species. Among these, *Thymbra, Micromeria, Satureja*, and *Origanum* are considered the most significant. Identifying the chromosomes of thyme species is challenging due to their tiny size and similar morphological characteristics. Nevertheless, the classification of *Thymus* species is strongly associated with their chromosomal information, which is considered an essential feature in the classification process. *Thymus* is a notable genus that includes a diverse range of unique species. Therefore, thyme, as a widely distributed plant, consists of numerous species and genera (Al-Fatimi et al., 2010; Patil et al., 2021). The scientific classification of *T. vulgaris* is further explained in detail below.

- **Kingdom**: *Plantae*
- **Class**: *Magnoliopsida*
- **Order**: *Lamiales*
- **Family**: *Lamiaceae*
- **Subfamily**: *Nepetoideae*
- **Genus**: *Thymus* L.
- **Species**: *Thymus vulgaris* L. (Prasanth et al., 2014).

Thyme has been recognized since ancient times; nevertheless, the formal description of the *T. vulgaris* species was first documented over 270 years ago in the initial edition of Linné's book Species Plantarum in 1753. However, there may have been earlier descriptions by Dodonaeus in 1616 and Bauhin in 1623 (Novak and Blüthner, 2020). It is crucial to emphasize that *T. vulgaris* is a semi-evergreen, aromatic perennial herbaceous shrub. The height of the stem can reach 10–50 cm and spans 40–50 cm in width, depending on the temperature and geographical conditions. The plant features several branches that are either upright or creeping (Dajawi, 1996; Morales, 2002; Hanrahan and Odle, 2005). Additionally, the stem of thyme has a quadrangular shape and tends to become woody as it ages. Depending on the variety, the stem can appear slender or even square (Morales, 2002). Its leaves are characterized by their small size, noticeable color contrast, and oblong-linear to lanceolate shape. They are typically marked with glandular spots and do not exceed lengths of 5–10 mm, with widths ranging from 0.8–2.5 mm. The leaves also have distinctive margins that are frequently present (Malhotra and Peter, 2012). Furthermore, the shape and density of the hairs on these leaves vary significantly, which can be attributed to the diverse types of thyme. Each type of thyme leaf has its own unique aroma,

distinct from the scent of other species. Thyme plants prefer sunlight and do not thrive in shaded areas, as sunlight is essential for their optimal growth (Prasanth et al., 2014).The plant produces small flowers that range in color from pink to purple. These blossoms possess a remarkable fragrance, attributed to their high concentration of essential oils. The flowers are characterized by a sinuous tube and have sepals measuring 3–4 mm in length. The appearance of the flowers, much like the leaves, can vary depending on whether they are found in the wild or cultivated (Tutin et al., 1976; Morales, 2002). Lastly, the fruits of the thyme plant are tiny and consist of capsules containing clusters of wrinkled black seeds. These fruits are visually distinctive due to their unique shape, fragrance, and slightly sweet taste. It is noteworthy that *T. vulgaris* seeds are easy to cultivate and can thrive in various soil types (Davis, 1982; Dajawi, 1996; Hanrahan and Odle, 2005).

3. Origin and Distribution

Despite its widespread existence across numerous regions worldwide, there is a significant divergence in determining the native habitat of thyme. Some argue that thyme is native to the western Mediterranean region, including areas from Spain and the Balearic Islands to southern Italy. Conversely, other researchers contend that it originates from southern and central Europe, along with parts of Africa and Asia (Amouretti and Comet, 1993; Silva et al., 2021). Moreover, natural populations of *T. vulgaris* have been observed in a number of geographical locations, including the northern regions of the western Mediterranean, such as Spain, France, and Italy, as well as the Italian Alps, Portugal, and Greece (Rey, 1989; Cabezudo et al., 2009). Regardless of whether its origin can be attributed to Southern Europe or another location, there is undeniable evidence that thyme is a plant that has achieved global distribution. It can be found abundantly not only in the European Mediterranean region as a whole but also in North African countries like Egypt, Libya, Tunisia, and Morocco. Furthermore, it thrives in various African countries, such as Nigeria and Cameroon. Additionally, thyme is well-established in the European countries situated along the coastal regions of the Mediterranean Sea, as previously mentioned (Stahl-Biskup and Sáez, 2002; Hosseinzadeh et al., 2015).

4. Chemical Constituents

Overall, there is unquestionable evidence that the common thyme plant contains numerous chemical constituents with significant benefits and applications. However, the phytochemical profile of *T. vulgaris*, particularly its monoterpenes, varies due to various factors such as genotype, environmental conditions, and cultivation practices. These factors include aspects like location, altitude, cultural practices, harvest time, drying methods, and storage conditions (Novak and Blüthner, 2020). Several studies have been conducted to identify the chemical ingredients of *T. vulgaris L*. using different techniques such as gas mass spectrometry (GCMS), high-performance liquid chromatography (HPLC), and thin-layer chromatography (HPLC/HPTLC). These studies have concluded that thyme primarily consists of a wide range of chemical compounds classified as phenolic compounds, terpenoids, flavonoids, stimulants, alkaloids, tannins, and saponins. Most of these compounds are volatile chemicals derived from plant oils (Abdelli et al., 2017; Al-Asmari et al., 2017). Impressively, thyme possesses a notable concentration of flavonoids and phenolic antioxidants, including zeaxanthin, lutein, apigenin, naringenin, luteolin, and thimonin. Moreover, among all herbs, thyme stands out for having the highest levels of antioxidants, particularly when it is fresh. Additionally, it is rich in minerals and vitamins, which are crucial for maintaining good health, thus establishing it as an exceptional herb due to its significant chemical components (Komaki et al., 2016). Whereas thyme contains various essential chemicals such as carvacrol, eugenol, linalool, apigenin, rosmarinic acid, and many others, thymol, which is 2-isopropyl-5-methylphenol, stands out as the most well-known compound. Thymol is a monoterpenoid phenol found in *Thymus vulgaris* and other plants of the *Lamiaceae* family (Buckingham, 1995; Javed et al., 2013). Numerous studies have revealed that thyme, especially its leaves and essential oils; contain approximately 40 active phenols and terpenoids. The concentrations of these compounds vary depending on the type of thyme. Phenols such as thymol and carvacrol are prominent constituents, with a concentration of 51.34%. Other compounds present include Pinen, Limonene, Cymen, and monoterpene hydrocarbons. Thyme extracts also exhibit oxygenated monoterpenes (56.53%), sesquiterpene hydrocarbons (5.04%), oxygenated sesquiterpenes (1.84%), and four butanol-soluble acetophenone glycosides (Hänsel et al., 1994). It is worth mentioning that a study conducted on Moroccan thyme using GC/FID and GC/MS identified 43 chemical compounds, which accounted for 97.85% of the total contents of the 1% oil sample. The main components observed included camphor, camphene, β-pinene, 1,8-cineole, borneol, and β-pinene. Camphor was found to be the most abundant compound, comprising 38.54% of the total, followed by camphene at 17.19%. β-pinene and 1,8-cineole made significant contributions to the oil composition, accounting for 9.35% and 5.44%, respectively. Borneol and β-pinene were also present in notable concentrations, constituting 4.91% and 3.90% of the total, respectively. These findings provide insights into the chemical constituents of Moroccan thyme oil and highlight its potential applications in medicine, cosmetics, and food production (Imelouane et al., 2009). Besides, approximately 100 grams of thyme leaves are estimated to contain around 276 calories, 7.8% water, 9.1 grams of protein, and 7.4 grams of fat. They also provide

approximately 64 grams of carbohydrates and around 19 grams of fiber. Thyme leaves are rich in important minerals, including 1890 mg of calcium, 201 mg of phosphorus, 123.6 mg of iron, 220 mg of magnesium, 55 mg of sodium, and 814 mg of potassium. The zinc content is approximately 6.2 mg. Thyme leaves are known to contain various essential vitamins and minerals, making them a valuable addition to any diet. They provide 3800 mg of vitamin A, serving as an excellent source of this crucial nutrient. Thyme leaves also offer 0.51 mg of thiamine (B1), 0.4 mg of riboflavin (B2), and 4.94 mg of niacin. Overall, thyme leaves are a nutrient-rich food that provides a wide range of essential minerals and elements (Duke and Ayensu, 1985).

5. Economical and Edible Uses

Thyme has long been acknowledged for its multitude of advantages, spanning medicinal, economic, and nutritional realms, dating back to ancient civilizations like the Egyptians and Romans. Its aromatic nature has made it a popular choice for fragrance throughout history. Moreover, thyme remains a prominent ingredient in culinary applications, adding flavor to cheese, meat, beverages, and herbal mixtures. Its essential oil content also lends itself to the treatment of hair loss and dental plaque(Mewes et al. 2008; Hosseinzadeh et al. 2015; Satyal et al. 2016).Thyme is increasingly employed in the manufacturing of various cosmetics, including shampoos, toothpastes, hair conditioners, colognes, soaps, detergents, and creams (Lawrence and Tucker, 2002).Moreover, it a versatile plant that has been utilized by various industries throughout history. In addition to its culinary uses, it has been employed in diverse applications such as deodorants, pesticides, sedatives, and stimulants. Its antibacterial properties make it a valuable ingredient in deodorants and personal care products.Thyme oil acts as a natural repellent against pests, effectively warding them off from plants and homes. As a sedative, thyme can alleviate tension and promote relaxation. Conversely, it can also serve as a stimulant, boosting energy levels and enhancing focus. With its distinct flavor profile and ability to enhance the taste of other ingredients, thyme is commonly incorporated into appetizers (Duke, 2002; Mandal and DebMandal, 2016).The applications of this plant also extended to the preservation of food products such as meat, chicken, and fish, in addition to its usage for ornamental purposes, flowering, perfumery, and fumigation industries (Basch et al., 2004; Mogoşanu et al., 2017; Vouillamoz and Christ, 2020).It is important to highlight that two key chemical components present in thyme, namely thymol and carvacrol, possess insecticidal properties that are effective against a wide range of insects. These chemicals have demonstrated potential as natural alternatives to synthetic pesticides due to their effectiveness and low toxicity to humans and the environment. They can disrupt the nervous system of insects, inhibit their feeding, and affect their growth and development (Szczepanik et al., 2012). Moreover, thyme leaves and flowers are used in their raw form in salads, as well as for garnishing and adding flavor to cooked dishes. Additionally, it should be mentioned that thyme tea can be prepared using either fresh or dried leaves (Lust, 1983; Facciola, 1990; Bown, 1995).

6. Medicinal Uses

Thyme has been historically utilized in traditional medicine for treating various ailments. The herb is renowned for its anti-inflammatory and antioxidant properties. It is rich in vitamins and minerals. Throughout the centuries, thyme has been employed to address respiratory disorders such as bronchitis and asthma, as well as digestive issues such as bloating and indigestion. Moreover, thyme has exhibited antibacterial characteristics that aid the body in combating harmful microorganisms. Topically, thyme oil is utilized to treat skin conditions such as acne and eczema (Khare, 2008; Patil, et al., 2021; Taher et al., 2021). Meanwhile, thyme exhibits antibacterial, antiviral, antispasmodic, mild analgesic, and expectorant properties. It is used for the treatment of coughs and colds. The German Commission has approved the use of *T. vulgaris* in the treatment of bronchitis, whooping cough, and upper respiratory catarrh. Additionally, it is employed for the treatment of stomatitis. The flavonoid fraction has demonstrated significant effects on smooth muscle in the trachea and ileum. Thymol, one of the essential chemical constituents of thyme, serves as an expectorant and antibacterial agent. Whereas thymol and carvacrol possess spasmolytic characteristics. Furthermore, thymol exhibits anti-anthelmintic properties in addition to a urinary system antiseptic (Duke, 2002; Khare, 2008; Nabissiet al., 2018).Moreover, the utilization of *T. vulgaris L*. for wound treatment is widely recognized due to its undeniable healing and antibacterial properties. It is also significant to highlight that in ancient Europe, the aerial parts of this plant were employed for fumigation and the treatment of various skin and respiratory ailments, and these practices continue to be prevalent in most regions of the world nowadays (Basch et al., 2004; Kuete, 2017). In addition to the aforementioned properties, thyme also possesses anti-rheumatoid arthritis, anti-calcium, carminative, diuretic, expectorant, fungicide, hypolipidemic, hypotensive, and mucolytic properties (Duke, 2002).Additionally, *T. vulgaris L*. is believed to possess astringent and carminative properties, and it appears to be effective in combating intestinal infections as well as infections caused by ascarids, hookworms, fungi, yeast, and bacteria. It has also been utilized in the treatment of various skin issues, including acne, greasy skin, dermatitis, insect bites, sciatica, and rheumatic pain (Diánez et al., 2018; Gucwa et al., 2018; Tian et al., 2018). Besides its antibacterial properties, thyme exhibits antiviral activity, specifically against

the HSV-1 and HSV-2 viruses, including the resistant strain of HSV-1. Additionally, thyme is employed in the treatment of laryngitis, diarrhea, and gastritis. It is important to mention that thyme also possesses antifungal and anti-yeast properties (Leung and Foster, 1996; Abe et al., 2003). Aljelehawy et al. conducted a study investigating the diverse pharmacological effects of thymol, a naturally occurring compound found in thyme and other plants. Researchers have attributed several properties to thymol, including anti-neurodegenerative, anti-cancer, and anti-diabetic effects. The anti-neurodegenerative effect of thymol is thought to be associated with its ability to protect neurons against damage caused by oxidative stress. Likewise, its anti-inflammatory properties have been linked to antirheumatic activity, as thymol has demonstrated the ability to suppress pro-inflammatory cytokines. Thymol's efficacy as an anticancer agent is attributed to its ability to induce apoptosis (programmed cell death) in cancer cells and inhibit their proliferation and invasion. as well, thymol has shown potential as an anti-diabetic agent by improving glucose tolerance and insulin sensitivity (Aljelehawy et al., 2023).Numerous studies have extensively documented the antibacterial and antioxidant properties of the plant. For instance, Aldosary et al. (2021) conducted a study investigating the antioxidant and antimicrobial effects of *T. vulgaris* essential oil and its combination with silver nanoparticles. The researchers found that the essential oil displayed significant antioxidant activity, characterized by high levels of total phenolic and flavonoid content. Moreover, the essential oil exhibited antibacterial activity against various bacterial species, including *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* (Aldosary et al., 2021).It is fascinating to note that this herb is recognized as an herbal remedy for enhancing activity in cases of anxiety, offering a natural alternative for addressing physical and mental weakness, as well as potentially aiding in the treatment of insomnia. *T. vulgaris* contains various flavonoids such as thymol, carvacrol, eugenol, phenols, luteolin, and tetramethoxylates, which contribute to its medicinal properties. Additionally, several recent studies have suggested the use of thyme as a potential alternative for cancer prevention (Abd El Kader and Mohamed, 2012).Tonsillitis and gum disease can be treated externally and topically with this plant. The whole herb is utilized for treating digestive problems, soothing sore throats, managing fevers, and addressing various other health conditions. Thyme essential oil holds significant importance in the field of aromatherapy as well (Westwood, 1991; Bown, 1995). Furthermore, this plant has been employed as a pain reliever, including for menstrual pain in women, as evidenced by the study conducted by Salmalian et al. The study revealed that both *T. vulgaris* and ibuprofen were effective in reducing the severity of menstrual pain. This suggests that *Thymus vulgaris* could be as beneficial as ibuprofen in alleviating symptoms of primary dysmenorrheal (Salmalian et al., 2014).

7. Anti-Parasitic activity of *T. vulgaris*

A pathogenic parasite is characterized as an organism that relies on the host for its nutrition and vitality, nonetheless instead of benefiting the host, it causes harm. On the other hand, a parasitic disease is defined as an infectious disease caused by parasites, including protozoa and helminthes, and may also include arthropods (ectoparasites) that either directly induce disease or function as carriers for various infections. Overall, parasitic diseases of various kinds are considered a public health concern that poses a threat to human and animal well-being, as well as the environment, in numerous regions across the globe (Wang, 2017; Hikal, 2020). The range of parasitic ailments can vary from minor symptoms to potentially life-threatening conditions if left untreated. The severity and prevalence of these diseases differ across different geographical regions, with developing countries often being the most affected. Parasitic tropical diseases encompass a variety of types, with notable examples including lymphatic filariasis, schistosomiasis, onchocerciasis, leishmaniasis, African trypanosomiasis, malaria, and others (Hikal et al., 2021). Shockingly, it is estimated that around 200,000 people lose their lives each year due to severe ailments caused by approximately 300 species of helminthes and 70 species of protozoa that can lead to parasitic diseases in humans. It is worth noting that the pharmacopoeia used to treat neglected tropical diseases has seen limited changes since the mid-20th century, possibly because these diseases disproportionately affect the most impoverished populations worldwide (Hotez et al., 2006; Melo et al., 2017). Since relying solely on medication to tackle parasitic diseases is insufficient, as the environment, water, and food serve as significant sources of infection, it is noteworthy to note that indiscriminate use of pharmaceuticals can contribute to the development of drug resistance among parasites. As a result, the significance of medicinal plants in research has been acknowledged, as they provide an alternative approach to treating parasitic infections (Strothmann et al., 2022). Consequently, there has been a shift in focus towards medicinal herbs as a safe and natural therapeutic alternative to combat parasites. Among these plants, *T. vulgaris L*. stands out as one of the most significant, with numerous studies demonstrating its anthelmintic properties. This plant has gained a strong reputation within the medical community for its remarkable efficacy in treating intestinal diseases and infections caused by roundworms and hookworms (Stahl-Biskup, and Venskutonis, 2012; Patil et al., 2021).

7.1. The anti-parasitic activity of *Thymus vulgaris* against *Trypanosoma spp*

The protozoan parasite *Trypanosoma cruzi* is responsible for causing Chagas disease, also known as American trypanosomiasis. The transmission of this parasite occurs through triatomine bugs, commonly referred to as "kissing bugs," which infect both humans and animals in Central and South America. It is noteworthy that this devastating

disease affects an estimated 11 million individuals in the New World, spanning from Argentina to the southern United States of America. Furthermore, due to migration patterns, the disease has become increasingly prevalent in numerous other countries across the globe, with significant cases identified in Canada, North America, Europe, and Australia.(Coura and Vi˜nas, 2010).The life cycle of *Trypanosoma cruzi* includes several stages. The parasite undergoes replication in the stomach of the insect vector, known as a triatomine bug, in the form of replicating trypomastigotes. When the bug feeds on blood, it excretes waste, releasing infective trypomastigote forms onto the skin. These trypomastigotes can enter the host through mucous membranes, or insect bite sites. Once inside the host, *T. cruzi* transforms into intracellular amastigotes, which multiply in various tissues, including the heart muscle, digestive system, and brain system. Furthermore, amastigotes possess the ability to invade and propagate within the cells of several organs, leading to tissue damage and inflammation (Gunn and Pitt, 2022). On the other hand, the protozoan parasite *Trypanosoma evansi* is responsible for surra, also known as surra fever. This disease affects animals, with a particular emphasis on domestic livestock like cattle, horses, camels, and water buffaloes. Nevertheless, it has the ability to infect other animals, including dogs, cats, in addition to humans (More et al., 2017). Controlling *T. cruzi* is a daunting task due to its ability to infect not only humans but also a diverse array of domestic and wild species. This includes dogs, cats, bats, rats, and armadillos (Gunn and Pitt, 2022). Due to the toxicity, high cost, inefficacy, rapid development of drug resistance, and frequent recurrence rates observed with current available medications, as well as their detrimental impact on both trypanosomes and the organs of the host, where they accumulate metabolic waste products causing damage, there has been a shift in focus towards herbal medicine. This shift aims to explore natural alternatives that do not have any side effects(Tasdemir et al., 2005; Gressler et al., 2012).

In an effort to explore potential effects on *Trypanosoma*, researchers have directed their attention towards thyme. In a study conducted by Farrag et al. (2021), the anti-trypanosomal activity of aqueous extracts from thyme (*Thymus vulgaris*), mint (*Mentha piperita*), and cardamom (*Elettaria cardamomum*) against *Trypanosoma evansi* was investigated. Among the three extracts, thyme was found to exhibit the highest efficacy in terms of its trypanocidal activity. *In vitro* experiments revealed that thyme, mint, and cardamom aqueous extracts at doses of 2500, 2000, and 1000 µg/ml, respectively, immobilized *T. evansi* parasites. Furthermore, the extracts demonstrated a reduction in both the number of parasites and their infectivity. In an animal model, rats were infected with *T. evansi* and subsequently treated with aqueous extracts of thyme, mint, and cardamom, as well as the reference medication Intropar®. All three extracts demonstrated effectiveness in reducing parasitemia and enhancing the survival rates of the infected rats (Farrag et al., 2021). On another hand, Santoro et al. (2007) conducted a study on the *in vitro* impact of oregano (*Origanum vulgare L.*) and thyme (*Thymus vulgaris L.*) essential oils on *Trypanosoma cruzi*, the parasite responsible for Chagas disease. Both essential oils exhibited effectiveness in inhibiting the growth of *T. cruzi*. The IC_{50} values for oregano and thyme essential oils were determined to be 175 and 77 µg/ml, respectively. This indicates that oregano essential oil inhibited the growth of 50% of *T. cruzi* cells at a concentration of 175 µg/ml, while thyme essential oil achieved the same inhibition at a concentration of 77 µg/ml. The researchers also examined the ultrastructure of *T. cruzi* cells treated with oregano and thyme essential oils, revealing induced morphological abnormalities, including cytoplasmic enlargement, plasma membrane rupture, and flagella damage. These findings suggest that oregano and thyme essential oils possess anti-trypanosomal properties. Further research is necessary to validate these findings and investigate the mechanisms of action underlying these essential oils' effects (Santoro et al., 2007).

7.2. The anti-parasitic activity of T. vulgaris against Echinococcus granulosus

Echinococcus granulosus is a parasitic tapeworm capable of infecting both animals and humans. It is recognized as the main cause of cystic echinococcosis (CE), commonly known as hydatid disease. Adult tapeworms mostly inhabit the small intestines of dogs and other canids. Moreover, the eggs are excreted in the feces of infected dogs and can remain viable in harsh environmental conditions for several years. Human infection can occur through various routes, such as direct contact with contaminated soil, ingestion of contaminated food or water, or inhalation of the eggs. Upon ingestion, the eggs hatch in the human intestines, and the larvae migrate to different organs, including the liver, lungs, and brain. Consequently, the larvae can trigger a range of symptoms, including cough, fever, weight loss, nausea, vomiting, jaundice, seizures, headaches, and visual impairments (Budke et al., 2006; Bogitsh et al., 2018). Among the studies conducted in this field, Pensel et al. (2014) conducted research on the effectiveness of thyme (*Thymus vulgaris*) and oregano (*Origanum vulgare*) essential oils against *Echinococcus granulosus*. The study focused on *in vitro* experiments using isolated cells and cell clumps from hydatid cysts. The researchers examined the impact of various doses of essential oils on cell viability and reproduction. The results indicated that both thyme and oregano essential oils demonstrated efficacy in eliminating *E. granulosus* cells. Notably, thyme essential oil exhibited greater effectiveness compared to oregano essential oil, even at lower doses. The study concluded that both thyme and oregano essential oils possess antiparasitic potential for the treatment of cystic echinococcosis (CE) (Pensel et al., 2014).In addition, Fabbri et al. (2016) conducted a study to evaluate the effectiveness of carvacrol against *Echinococcus granulosus* both *in vitro* and *in vivo*. Interestingly, carvacrol is a highly significant chemical compound present in several plant species, with common

thyme being the most notable source (Buckingham, 1995; Javed et al., 2013). For more detailed insights, the study was conducted using *in vitro* methods, utilizing isolated cells and cell clumps obtained from hydatid cysts. Carvacrol, at various concentrations, was evaluated to assess its impact on cell viability and proliferation. Remarkably, carvacrol exhibited effectiveness in eliminating *E. granulosus* cells, with (LC_{50}) of 10µg/ml required to kill 50% of the cells. Furthermore, the results demonstrated that carvacrol impeded the growth of *E. granulosus* cells. The investigation also explored the *in vivo* efficacy of carvacrol by infecting mice with *E. granulosus* and subsequently administering carvacrol. Encouragingly, carvacrol was found to reduce the number of cysts in mice. In conclusion, this study revealed that carvacrol possesses antiparasitic properties, which could be utilized as a potential treatment for cystic echinococcosis (Fabbri et al., 2016).

7.3. The anti-parasitic activity of *T. vulgaris* against *Leishmania spp.*

Leishmania, a pathogenic parasite, is responsible for causing leishmaniasis, a group of diseases that can affect both humans and animals. The transmission of this parasite occurs through the bites of sand flies. Leishmaniasis can be categorized into two main types: cutaneous and visceral. Cutaneous leishmaniasis results in the development of skin ulcers, while visceral leishmaniasis affects internal organs such as the spleen, liver, and bone marrow. Additionally, the parasite exists in two distinct forms: promastigotes and amastigotes. Promastigotes represent the motile form of the parasite found within sand flies, while amastigotes are the non-motile form that thrives inside the host's cells. The life cycle of *Leishmania* commences when a sand fly, which injects the promastigotes into the host's bloodstream, bites an infected animal or human. Subsequently, they migrate to either the skin or internal organs, where they multiply and initiate the disease. The course of the disease caused by *Leishmania* varies based on the parasite species and the immune response of the host. In certain instances, the infection may remain asymptomatic or result in only mild symptoms. However, in other cases, the infection can progress to a severe and potentially life-threatening condition. Symptoms of *Leishmania* infection may include fever, weight loss, anemia, and skin lesions. Besides, in some cases, the infection can affect internal organs like the liver and spleen (Ridley, 2012; Zeibig, 2012). It is crucial to note that research on the antiparasitic properties of the thyme plant has expanded to include the *Leishmania* parasite. In one study, Nilforoushzadeh et al. (2008) assessed the efficacy of three herbal extracts, namely thyme, yarrow, and propolis, in treating cutaneous leishmaniasis in Balb/c mice. These herbal extracts were compared to systemic glucantime, a commonly used therapy for cutaneous leishmaniasis. The results of the study demonstrated that the herbal extracts were more effective than glucantime in reducing lesion size. The thyme group exhibited a 43.29% reduction, the propolis group showed a 43.77% reduction, and the yarrow group demonstrated a 36.09% reduction in lesion size. In contrast, the glucantime group only exhibited an average reduction of 22.57% in lesion size. The laboratory animals tolerated the herbal extracts well, as indicated by the research. Based on their findings, the authors concluded that the herbal extracts of thyme, yarrow, and propolis could be beneficial in treating cutaneous leishmaniasis in mice (Nilforoushzadeh et al., 2008). Furthermore, Agha and Baaj (2018) conducted a study in the same context, aiming to examine the chemical composition of the volatile oil present in the leaves of *Thymus vulgaris L*. and evaluate its anti-*Leishmania* activity, specifically against *Leishmania infantum*, the causative agent of visceral leishmaniasis. Remarkably, the results demonstrated the significant efficacy of thyme volatile oil in combating visceral leishmaniasis. Based on the outcomes of this investigation, the authors concluded that thyme volatile oil holds immense potential as a natural treatment for bacterial infections, as well as visceral leishmaniasis (Agha and Baaj, 2018).

7.4. The anti-parasitic activity of T. vulgaris against Haemonchus contortus

Haemonchus contortus is a parasitic nematode, commonly known as a roundworm, which infects ruminant animals, particularly sheep and goats. This parasite is considered one of the most economically significant and detrimental parasites affecting small ruminants worldwide. *Haemonchus contortus* sustains itself by feeding on the blood of its host, leading to anemia and severe damage to the abomasum, the fourth compartment of the ruminant stomach. The intensity of the infection depends on factors such as the number of worms present, the age and nutritional status of the host, as well as the presence of concurrent ailments. Without proper treatment, heavy infestations can result in weight loss, stunted growth, decreased milk production, and, in severe cases, even death (Roberts and Janovy, 2000; Emery et al., 2016). Research on the antiparasitic properties of thyme has expanded its focus to include veterinary applications. One study in this field aimed to investigate the effects of *Thymus vulgaris L*. essential oil and its main component, thymol, on the parasitic worm *Haemonchus contortus*. The researchers obtained mature *Haemonchus contortus* worms from naturally infected sheep and exposed them to different concentrations of *Thymus vulgaris* essential oil and thymol. They examined the effects on egg hatching, larval growth, and adult motility. Astonishingly, the study revealed that both *Thymus vulgaris* essential oil and thymol exhibited significant anthelmintic activity against *Haemonchus contortus*. The essential oil demonstrated dose-dependent effects in inhibiting egg hatching and larval growth. Thymol, the primary active ingredient of thyme essential oil, displayed a highly effective mechanism for restricting larval development and reducing the movement of adult worms. These promising findings undoubtedly open up new possibilities for the potential use of thyme in veterinary applications (Ferreira et al., 2016).

7.5. The anti-parasitic activity of *T. vulgaris* against *Blastocystis hominis*

Blastocystis hominis is a highly prevalent parasite worldwide, with observed cases reaching up to 60% in tropical, subtropical, and poor countries (Tan, 2004). An anaerobic parasite relies on oxygen-free environments to survive. However, the majority of infected individuals do not display any symptoms. Some people may experience symptoms such as diarrhea, stomach discomfort, gas, and weight loss. These symptoms can resemble those of other digestive conditions like irritable bowel syndrome or food poisoning, making diagnosis challenging. Unfortunately, there is no specific treatment available for this disease, and in most cases, the infection resolves on its own. However, certain patients may require antibiotics or mainstream antiparasitic drugs. *Blastocystis hominis* is believed to spread through the fecal-oral route, which means it can be transmitted by consuming contaminated food or water. Currently, there is no vaccine to prevent human infection. Additionally, this parasite can reproduce both sexually and asexually through processes such as binary fission and the extension and retraction of pseudopodia (Tan, 2004; Cuomo et al., 2009; Mehlhorn, 2010). El-Sayed (2009) conducted a study to assess the effectiveness of sweet basil (*Ocimum basilicum*) and common thyme (*Thymus vulgaris*) extracts against *Blastocystis hominisin vitro*. Fresh leaves of the plants were used to prepare the extracts, which were then assessed against *B. hominis*. The study findings demonstrated that thyme extract inhibited the development of thetrophozoites by 98.2% at a concentration of 100 mg/ml,additionally; the growth of *B. hominis* cysts was inhibited by 99.64% at the same concentration of thyme extract. These results indicate that ethanol extracts of sweet basil and thyme have the potential to act as agents against *Blastocystis hominis*. The emergence of anti-*Blastocystis hominis* properties in sweet basil and thyme extracts is significant in the field of medication, particularly because there are limited treatment options available for this protozoan parasite. Notably, thyme extract demonstrated encouraging results in inhibiting the development of *B. hominis* trophozoites and reducing cyst growth at a concentration of 100 mg/ml. These findings suggest that natural plant extracts could serve as a viable alternative to conventional medications for the treatment of *B. hominis* infections (El-Sayed, 2009).

7.6. The anti-parasitic activity of *T. vulgaris* against *Cryptosporidium spp.*

Cryptosporidium is a parasitic protozoan that can cause diarrhea in both humans and animals. It is present in the feces of infected individuals and can be transmitted through contaminated water, food, or surfaces. The onset of symptoms typically occurs within 2–10 days after infection and can persist for several weeks. While the disease is usually mild in individuals with a healthy immune system, it can be more severe in those with weakened immune systems. Due to its resistance to many disinfectants, *Cryptosporidium* necessitates boiling water or filtering to be removed. A study revealed that between 2005 and 2015, *Cryptosporidium* spp. caused over 1 million deaths, with half a million occurring in children under the age of 5, and more than 71 million disability-adjusted life years (DALYs) were affected. Developing countries, particularly those in sub-Saharan Africa, experienced the highest rates of mortality (Schmidt and Roberts, 2013; Meurs et al., 2017). In a particular investigation, rats were spotted to determine the occurrence of *cryptosporidium* infection and assess the potential impact of thyme extract. The results indicated that thyme extract demonstrated effectiveness in both preventing and treating rat cryptosporidiosis. Particularly the prophylactic group of rats treated with thyme extract exhibited significantly lower levels of *Cryptosporidium parvum* infection compared to the control group. Furthermore, the treatment group displayed substantially reduced infection levels compared to the infected group. These impressive findings led the researchers to conclude that administering thyme extract orally is a safe and effective treatment for rats exhibiting cryptosporidiosis (Kara et al., 2023).In further research, the impact of essential oils, including thyme and its major constituents such as thymol and carvacrol, on *Cryptosporidium baileyi* and *Cryptosporidium galli* oocysts was assessed using a direct contact technique. The results revealed that all essential oils and their major components were capable of eliminating both forms of *Cryptosporidium*. Thymol, carvacrol, and eugenol exhibited the highest effectiveness, with LC_{50} values below 0.4 mg/ml (the dosage required to eliminate 50% of the oocysts). Given that the other essential oils had slightly higher LC_{50} values, they still demonstrated efficacy in eradicating the oocysts. Hence, the researchers concluded that essential oils, including thyme and its core constituents, held significant potential as a novel therapy for cryptosporidiosis (Tanghort et al., 2019).

7.7. The anti-parasitic activity of T. vulgaris against Toxoplasma gondii

Toxoplasma gondii is a protozoan parasite capable of infecting humans and other warm-blooded animals. Intriguingly, it possesses the distinction of being the most pervasive parasitic infection worldwide, with an estimated 2–3 billion individuals affected. The parasite can be transmitted through numerous means, including the feces of infected cats, consumption of undercooked meat, contaminated water, and soil that may harbor the parasite (Tanter et al., 2000). In most individuals, *T. gondii* infection typically does not cause any obvious symptoms. However, certain people, such as pregnant women, newborn babies, and individuals with compromised immune systems, are likely to experience more severe effects. The symptoms of toxoplasmosis can vary depending on the individual's immune status. In individuals with a healthy immune system, the disease often remains asymptomatic. Nonetheless, some people may develop mild flu-like symptoms (Mohanty et al., 2012; Torgerson and Mastroiacovo, 2013). Moreover, *T. gondii* has the potential to

cause serious congenital defects in infected fetuses, such as hydrocephalus and intellectual impairments. In addition, neonates infected with *T. gondii* might develop chorioretinitis, a potentially serious eye ailment. On the other hand, patients with compromised immune systems, such as those suffering from HIV/AIDS, are more vulnerable to severe toxoplasmosis. Fever, headache, muscular soreness, exhaustion, convulsions, and the existence of brain lesions are all possible symptoms (Zeibig, 2014; Leventhal and Cheadle, 2019).In a study conducted by Eraky et al. (2016), researchers investigated the effects of an ethanolic extract derived from *Thymus vulgaris* on chronic toxoplasmosis in mouse models in order to evaluate the potential therapeutic impact of thyme on *Toxoplasma gondii*. The findings of the study demonstrated that this extract possesses significant preventive and therapeutic properties against chronic toxoplasmosis. Prior to infection with *T. gondii*, the mice were administered the extract for a duration of 5 days. Remarkably, the mice treated with the alcoholic extract of thyme exhibited a lower number of brain cysts compared to the control group. Subsequently, following infection, the infected mice received the extract for 10 days as part of the treatment investigation. As a result, the treated mice displayed considerably fewer brain cysts and reduced degenerative damage in comparison to the control group, which is an encouraging outcome. The study suggests that the alcoholic extract of thyme holds potential as a novel natural medicinal agent for the treatment of chronic toxoplasmosis (Eraky et al., 2016).Another study, in line with the previous research conducted by Farag et al. (2019), aimed to investigate the therapeutic effectiveness of ethanolic extracts derived from *Thymus vulgaris and Myristica fragrans* Houtt (Nutmeg) against toxoplasmosis using a rat model. The study unambiguously demonstrated that both extracts were successful in reducing the number of brain cysts and the associated damage caused by *Toxoplasma gondii*. It is worth noting that their study utilized a rat model, and the extracts were administered orally for duration of 10 days. Besides, the results indicated that both extracts were effective in reducing brain cysts in rats with toxoplasmosis, while the thyme extract showing greater efficacy compared to the nutmeg extract. Importantly, both extracts were well tolerated by the rats and did not induce any significant side effects. The study suggested that both nutmeg and thyme extracts have the potential to be utilized as therapeutic agents for toxoplasmosis. However, further research is necessary to validate these findings, establish the optimal dosage, and determine the appropriate duration of treatment (Farag et al., 2019).

7.8. The anti-parasitic activity of *T. vulgaris* against *Entamoeba histolytica*

Entamoeba histolytica, a unicellular parasite, is responsible for the development of amoebic dysentery, a highly hazardous gastrointestinal disorder. This infection is common worldwide, affecting a significant number of individuals, estimated to be between 50 and 100 million. The parasite is transmitted through the fecal-oral route, through the consumption of contaminated food or water. Additionally, contact with contaminated soil or objects that are contaminated can also contribute to its transmission. Upon ingestion, the active form of the parasite, known as trophozoites, migrate to the intestines, where they cause inflammation and the formation of ulcers. Amoebic dysentery manifests through symptoms such as diarrhea, abdominal discomfort, fever, and the existence of blood in the stool. The main drugs utilized for the treatment of E. histolytica infection are metronidazole and iodoquinol. Even though these medications effectively eradicate the parasite, they can also result in side effects such as nausea, vomiting, and diarrhea (Chou and Austin, 2020). Behnia et al. (2008) conducted a study to investigate the potential anti-amoebic properties of different extracts derived from thyme (*Thymus vulgaris*) against *Entamoeba histolytica*. The results indicated that all tested extracts displayed some degree of inhibitory effect on the growth of *E. histolytica*, with the hydroalcoholic extract showing the highest efficacy. The minimum inhibitory concentration (MIC) of the hydroalcoholic extract was determined to be 4 mg/ml, demonstrating that this concentration was sufficient to hinder parasite development. Importantly, the research revealed that thyme extracts operated through a distinct mechanism compared to the commonly used drug metronidazole, which is an encouraging finding. Metronidazole is known to alter the parasite's DNA, whereas thyme extracts were observed to cause damage to the parasite's cell membrane. In conclusion, the study suggested that thyme extracts could potentially serve as an alternative treatment for *E. histolytica* infection (Behnia et al., 2008).

Dardona and Al-Hindi (2014) conducted another study to investigate the effects of various extracts, including thyme (*Thymus vulgaris L.*), on *Entamoeba histolytica*. Their research demonstrated that all the tested extracts exhibited some amoebicidal effect on *E. histolytica*. Among them, the alcoholic extract of pomegranate (*P. granatum* pulp) was determined to be the most effective. The study revealed that while thyme extracts do possess some anti-amoebic activity, they are not as potent as other plant extracts, such as pomegranate. Moreover, the study findings showed that thyme extracts do not exhibit a synergistic effect when combined with metronidazole (Dardona and Al-Hindi, 2014).

7.9. The anti-parasitic activity of *T. vulgaris* against *Toxocara vitulorum*

Toxocara vitulorum is a parasitic worm frequently prevalent in tropical and subtropical regions, predominantly infecting cattle, buffalo, zebu, and sheep. The adult worms are large and appear white, whereas their eggs range in size from 69 to 95 µm in length and 60 to 77 µm in width. The life cycle of this parasite is relatively uncomplicated, with

vertical transmission through milk being the major mode of transmission. In calves, infection with *T. vitulorum* can result in stunted growth, inflammation of the intestines (referred to as catarrhal enteritis), diarrhea, intestinal blockage, and peritonitis. Water buffalo, in particular, are highly susceptible, exhibiting severe anemia, diarrhea, loss of appetite, and weight loss, which can be fatal. Treatment choices include the administration of benzimidazoles and ivermectin, which help prevent the larvae from reaching maturity within the 3–6-week age range (Woodbury et al., 2012). In the study conducted by Amin and El-Kabany (2013), the aim was to examine the protective and therapeutic effects of thyme oil derived from *Thymus vulgaris* on *Toxocara vitulorum* (*T. vitulorum*) infection in rats. Interestingly, the results demonstrated that thyme oil exhibited both protective and therapeutic effects against *T. vitulorum* infection in rats. Specifically, rats that received thyme oil prior to being infected with *T. vitulorum* showed a significantly lower likelihood of developing VLM (visceral larva migrans) compared to rats that did not receive thyme oil. Furthermore, rats that were already infected with *T. vitulorum* and subsequently treated with thyme oil displayed noticeable improvements in their clinical symptoms and a reduction in the parasite load within their bodies. Based on these findings, the study concluded that thyme oil shows great potential as a natural product for both the prevention and treatment of *T. vitulorum* infection (Amin and El-Kabany, 2013).

7.10. The anti-parasitic activity of *T. vulgaris* against *Anisakis simplex*

Anisakis simplex is a parasitic nematode that can cause anisakiasis, a foodborne disease, in humans. The larvae of this nematode are found in the stomachs of marine mammals such as whales, dolphins, and seals. When these mammals defecate, the larvae are released into the water, where fish can ingest them. Within the fish, the larvae mature into adults. If humans consume raw or undercooked fish containing *Anisakis* larvae, the larvae can penetrate the intestinal wall and cause an infection. The most common symptoms of anisakiasis include abdominal pain, nausea, vomiting, and diarrhea. In some cases, anisakiasis may also trigger allergic reactions such as hives, angioedema, and anaphylaxis (Pravettoni et al., 2012). Giarratana et al. (2014) conducted a study to examine the therapeutic properties of thyme essential oil (TEO) in eradicating *Anisakis* larvae. The findings revealed that TEO demonstrated significant larvicidal activity against *Anisakis* larvae when assessed in laboratory conditions. At concentrations of 10% and 5%, TEO caused complete mortality of the larvae within 7 and 14 hours, respectively. Even at lower concentrations, TEO exhibited some effectiveness, although it required a longer time to achieve larval death. Based on these findings, the researchers suggest that TEO has the potential to be used as a larvicidal agent for the prevention of anisakiasis. They also propose the incorporation of TEO into the industrial marination process as a means to eliminate *Anisakis* larvae in seafood products (Giarratana et al., 2014).

7.11. Other Parasites

Thyme's ability to combat parasites extends beyond the ones mentioned and has been observed against various parasites over time. For instance, in a particular study, the researchers investigated the antiprotozoal activity of a thyme methanol extract against three different protozoan parasites: *Giardia lamblia*, *Trichomonas vaginalis*, and *Entamoeba histolytica*. They divided the extract into various components, or fractions, and assessed the antiprotozoal activity of each fraction. Furthermore, the methanol extract of thyme exhibited significant antiprotozoal activity against all three parasites. The fraction containing ursolic acid showed the highest activity, with IC50 values of 8.12 µg/ml against *G. lamblia* and 5.51 µg/ml against *T. vaginalis*. In addition, these findings suggest that thyme has potential as a natural antiprotozoal agent (Garza-González et al., 2017).Yet, investigations into the antiparasitic characteristics of thyme have extended to *Trichinella spiralis*, a parasitic nematode known to cause trichinellosis in humans. In a certain study, researchers examined the effects of myrrh and thyme extracts on both the enteral and parenteral phases of *T. spiralis* infection in mice. The extracts were administered orally or intraperitoneally, followed by infection with *T. spiralis* larvae. The scientists assessed the larval count in the mice's tissues and the expression of inducible nitric oxide synthase (iNOS) in these tissues. Intriguingly, both myrrh and thyme extracts demonstrated efficacy in reducing the number of larvae in the mice's tissues. During the enteral phase of infection, the myrrh extract exhibited greater effectiveness in reducing larvae; however, the thyme extract showed more effectiveness during the parenteral phase. Moreover, both extracts increased the expression of iNOS in the mice's tissues (Martins et al., 2015).Thyme has also been shown to be effective in treating ascariasis, a parasitic infection caused by the roundworm *Ascaris caninum*. A study was conducted to evaluate the effectiveness of thyme extract as a treatment for naturally infected puppies with ascariasis. The puppies were divided into two groups: the treatment group received oral administration of thyme extract for 10 days; meanwhile the control group did not receive any treatment. The researchers evaluated the number of worms detected in the puppies' feces and observed their clinical symptoms. The results of the study showed that the thyme extract was effective in reducing the number of worms present in the puppies' feces. At the end of the study, the treatment group exhibited significantly fewer worms compared to the control group. Additionally, the puppies in the treatment group developed fewer clinical symptoms associated with ascariasis compared to the control group. These findings suggest that thyme extract may be a safe and effective treatment for ascariasis in puppies. However, further research is needed to confirm these findings and determine the optimal dosage and duration of treatment (Duru et al., 2023).Eventually, Abu El Ezz et

al. (2020) evaluated the therapeutic effects of *Moringa oleifera* and *Thymus vulgaris* oils on hepatic coccidiosis in experimentally infected rabbits. Their study aimed to assess the efficacy of these oils in treating hepatic coccidiosis, a parasitic infection of the liver caused by the protozoan parasite *Eimeria stiedae*. This infection can be fatal in rabbits, and currently, there are no approved drugs available for its treatment. The findings of the study indicated that both *Moringa oleifera* and *Thymus vulgaris* oils showed effectiveness in treating hepatic coccidiosis in rabbits. These oils were able to decrease the number of oocysts, which are the infective stages of the parasite, shed by the rabbits. Likewise, the oils improved the clinical signs associated with the infection. Based on these results, the study concluded that both *Moringa oleifera* and *Thymus vulgaris* oils have potential as treatments for hepatic coccidiosis in rabbits (Abu El Ezz et al., 2020).

8. Conclusion

The present investigation revealed that Thyme has been utilized for millennia for its therapeutic benefits, which are attributed to the existence of bioactive compounds such as thymol, carvacrol and others. These compounds have antibacterial, antioxidant, and anti-inflammatory effects. Thyme has long been used to heal respiratory diseases, digestive issues, and as a natural disinfectant. In addition to its traditional usage, thyme has been demonstrated to have antiparasitic particularly, antiprotozoal, and larvicidal activity against a variety of parasites and diseases. Ongoing research continues to reveal the therapeutic properties of thyme, confirming its significance in both traditional and modern medicine.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no competing interests.

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