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A Review of Coccidiosis in Small Ruminants and Antiparasitic Activity of Essential Oils Worldwide

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ABSTRACT

Coccidiosis has been reported to cause severe economic losses in the small ruminants livestock industry. Subclinical coccidiosis is common among small ruminants and clinical occurs mainly in young's animals. Coccidiosis is caused by highly host-specific *Eimeria* species. Strategies to control traditionally rely on the use of management practices combined with anticoccidial treatments. The development of alternative, safer, and eco-friendly anticoccidial agents have become a priority in most parts of the world. Essential oils have been shown to exhibit antiparasitic activity and may control protozoal pathogens. The purpose of this review is to provide an overview of *Eimeria* species in sheep and goats and demonstrated the life cycle, clinical signs, diagnosis, andpotency use of essential oilssuch as *Rosmarinus officinalis, Origanum vulgare (lamiaceae) and Citrus spp. (citraceae)*as antiparasit in the treatment of coccidiosis.

Keywords: *Eimeria* sp., Essential Oils, Goat, Sheep

INTRODUCTION

Small ruminants are important domestic animals (More *et al*., 2015). Sheep and goats have been recognized as important livestock that contributes significantly to the food security and economy of developing countries (Thlama *et al*., 2016). Goat production is an important component of the livestock sector that contributes to food and nutritional security, incomes and sustainable agriculture especially in developing countries (Namutosi *et al*., 2019). Sheep are regarded as being one type of potential livestock that are widely raised invarious regions around the world for both purposes of producing meat and wool (Gondipon and Malaka, 2021).

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Sheep and goats share many health problems (Pezzanite *et al*., 2022). Internal parasites (or endoparasites) of various taxonomic groups, including protozoans (coccidians) infect ruminant livestock (Verocai, 2020). Parasites significant impact on domestic ruminant health and production fora long time (Maurizio *et al*., 2021). Parasitic infection is a serious constrain to health and productivity of the livestock in tropical and sub-tropical parts of the world (Kumar *et al*., 2016). They are responsible for high morbidity, weight loss, poor reproductive status and likely mortality in livestock (Grzybek *et al*., 2016). The prevalence of *Eimeria* infection in sheep and goats in Geneffe village, Suez Governorate, Egypt was (60%) of goats and (57.70%) of sheep were suffering from subclinical coccidiosis *(Mohamaden et al*., 2018). Infection by more than one species of gastrointestinal parasites in sheep while grazing is common (Yan *et al*., 2021). *Eimeria* spp. infections are one of the most economically significant diseases of sheep and goats (Hassanen *et al*., 2020).

Coccidiosis is a common disease in ruminants worldwide and causes significant economic losses in livestock (Bangoura & Bardsley, 2020). The observed morbidity usually between 10- 40 %, but mortality often is more than 10% (Albayati *et al*., 2020). Economic losses may reach 341 million dollars annually in the United States(de Macedo *et al*., 2020). However, for some parasites (e.g., Coccidia), acquired immunity plays an important role, causing a higher resistance to infection in adult animals (Casini *et al*., 2021). Lambs are more susceptible to coccidiosis, especially in stressful conditions, being infected by different parasite (Martins *et al*., 2020).

Small ruminant coccidiosis is an apicomplexan disease caused by different species of the genus *Eimeria*, which causes severe enteritis and/or typhlocolitis (Hermosilla *et al*., 2016). Coccidiosis caused by *Eimeria*sp. have been reported to cause severe economic losses in small ruminants livestock industry (Khor *et al*., 2018). Ingestion of contaminated food and water are the main source of infection and the symptoms of the disease (Majeed *et al*., 2020). The prevalence rate of coccidiosis is higher during the rainy season because it is positively influenced by the warm and humid weather (Mohammed & Alobaidii, 2021).

Parasite control is an important concern in sheep and goat production systems (Junkuszew *et al*., 2015). Coccidiosis is mostly treated with synthetic anticoccidial drugs but this approach is facing a serious threat of development of resistance in *Eimeria* strains (Zhou *et al*., 2020). Plant extracts provide a possible natural source for such drugs (Daiba *et al*., 2022). The popularity of Essential Oils in the animal field and health has increased rapidly during the last decade (Nehme *et al*., 2021). Some studies have reported

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the *in vivo* efficacy of natural plant extracts in the treatment of coccidiosis (Ashraf *et al*., 2020). The purpose of this review is to provide an overview of *Eimeria* species in sheep and goats and demonstrated the life cycle, clinical signs, diagnosis, andpotency use of essential oils such as *Rosmarinus officinalis, Origanum vulgare (lamiaceae)* and *Citrus spp. (citraceae)* as antiparasit in the treatment of coccidiosis.

REVIEW(S)

Small Ruminants Coccidiosis

Etiology

Coccidiosis is one of the most widely distributed parasitic diseases throughout the world (Sufi *et al*., 2017), common disease in ruminants worldwide and causes significant economic losses in livestock; it is caused by highly host-specific *Eimeria* species (Bangoura & Bardsley, 2020). The productivity of smallholder sheep and goat flocks is constrained by high morbidity and mortality of young stock due to helminthosis and coccidiosis (Paul *et al*., 2020). Mostly lambs aged between four and eight weeks (Kyriánová *et al*., 2017). Young animals are the most susceptible, but adult animals can alsobe affected and become a source of infection (Santos *et al*., 2022). The global prevalence of coccidia is high; infections are common in all ruminants and most infections involve multiple species (Bangoura & Bardsley, 2020).

Coccidiosis is species–specific (More *et al*., 2015). Each species infects a specific cell type of the gut (Gondipon and Malaka, 2021). Ingestion of excessive amounts of soil could potentially result in uptake of high numbers of *Eimeria* spp. oocysts as they can survive for at least 1 year in soil (Odden *et al*., 2018). The genus *Eimeria* causes the death of a large number of host intestinal cells and enterocytes leading to reduced absorbance of the critical electrolytes and nutrients (Ahmadi *et al*., 2021).

Eimeria sp. in Sheep

Sheep in Colombian Northeastern Mountain were infected with helminths and coccidian (Carlos *et al*., 2019). The *Eimeria* species were identified as *E. crandallis, E. granulosa, E. ovina, E. parva, E. faurei, E. ovinoidalis, E intricate, E. pallida, E. arloingi,* and *E. ahasta* in sheep (Mohamaden *et al*., 2018).The most prevalent species was *E. ovinoidalis* (Kyriánová *et al*., 2017). *E. ahsata* was pathogenic in lambs and the macro and microscopic lesions were mostly seen in the jejunum (Ahmadi *et al*., 2021). Other ovine *Eimeria* species with pathogenic effects include *E. crandallis* and *E. bakuensis* (Bangoura & Bardsley, 2020). The wide distribution of this protozoan and the high frequency of pathogenic species show the importance and potential damage of sheep coccidiosis (Martins *et al*., 2020). The distribution of *Eimeria* species were identified in the sheep shown in table 1.

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Table 1. The distribution of *Eimeria* species were identified in sheep

Location	Species *Eimeria*	References
Czech Republic	*E. ovinoidalis, E. crandallis, E. parva, E. intricata*	Kyriánová *et al*., 2017
Indonesia	*E. ahsata, E. intricate, E. parva*	Cahyaningsih and Supriyanto, 2007
Egypt	*E. ahsata, E. pallida, E. intricata, E. ovinoidalis, E. marsica, E. bakuensis, E. faurei, E. granulosa, E. crandallis,E. parva*	Hassanen*et al*., 2020
Brazil	*E. ovinoidalis, E. granulosa, E. faurei, and E. crandallis,E. ovinoidalis and E. crandallis*	Souza *et al*., 2015
Southern Brazil	*E. ovinoidalis,E. crandallis, E. granulosa, E. parva,E. ahsata, E. punctata, E. bakuensis,E. faurei, E. pallida*	Martins *et al*., 2020
Eastern Algeria	*E. intricata, E. bakuensis, E. ovinoidalis, E. crandallis, E. parva, E. weybridgensis, E. pallida, E. ashata*	Meradi, 2021
Suez, Egypt	*E. crandallis, E. granulosa, E. ovina, E. parva, E. faurei, E. ovinoidalis, E intricate, E. pallida, E. arloingi, E. ahasta*	Mohamaden *et al*., 2018
Iraq	*E. ahsata, E. weybridgensis, E. ovinoidalis, E. bovis, E. auburnensis.*	Majeed *et al*., 2020
Dakahlia, Egypt	*E. ahsata, E. bakuensis, E. crandallis, E. faurei, E. granulosa, E. intricata, E. marsica, E. ovinoidalis, E. pallida, E. parva and E. webybridgensis.*	Abbas *et al*., 2020

Eimeria sp. in Goat

The coccidia infestations were prevalent in goats located in the highlands and foothills (Matsepe, 2021). *Eimeria ninakohlyakimovae, E. hirci, E. caprina, E. christenseni, E. jolchijevi, E. apsheronica* and *E. arloingi* in goats (Mohamaden *et al*., 2018).Coccidiosis in goats is seasonally occurring disease, most commonly affecting animals of less than one year age (Sharma *et al*., 2017). *Eimeria ninakohlyakimovae* in goats are the most pathogenic species (Chartier & Paraud, 2012).The distribution of *Eimeria*species were identified in the goat shown in table 2.

Life Cycle of *Eimeria* species

The life cycle of *Eimeria*species contains 3 major phases; the first 2 phases are internal (asexual and sexual replication), followed by environmental sporogony (sporulation) (Bangoura & Bardsley, 2020). *Eimeria* required single

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Table 2. The distribution of *Eimeria* species were identified in goat

Location	Species *Eimeria*	References
India	*Eimeria arlongi, E. ninakohlyakimovae, E. hirci, E. christenseni and E. caprina*	Singh *et al*., 2020
Egypt	*E. arloingi, E. alijevi, E. ninakohlyakimovae, E. hirci,E. christenseni, E. aspheronica, E. jolchijevi, E. caprina, E. caprovina*	Hassanen, 2020
India	*E. arloingi, E. ninakohlyakimovae,E. christenseni, E. aljivae, E. hirci, E. capriovina*	Sharma *et al*., 2017
Suez, Egypt	*E. ninakohlyakimovae, E. hirci, E. caprina, E. christenseni, E. jolchijevi, E. apsheronica, E. arloingi*	Mohamaden *et al*., 2018

host to complete its life cycle which pass in different stages including schizogony, gametogony and sporogony (Majeed *etal*., 2020). Ingested oocysts release sporozoites that invade the epithelial cells of the small intestine and transform into schizonts. The schizonts begin their asexual multiplication (schizogony), releasing schizozoites that invade the epithelial cells of the large intestine where sexual multiplication occurs (gamogony) that will lead to the formation of non sporulated oocysts that will be released with the feces into the external environment (Meradi, 2021). The infectivity potential of oocysts is dependent upon the sporulation rate and wall structure, which for *Eimeria* spp. provides a strong defense and resilience to chemical, mechanical and physically damaging stressors including anti-coccidia and other antimicrobial substances (Balta *et al*., 2021). The high oocysts excretion may involve poor hygiene, high stocking rates in premises, breeding intensification and causes of physiological and nutritional stress (Singh *et al*., 2020). The life cycle of *Eimeria* species shown in figure 1.

Clinical Sign

Subclinical coccidiosis is common among small ruminants (Mohamaden *et al*., 2018), and characterized by poor growth (Tammy & Keeton, 2018). Subclinical infection of in adult sheep cause loses in animal production especially for animals under stress including susceptible animals imported to a new environment (Jawasreh & Qader, 2013). Clinical coccidiosis occurs as a result of ingestion of large numbers of sporulated oocysts and/or asexual multiplication in the host as a result of decreased resistance of the animal (Gibbons *et al*., 2016). The health losses of goats due to endoparasite infection include weight loss, dehydration, fatigue, while severe infections can cause diarrhea (Abdillah *et al*., 2021).

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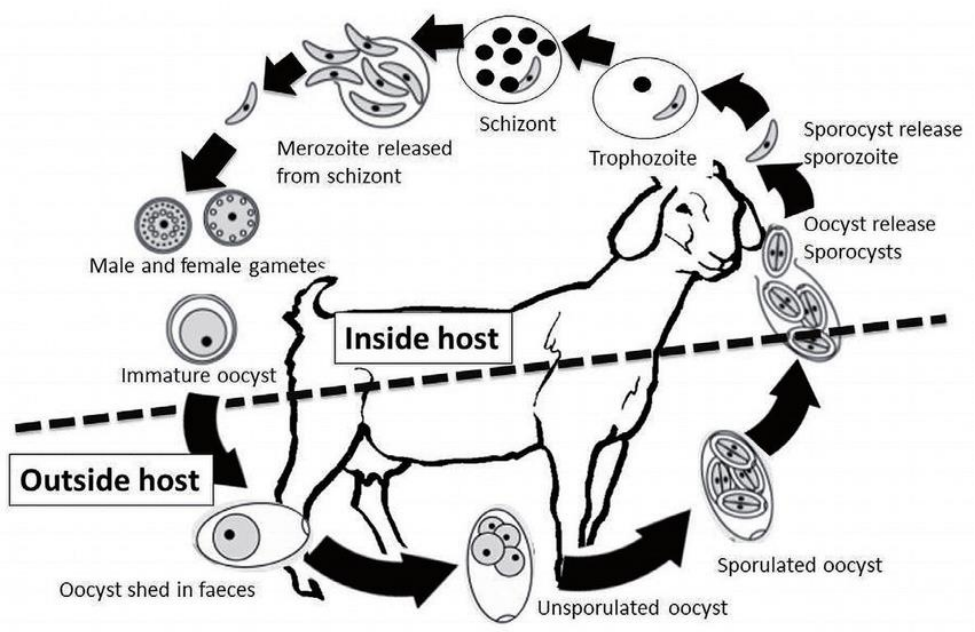

Figure 1. The life cycle of *Eimeria* species in goat (Bawm & Lat Htun, 2021).

Clinical Coccidiosis causes diarrhea, dullness, abdominal pain, leading to dehydration and lose of weight (Engidaw *et al.*, 2020).

Diagnosis

Diagnosis is often based only onclinical symptoms or presence of oocysts in feces(Kyriánová *et al*., 2017). Fecal examination is foremost for detecting parasites of the gastrointestinal tract (Verocai, 2020). Fecal parasitology tests are broadly classified as either qualitative or quantitative (Verocai, 2020). *Eimeria* diagnosis usually depends on morphological detection of the oocysts by light microscope (Mohamaden *et al*., 2018). The species were determined based on themorphology of oocysts (color, form index, shape, presenceor absence of residual as well as oocystic mass, presence orabsence of micropyle and its cap, polar and stieda bodies)and sporulation time (Singh *et al*., 2020). The McMaster is the most widely useddilution Fecal Egg Counts (FEC) method (Verocai, 2020). Oocysts per gram of feces (OPG) were examined using the modified McMaster technique with saturated saline solution to determine the parasitic load (Hao *et al*., 2018). Molecular detection of *Eimeria* species in fecal samples helpful for experimental and diagnostic purposes (Reginato *et al*., 2020). Morphology of sporulated *Eimeria* oocysts in feces of black goats in Liangshan, Chinashown in figure 2.

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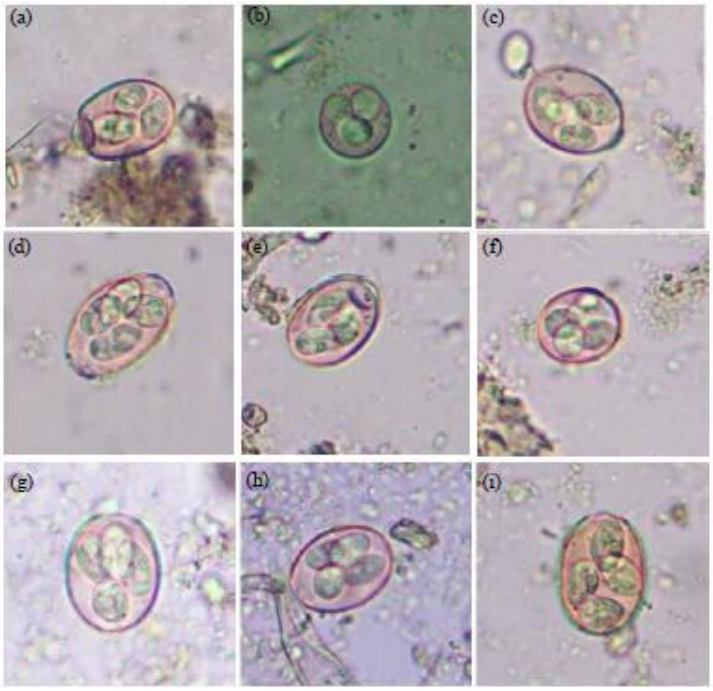

Figure 2. Sporulated *Eimeria* oocysts in feces of black goats in Liangshan prefecture, 400×magnification, (a) *E. arloingi*, (b) *E. alijevi*, (c) *E. hirci*, (d) *E. christenseni*, (e) *E. jolchijevi*, (f) *E. ninakohlyakimovae*, (g) *E. caprina*, (h) *E. caprovina* and (i) *E. apsheronica* (Hao *et al*., 2018).

Treatment, Control, and Prevention

Effective control and management programs should be applied including proper usage of anticoccidials to improve the health and productivity of the animals (Akyüz *et al*., 2019). Strategies to control goat coccidiosis traditionally rely on the use of management practices combined with anticoccidial treatments (Barba *et al*., 2022). The largest serving anticoccidial agents in small animals and poultry are Sulfonamide drugs. They include Sulfadimethoxine, Sulfaquinoxaline, and Sulfamerazine, Sulfachloropyrazine (Garba *et al*., 2020). The treatment and prevention of coccidiosis in goats is costly to backyard farmers (Gonzaga *et al*., 2021). The development of alternative, safer and ecofriendly anticoccidial agents have become priority in most parts of the world (Ashraf *et al*., 2020). The development of resistance to coccidiostats and increasing consumer demand for natural food products has fuelled the development of natural, plant-based alternatives for coccidial control (Kostadinović *et al*., 2019). The surge of botanicals as anticoccidial molecules is on the rise (Felici *et al*., 2021). It is important to develop antiparasitics that are safe, effective, inexpensive, and

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environmentally safe (Kļaviņa *et al*., 2021).

Essential Oils

Plants have already been used for medical purposes by ancient civilizations and are currently considered a more sustainable and more easily accessible therapeutic and/or preventive alternative to synthetic drugs (Ferreira *et al*., 2018).Plant essential oils and active components can be used as alternatives or additions to current antiparasitic therapies(PÉREZ *et al*., 2012). Essential oils have a unique mechanism of action in livestock production (Andri *et al*., 2020). The discovery of new drugs is urgent which has led to attention on the search for natural compounds as drugs due to the resistance of some parasites to the synthetic/chemical drugs (Hikal *et al*., 2021). The inclusion of essential oils in livestock diets is nowadays becoming a common practice (Simitzis, 2017).

Plant essential oils (EO) are volatile and lipophilic compound mixtures extracted from plants through distillation (Lin *et al*., 2013). Different solvent preparations of the plant extract are recommended to arrive at a certain conclusion about the anticoccidial efficacy of Artemisia absinthium, which has been reported to be highly effective against other parasites in ruminants (Iqbal *et al*., 2013). Essential oils derived from entire plants may contain up to 40 components that can be divided into major bioactive components (Katiki *et al*., 2017). Research in the field of medicinal plants is a good source of knowledge regarding the potential action of plant extracts on certain diseases (Carvalho *et al*., 2012).The active components of EOs can be isolated by HPLC and gas liquid chromatography and characterized by differentdetectors (Monzote *et al*., 2012). Essential oils are volatile nature demands a high degree of stability (Amin *et al*., 2021). Some essential oils used in the small ruminant are shown in table 3.

Recognition and development of herbal medicine offer treatment methods that are more environmentally benign (Hayajneh *et al*., 2019). Essential oil (EO) dietary supplementation is a new strategy to improve animal health (Sabino *et al*., 2018), for example, bioactive components reported in green tea EO include tannins, caffeine, amino acids and vitamins (Ahmed *et al*., 2014). Australian tea tree (*Melaleuca alternifolia*) oil (TTO) and its monoterpene constituents such as terpinen-4-ol (T4O), 1,8-cineole, limonene, p-cymene, and α-terpinene have been shown to be effective in controlling a wide range of parasitic infections. The anti-parasitic effects of these compounds are mainly due to their antihistamine and anti-acetylcholinesterase activities as well as their ability to modulate host inflammatory responses (Lam *et al*., 2020).

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Table 3. Some essential oils used in small ruminant

Essential oil	Effect	Animal	Reference
Rosmarinus ofcinalis L.	Against *Eimeria* spp. oocysts	Sheep	Aouadi *et al*., 2021
Citrus	Introduce selective pressure on rumen microbes and induce methanogenesis adaptation in microbial communities	Sheep	Wu *et al*., 2018
Artemisia absinthium	Highly effective against parasites in ruminants	Goat	Iqbal *et al*., 2013
Cobalt	Improve animal growth performance, meat quality and fiber quality	Goat	Lei *et al*., 2018
Oregano	Replace monensin in lamb diets with improvements in the quality of the meat	Lamb	Garcia-galicia *et al*., 2020
Oregano	Inhibits rumen gas production (GP)and regulates animal digestive metabolism	Sheep	Wang *et al*., 2022
Green tea	Affect the growth performance, meat quality, blood metabolites and immune cell proliferation	Goat	Ahmed *et al*., 2014
Cymbopogon citratus	Anthelmintic efficacy on *H. contortus*	Sheep	Macedo *et al*., 2019
Eucalyptus citriodora	Reduced sheep epg at 14 days post treatment	Sheep	De Araújo Filho *et al*., 2019
Oregano	May be used for altering the ruminal pH and microbial populations of sheep	Sheep	Zhou *et al*., 2019
Origanum vulgare and *Citrus* spp.	Decreases in both the intensity and prevalence of coccidian infection	Sheep	Dudko *et al*., 2018
Myrtus communis L.	Improves meat's oxidative status without negative effects on FA profile	Goat	Smeti *et al*., 2020

Oregano essential oil (OEO) is an aromatic volatile oil extracted from oregano (*Origanum vulgare L.*). The principal compounds of OEO are carvacrol, thymol, γ-terpinene, *p*-cimene and linalool (Zhou *et al*., 2019). The active components (carvacrol and thymol) of Oregano essential oil are potent antimicrobials affecting protozoa (Garcia-galicia *et al*., 2020). The OEO can improve the performance of Sewa sheep by changing the intestinal morphology and regulating the intestinal flora (Sun *et al*., 2022).

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Herbal extracts, such as *Curcuma longa*, *Artemisia absinthium*, *Saussurea lappa*, *Ageratum conyzoides*, *Olea europaea*, *Ruta pinnata*, and *Trachyspermum ammi*, have been shown to have antiparasitic activity and to enhance the immune system and growth performance, thereby helping the host to overcome coccidiosis infection (Daiba *et al*., 2022). Herbal products such as essential oils may play a promising role in the treatment ofinfections caused by gastrointestinal nematodes (Štrbac *et al*., 2022). Local, traditional herbal plants such as tansy, mugwort, wormwood, and heather may serve as treatments for intestinal parasites of sheep (Kļaviņa *et al*., 2021). The positive effect on reducing coccidiosis and increases in lamb growth in the application of essential oils from Thymus vulgaris, Allium sativum, Artemisia absinthium, Dryopteris filix-mas, Tanacetum vulgare, Cucurbita pepo, Chenopodium ambrosioide, Inula helenium, Peumus boldus, Corallina rubens (Dudko *et al*., 2018). Essential oils has been shown to exhibit antibacterial, antiviral, antimycotic (Monzote *et al*., 2012) and antiparasitic activity (Nehme *et al*., 2021). Essential oils may control protozoal pathogens such as coccidian (Passetti *et al*., 2021).

DISCUSSION

Coccidiosis is significant diseases with economic impact to the small ruminants in the world.*Eimeria* spp. infections are one of the diseases of sheep and goats. The main species that infect goats are *Eimeria arloingi* and *Eimeria ninakohlyakimovae*, whereas sheep are mainly affected by *Eimeria ovinoidalis* and *Eimeria crandallis*.Control and management programs should be applied including proper usage of anticoccidials. The development of alternative, safer and eco-friendly anticoccidial agents has become a priority. The anticoccidial activity of *Rosmarinus officinalis* essential oil was estimated by the inhibition percentage of the oocyte sporulation in addition to the unsporulated and degenerated *Eimeria* oocysts using a haemocytometer after exposure to essential oils. The *Rosmarinus officinalis*essential oil was active against *Eimeria* spp. oocysts of sheep. The inclusion of the preparation containing the essential oil blend of *O. vulgare* and *Citrus spp.* in the diet of sheep resulted in decreases in both the intensity and prevalence of coccidian infection within the flock as well had influence increases in lamb growth.Essential oil compounds have antiparasitic, antimicrobial, antiviral, antimycotic, antioxidant and anti-inflammatory properties.In addition, more future work must be undertaken with the goal to isolate and purify the bioactive compounds of essential oils involved in the anticoccidial activities. This study provides insight of the potency of essential oil as a antiparasit for small ruminants. However, the current findings should be interpreted

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with caution due to the limited data available. Moreover, the literature search only covers published literature, which could lead to publication bias. For that reason, further research in this topic is highly encouraged to provide stronger evidence.

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REFERENCES

Abbas, I., Al-kappany, Y., Al-araby, M., Abu-elwafa, S., & Dubey, J. P. (2020). Prevalence of *Eimeria* species in sheep (Ovis aries) from Dakahlia. Journal of Parasitic Diseases. 44(3): 559–573. https://doi.org/10.1007/s12639-020-01229-1

Abdillah, M.F., Lastuti, N.D.R , Utama, S., Suprihati, E. (2021). Identification and Prevalence of Digestive Tract Endoparasites of Goats in. 5(2), 61–64.

Ahmadi, N., Baberi, S., Karimi, I., Nourani, H., Alavije, H. A., & Razmi, G. (2021). Parasitological and pathological findings of coccidiosis in an experimental infection caused by. 98(51). https://doi.org/10.22067/ijvst.2021.71247.1057

Ahmed, S. T., Lee, J., Mun, H., & Yang, C. (2014). Effects of supplementation with green tea by-products on growth performance , meat quality , blood metabolites and immune cell proliferation in goats. 1–11. https://doi.org/10.1111/jpn.12279

Albayati, H. H., Jarad, N. I., Al-Difaie, R. S., & Khudhair, O. H. (2020). Microscopic and molecular diagnosis of *Eimeria* spp. In sheep as a model of health investigation. Annals of Tropical Medicine and Public Health.23(14). https://doi.org/10.36295/ASRO.2020.231405

Amin, N., Tagliapietra, F., Arango, S., Guzzo, N., & Bailoni, L. (2021). Free and Microencapsulated Essential Oils Incubated In Vitro : Ruminal Stability and Fermentation Parameters. 1–12.

Andri, Faizal, Marjuki, M., & Huda, A. N. (2020). The use of essential oils as a growth promoter for small ruminants: A systematic review and meta-analysis. F1000Research.9: 1–11. https://doi.org/10.12688/f1000research.24123.1

Anna Maurizio, A. F. di R. and R. C. (2021). Quantitative Monitoring of Selected Groups of Parasites in Domestic Ruminants : A Comparative Review.

Aouadi, M., Sebai, E., Saratsis, A., Kantzoura, V., Saratsi, K., Msaada,

©2023. Nurdianti *et al*. Open access under CC BY–SA license, doi:10.20473/mkh.v34i1.2023.60-79
Received:06-08-2022, Accepted:13-09-2022,Published online:08-01-2023
Available at https://e-journal.unair.ac.id/MKH/index

Nurdianti. MKH (2023).60-79
DOI: 10.20473/mkh.v34i1.2023.60-79

K., Sotiraki, S., & Akkari, H. (2021). Essential oil of Rosmarinus officinalis induces in vitro anthelmintic and anticoccidial effects against Haemonchus contortus and *Eimeria* spp. In small ruminants. Veterinarni Medicina.66(4): 146–155. https://doi.org/10.17221/139/2020-VETMED

Ashraf, A., Shahardar, R. A., Bulbul, K. H., Wani, Z. A., & Allaie, I. M. (2020). Anticoccidial efficacy of Curcuma longa (turmeric) and Zingiber officinale (ginger) in goats in central Kashmir. 9(4): 354–360.

Balta, I., Marcu, A., Linton, M., Kelly, C., Stef, L., Pet, I., Ward, P., Pircalabioru, G. G., Chifiriuc, C., & Gundogdu, O. (2021). The in vitro and in vivo anti - virulent effect of organic acid mixtures against *Eimeria tenella* and *Eimeria bovis*. Scientific Reports. 1–11. https://doi.org/10.1038/s41598-021-95459-9

Bangoura, B., & Bardsley, K. D. (2020). Ruminant Coccidiosis. Veterinary Clinics of NA: Food Animal Practice.36(1): 187–203. https://doi.org/10.1016/j.cvfa.2019.12.006

Barba, E., Carmen, A., José, G., Molina, M., Martín, S., Carmen, M., Ferrer, O., Carlos, P., Carlos, L., Anja, H., & Antonio, T. (2022). Immunoprotection against mixed *Eimeria* spp . infections in goat kids induced by X-irradiated oocysts. Parasitology Research. 1517–1525. https://doi.org/10.1007/s00436-022-07465-z

Bawm, S., & Lat Htun, L. (2021). Management and Control of *Eimeria* Infection in Goats . Goat Science Environment, Health and Economy [Working Title]. https://doi.org/10.5772/intechopen.98979

Cahyaningsih, U. and Supriyanto. (2007). Identification of *Eimeria* sp. which Infectec 6 to 12 month old in Sheep Farm, Bogor. Prosiding Seminar Persada XIII. Faculty of Veterinary Medicine, IPB University.

Carcereri, A., Stancampiano, L., Marchiori, E., Sturaro, E., Ramanzin, M., Cassini, R.(2021). Factors influencing gastrointestinal parasites in a colony of Alpine ibex (Capra ibex) interacting with domestic ruminants Study area and animals. 32: 95–101. https://doi.org/10.4404/hystrix

Carlos, J., León, P., Delgado, N. U., & Florez, A. A. (2019). Prevalence of gastrointestinal parasites in cattle and sheep in three municipalities in the Colombian Northeastern Mountain. 12: 48–54. https://doi.org/10.14202/vetworld.2019.48-54

Carvalho, C. O., Chagas, A. C. S., Cotinguiba, F., Furlan, M., Brito, L. G., Chaves, F. C. M., Stephan, M. P., Bizzo, H. R., & Amarante, A. F. T. (2012). The anthelmintic effect of plant extracts on Haemonchus contortus and Strongyloides

©2023. Nurdianti *et al*. Open access under CC BY–SA license, doi:10.20473/mkh.v34i1.2023.60-79
Received:06-08-2022, Accepted:13-09-2022,Published online:08-01-2023
Available at https://e-journal.unair.ac.id/MKH/index

Nurdianti. MKH (2023).60-79
DOI: 10.20473/mkh.v34i1.2023.60-79

venezuelensis. Veterinary Parasitology.183(3–4): 260–268. https://doi.org/10.1016/j.vetpar.2011.07.051

Chartier, C., & Paraud, C. (2012). Coccidiosis due to *Eimeria* in sheep and goats, a review. Small Ruminant Research.103(1): 84–92. https://doi.org/10.1016/j.smallrumres.2011.10.022

Conceição, K. K. F. , dos S. L. O. de M. ; Â. I. da, dos Santos, L.A.; de Mendonça, C.L. Alves, L.C., Carvalho, R. A. N. R. ; G. A. de. (2022). Diversity of *Eimeria* (Apicomplexa : Eimeriidae) species and risk factors associated in natural infecting calves at the Southern Agreste Microregion in the State of Pernambuco , Brazil. Braz J Vet Parasitol.31(2): 1–10.

Daiba, A. R., & Kagira, J. M. (2022). In vitro anticoccidial activity of nanoencapsulated bromelain against *Eimeria* spp . oocysts isolated from goats in Kenya. 15.

De Araújo-Filho, J. V., Ribeiro, W. L. C., André, W. P. P., Cavalcante, G. S., Rios, T. T., Schwinden, G. M., Da Rocha, L. O., Macedo, I. T. F., de Morais, S. M., Bevilaqua, C. M. L., & De Oliveira, L. M. B. (2019). Anthelmintic activity of Eucalyptus citriodora essential oil and its major component, citronellal, on sheep gastrointestinal nematodes. Revista Brasileira de Parasitologia Veterinaria.28(4): 644–651. https://doi.org/10.1590/s1984-29612019090

de Macedo, L. O., Bezerra-Santos, M. A., de Mendonça, C. L., Alves, L. C., Ramos, R. A. N., & de Carvalho, G. A. (2020). Prevalence and risk factors associated with infection by *Eimeria* spp. in goats and sheep in Northeastern Brazil. Journal of Parasitic Diseases.44(3): 607–612. https://doi.org/10.1007/s12639-020-01235-3

Dudko, P., Junkuszew, A., Bojar, W., Milerski, M., Szczepaniak, K., Le Scouarnec, J., Schmidová, J., Tomczuk, K., & Grzybek, M. (2018). Effect of dietary supplementation with preparation comprising the blend of essential oil from Origanum vulgare (lamiaceae) and Citrus spp. (citraceae) on coccidia invasion and lamb growth. Italian Journal of Animal Science.17(1): 57–65. https://doi.org/10.1080/1828051X.2017.1346965

Eman AA Hassanen1, Reham GA Anter1, Wafaa M El-Neshwy2 and Ibrahim Elsohaby2, 3. (2020). Prevalence and Phylogenetic Analysis of *Eimeria* Species in Sheep and Goats in Sharkia Governorate, Egypt. Pak Vet J.40(4): 437–442. https://doi.org/10.29261/pakvetj/2020.015

Felici, M., Tugnoli, B., Piva, A., & Grilli, E. (2021). In Vitro Assessment of Anticoccidials : Methods and Molecules. 1–19.

Ferreira, L. E., Benincasa, B. I., Fachin, A. L., Contini, S. H. T., França, S. C.,

©2023. Nurdianti *et al*. Open access under CC BY–SA license, doi:10.20473/mkh.v34i1.2023.60-79
Received:06-08-2022, Accepted:13-09-2022,Published online:08-01-2023
Available at https://e-journal.unair.ac.id/MKH/index

Nurdianti. MKH (2023).60-79
DOI: 10.20473/mkh.v34i1.2023.60-79

Chagas, A. C. S., & Beleboni, R. O. (2018). Essential oils of Citrus aurantifolia, Anthemis nobile and Lavandula officinalis: in vitro anthelmintic activities against Haemonchus contortus. Parasites & Vectors.11(1): 269. https://doi.org/10.1186/s13071-018-2849-x

Garba, M. H., Na, S., Alhaji, A., & Mamman, M. (2020). Evaluation of The Efficacy of Oxytetracycline on Experimentally Induced Caprine Coccidiosis Due to *Eimeria* arloingi Infection. 10(1): 98–104.

Garcia-galicia, I. A., Arras-acosta, J. A., Huerta-jimenez, M., Renter, A. L., Loya-olguin, J. L., & Carrillo-lopez, L. M. (2020). Natural Oregano Essential Oil May Replace Antibiotics in Lamb Diets : E ff ects on Meat Quality. 1–18.

Gibbons, P., Love, D., Craig, T., & Budke, C. (2016). Veterinary Parasitology Efficacy of treatment of elevated coccidial oocyst counts in goats using amprolium versus ponazuril. Veterinary Parasitology.218: 1–4. https://doi.org/10.1016/j.vetpar.2015.12.020

GonzAGA. (2021). Research Article. Advances in Animal and Veterinary Sciences Anticoccidial.9(9): 1362–1367.

Grzybek, M., Kukula-Koch, W., Strachecka, A., Jaworska, A., Phiri, A. M., Paleolog, J., & Tomczuk, K. (2016). Evaluation of anthelmintic activity and composition of pumpkin (Cucurbita pepo L.) seed extracts—in vitro and in vivo studies. International Journal of Molecular Sciences.17(9): 1–21. https://doi.org/10.3390/ijms17091456

Hao, G., He, X., & XU, R. (2018). Prevalence of Gastrointestinal Parasites in Black Goats in Liangshan Prefecture, Southwest China. Asian Journal of Animal and Veterinary Advances.13(4): 346–351. https://doi.org/10.3923/ajava.2018.346.351

Hayajneh, F. M., Titi, H. H., Alnimer, M. A., & Irshaid, R. (2019). Evaluation of anthelmintics resistance against gastrointestinal parasites infection in awassi sheep in Jordan and the use of alternative herbal anthelmentics. American Journal of Animal and Veterinary Sciences.14(2): 122–126. https://doi.org/10.3844/ajavsp.2019.122.126

Hermosilla, C., Diakou, A., Psychas, V., Silva, L., & Taubert, A. (2016). Fatal *Eimeria* gilruthi-Induced Abomasal Coccidiosis : a still Neglected Parasitosis ? 17–21.

Hikal, W. M., Tkachenko, K. G., Said-Al Ahl, H. A. H., Sany, H., Sabra, A. S., Baeshen, R. S., & Bratovcic, A. (2021). Chemical Composition and Biological Significance of Thymol as Antiparasitic. Open Journal of Ecology. 11(03): 240–266. https://doi.org/10.4236/oje.2021.11

©2023. Nurdianti *et al*. Open access under CC BY–SA license, doi:10.20473/mkh.v34i1.2023.60-79
Received:06-08-2022, Accepted:13-09-2022,Published online:08-01-2023
Available at https://e-journal.unair.ac.id/MKH/index

Nurdianti. MKH (2023).60-79
DOI: 10.20473/mkh.v34i1.2023.60-79

3018

Iqbal, A., Tariq, K. A., Wazir, V. S., & Singh, R. (2013). Antiparasitic efficacy of Artemisia absinthium , toltrazuril and amprolium against intestinal coccidiosis in goats. 37: 88–93. https://doi.org/10.1007/s12639-012-0137-9

Jawasreh, K. I. Z., & Qader, A. A. (2013). Coccidiosis in Awassi , Romanov , Charollais and Suffolk sheep breeds during the winter and summer seasons in Jordan. 3(6): 10–15.

Junkuszew, A., Milerski, M., Bojar, W., Szczepaniak, K., Le Scouarnec, J., Tomczuk, K., Dudko, P., Studzińska, M. B., Demkowska-Kutrzepa, M., & Bracik, K. (2015). Effect of various antiparasitic treatments on lamb growth and mortality. Small Ruminant Research.123(2–3): 306–313. https://doi.org/10.1016/j.smallrumres.2014.11.019

Katiki, L. M., Barbieri, A. M. E., Araujo, R. C., Veríssimo, C. J., Louvandini, H., & Ferreira, J. F. S. (2017). Synergistic interaction of ten essential oils against Haemonchus contortus in vitro. Veterinary Parasitology.243: 47–51. https://doi.org/10.1016/j.vetpar.2017.06.008

Khor, S. K., Isa, J. M. A. T., Mazukhi, Z., Ali, S., Han, A., Azizan, S., Bahari, S., & Ree, A. (2018). A Survey of Gastrointestinal Parasitic Infection on Small Ruminant Farms in Seberang Perai Selatan. 1990: 15–21.

Kļaviņa, A., Keidāne, D., Šukele, R., Bandere, D., & Kovaļčuka, L. (2021). Traditional Latvian herbal medicinal plants used to treat parasite infections of small ruminants: A review. Veterinary World.14(6): 1548–1558. https://doi.org/10.14202/vetworld.2021.1548-1558

Kumar, B., Amit, B. R. M., & Joseph, J. P. (2016). Seasonal incidence of parasitic diseases in bovines of south western Gujarat (Junagadh), India. Journal of Parasitic Diseases.40(4): 1342–1346. https://doi.org/10.1007/s12639-015-0686-9

Kyriánová, I. A., Vadlejch, J., & Langrová, I. (2017). Eimeriosis Seasonal Dynamics Patterns at an Organic Sheep Farm in the Czech Republic. Scientia Agriculturae Bohemica.48(2): 70–75. https://doi.org/10.1515/sab-2017-0013

Lam, N. S., Long, X., Su, X. zhuan, & Lu, F. (2020). Melaleuca alternifolia (tea tree) oil and its monoterpene constituents in treating protozoan and helminthic infections. Biomedicine and Pharmacotherapy.130: 110624. https://doi.org/10.1016/j.biopha.2020.110624

Lei, Z., Zhang, K., Li, C., Wu, J., Davis, D., Casper, D., Jiang, H., Jiao, T., Wang, X., & Wang, J. (2018). Dietary supplementation with Essential-oils-cobalt for improving growth

©2023. Nurdianti *et al*. Open access under CC BY–SA license, doi:10.20473/mkh.v34i1.2023.60-79
Received:06-08-2022, Accepted:13-09-2022,Published online:08-01-2023
Available at https://e-journal.unair.ac.id/MKH/index

Nurdianti. MKH (2023).60-79
DOI: 10.20473/mkh.v34i1.2023.60-79

performance , meat quality and skin cell capacity of goats. Scientific Reports. 1–12. https://doi.org/10.1038/s41598-018-29897-3

Lin, B., Lu, Y., Salem, A. Z. M., Wang, J. H., Liang, Q., & Liu, J. X. (2013). Effects of essential oil combinations on sheep ruminal fermentation and digestibility of a diet with fumarate included. Animal Feed Science and Technology.184(1–4): 24–32. https://doi.org/10.1016/j.anifeedsci.2013.05.011

Ljiljana Kostadinović1,*, Sanja Popović2, D. L. P., & Ivana Čabarkapa2, Olivera Đuragić2, J. L. (2019). Medicinal Plantsas Natural Alternative to Coccidial Synthetic. Journal of Agronomy, Technology and Engineering Management.2(5): 325–334.

Macedo, I. T. F., Oliveira, L. M. B. de, André, W. P. P., Filho, J. V. de A., Santos, J. M. L. dos, Rondon, F. C. M., Ribeiro, W. L. C., Camurça-Vasconcelos, A. L. F., Oliveira, E. F. de, Paula, H. C. B. de, & Bevilaqua, C. M. L. (2019). Anthelmintic effect of cymbopogon citratus essential oil and its nanoemulsion on sheep gastrointestinal nematodes. Revista Brasileira de Parasitologia Veterinaria.28(3): 522–527. https://doi.org/10.1590/s1984-29612019065

Mahavidyalaya, R. P., & Ambedkar, B. (2015). Observation of *Eimeria Parva* in Goat and Sheep from Beed, M . S ., India.. 6, 3076–3079.

Majeed, N. M., A'aiz, N. N., & Niemah, A. J. (2020). Molecular study to detect the *Eimeria* species in sheep in al-diwaniyah province, iraq. Iraqi Journal of Veterinary Sciences.34(2): 377–381. https://doi.org/10.33899/ijvs.2019.126064.1225

Malaka, G. and. (2021). Overview of coccidiosis in sheep: History of Disease Incidence in the World and Life Cycle. Hasanuddin J. Anim. Sci.3(1): 42–51.

Martins, N. S., Motta, S. P., Santos, C. C., Moreira, A. S., Farias, N. A. R., Ruas, J. L., S, A. M. N., Motta, S. P., Santos, C. C., Moreira, A. S., Farias, N. A. R., & Ruas, J. L. (2020). *Eimeria* spp . infection in lambs from southern Brazil. 40: 871–874. https://doi.org/10.1590/1678-5150-PVB-6745

Matsepe, L. G. (2021). Prevalence and fecal egg load of gastrointestinal parasites of Angora goats in four agro-ecological zones in Lesotho. 14.

Meradi, S. (2021). Lamb ' s *Eimeria* infections raised in a steppic region and their impacts on clinical indicators (FAMACHA Ó and Disco). Journal of Parasitic Diseases. https://doi.org/10.1007/s12639-020-01336-z

Mohamaden, W. I., Sallam, N. H., & Abouelhassan, E. M. (2018). Prevalence of *Eimeria* species among sheep and goats in Suez Governorate, Egypt. International

©2023. Nurdianti *et al*. Open access under CC BY–SA license, doi:10.20473/mkh.v34i1.2023.60-79
Received:06-08-2022, Accepted:13-09-2022,Published online:08-01-2023
Available at https://e-journal.unair.ac.id/MKH/index

Nurdianti. MKH (2023).60-79
DOI: 10.20473/mkh.v34i1.2023.60-79

Journal of Veterinary Science and Medicine.6(1): 65–72. https://doi.org/10.1016/j.ijvsm.2018.02.004

Mohammed, N. H., & Alobaidii, W. A. (2021). Coccidiosis in sheep and goats (review) nadia hamid mohammed; wasan amjad alobaidii and manal hammadi hasan. *67*(171): 33–39.

Monzote, L., Alarcón, O., & Setzer, W. N. (2012). Antiprotozoal activity of essential oils. Agriculturae Conspectus Scientificus.77(4): 167–175.

Muzaffer Akyüz, Rıdvan Kirman, Sali Yaya, Hatice Gülbeyen, E. G. (2019). Endoparasites Determined by Fecal Examination in Sheep in Erzurum Province. Turkiye Parazitol Derg.43(4): 187–193. https://doi.org/10.4274/tpd.galenos.2019.6512

Namutosi, W., Higenyi, J., Kizito, E., & Omodo, M. (2019). Prevalence and Risk Factors of Gastrointestinal Parasite Infection in Goats in Sironko District , Eastern Uganda. 19(1): 1–14.

Nehme, R., Andr, S., Pereira, R. B., Jemaa, M. Ben, Bouhallab, S., Ceciliani, F., Secundino, L., Rahali, F. Z., Ksouri, R., Pereira, D. M., & Abdennebi-najar, L. (2021). Essential Oils in Livestock : From Health to Food Quality.

Odden, A., Vatn, S., Ruiz, A., Robertson, L. J., Enemark, H. L., & Nes, S. K. (2018). Excretion of *Eimeria* spp. oocysts in young lambs following iron supplementation. Acta Veterinaria Scandinavica. 1–9. https://doi.org/10.1186/s13028-018-0404-6

Passetti, L. C. G., Passetti, R. A. C., & McAllister, T. A. (2021). Effect of essential oil blends and a nonionic surfactant on rumen fermentation, anti-oxidative status, and growth performance of lambs. Translational Animal Science.5(3). https://doi.org/10.1093/tas/txab118

Paul, B. T., Firdaus, F., Jesse, A., Lim, E., Chung, T., Amat, A. C., Azmi, M., & Lila, M. (2020). Risk Factors and Severity of Gastrointestinal Parasites in Selected Small Ruminants from Malaysia.

Paul Bura Thlama1, 2*, Biu aBuBakar aBdullahi2, Gadzama mercy ahmed2, ali mohammed2, & mana hoPe PhiliP1, J. yusuf. (2016). Point Prevalence and Intensity of Gastrointestinal Parasite Ova/ Oocyst and Its Association with Body Condition Score (BCS) of Sheep and Goats in Maiduguri, Nigeria. *3*(3): 81–88.

Pezzanite, L., Neary, M., Hutchens, T., & Scharko, P. (2022). Common Diseases and Health Problems in Sheep and Goats. Purdue University. 1–11.

Reginato, C. Z., Bräunig, P., Portella, L. P., Mortari, A. P. G., Minuzzi, C. E., Sangioni, L. A., & Vogel, F. S. F. (2020). DNA extraction methods for molecular detection of *Eimeria* spp.

©2023. Nurdianti *et al*. Open access under CC BY–SA license, doi:10.20473/mkh.v34i1.2023.60-79
Received:06-08-2022, Accepted:13-09-2022,Published online:08-01-2023
Available at https://e-journal.unair.ac.id/MKH/index

Nurdianti. MKH (2023).60-79
DOI: 10.20473/mkh.v34i1.2023.60-79

In cattle and sheep1. Pesquisa Veterinaria Brasileira.40(7): 514–518. https://doi.org/10.1590/1678-5150-PVB-6625

S. PÉREZ G. (2012). Antiprotozoa activity of some essential oils. Journal of Medicinal Plants Research.6(15). https://doi.org/10.5897/jmpr11.1572

Sabino, M., Adriano, V., Carmelo, O., Mazzoni, G., Cappelli, K., Capomaccio, S., Ajmone-marsan, P., Verini-supplizi, A., Trabalza-marinucci, M., & Kadarmideen, H. N. (2018). Gene co-expression networks in liver and muscle transcriptome reveal sex-specific gene expression in lambs fed with a mix of essential oils. 1–15.

Samuel Engidaw, M. A. and C. D. F. (2020). Coccidiosis in Small Ruminants Coccidiosis in Small Ruminants. https://doi.org/10.5829/idosi.ajbas.2015.7.6.96202

Sharma, D. K., Paul, S., Rout, P. K., Mandal, A., Bhusan, S., & Sharma, N. (2017). Caprine coccidiosis in semi-arid India : Dynamics and factors affecting fecal oocysts count. 7710: 52–57.

Simitzis, P. E. (2017). Enrichment of Animal Diets with Essential Oils—A Great Perspective on Improving Animal Performance and Quality Characteristics of the Derived Products. Medicines. 4(4): 35. https://doi.org/10.3390/medicines4020035

Singh, A. K., Shanker, D., Rout, P. K., Kumar, A., & Kumar, P. (2020). Studies on *Eimeria* Species in Goat of Mathura Region, Uttar Pradesh, India.. 59(1): 131–132.

Smeti, S., Tibaoui, S., Ramon, J., Yathreb, B., Mekki, I., Joy, M., & Atti, N. (2020). Effects of myrtle (Myrtus communis L .) essential oils as dietary antioxidant supplementation on carcass and meat quality of goat meat. 1–10. https://doi.org/10.1111/jpn.13483

Souza1, L. E. B. de, Neto, *; Jurandir Ferreira da Cruz2 ; Milton Rezende Teixeira, Albuquerque, R., Melo, B., Diego, A., & Tapia, T. (2015). Epidemiology of *Eimeria* infections in sheep raised extensively in a semiarid region of Brazil. Braz. J. Vet. Parasitol.

Štrbac, F., Bosco, A., Maurelli, M. P., Ratajac, R., Stojanović, D., Simin, N., Orčić, D., Pušić, I., Krnjajić, S., Sotiraki, S., Saralli, G., Cringoli, G., & Rinaldi, L. (2022). Anthelmintic Properties of Essential Oils to Control Gastrointestinal Nematodes in Sheep—In Vitro and In Vivo Studies. Veterinary Sciences.9(2): 1–15. https://doi.org/10.3390/vetsci9020093

Sufi, I. M., Cahyaningsih, U. M. I., & Sudarnika, E. (2017).*Eimeria* Species Composition and Factors Influencing oocyst Sheding in Dairy Farm, Bandung, Indonesia. 2(2), 104–113.

©2023. Nurdianti *et al*. Open access under CC BY–SA license, doi:10.20473/mkh.v34i1.2023.60-79
Received:06-08-2022, Accepted:13-09-2022,Published online:08-01-2023
Available at https://e-journal.unair.ac.id/MKH/index

Nurdianti. MKH (2023).60-79
DOI: 10.20473/mkh.v34i1.2023.60-79

https://doi.org/10.11598/btb.201

Sun, J., Cheng, Z., Zhao, Y., Wang, Y., Wang, H., & Ren, Z. (2022). Influence of increasing levels of oregano essential oil on intestinal morphology, intestinal flora and performance of Sewa sheep. Italian Journal of Animal Science.21(1): 463–472. https://doi.org/10.1080/1828051X.2022.2048208

Tammy, S., & Keeton, N. (2018). Coccidiosis in Large and Small Ruminants. Veterinary Clinics of NA: Food Animal Practice.34(1): 201–208. https://doi.org/10.1016/j.cvfa.2017.10.009

Verocai, G. G. (2020). Diagnostic Methods for Detecting Internal Parasites of Livestock. 36: 125–143. https://doi.org/10.1016/j.cvfa.2019.12.003

Wang, Z., Li, X., Zhang, L., Wu, J., & Zhao, S. (2022). Effect of Oregano Oil and Cobalt Lactate on Sheep In Vitro Digestibility, Fermentation Characteristics and Rumen Microbial Community. Animals.12: 118. https://www.mdpi.com/journal/animals

Wu, P., Liu, Z. B., He, W. F., Yu, S. B., Gao, G., & Wang, J. K. (2018). Intermittent feeding of citrus essential oils as a potential strategy to decrease methane production by reducing microbial adaptation. Journal of Cleaner Production.194: 704–713. https://doi.org/10.1016/j.jclepro.2018.05.167

Yan, X., Liu, M., He, S., Tong, T., Liu, Y., Ding, K., Deng, H., & Wang, P. (2021). An epidemiological study of gastrointestinal nematode and *Eimeria* coccidia infections in different populations of Kazakh sheep. 1–17. https://doi.org/10.1371/journal.pone.0251307

Zhou, R., Wu, J., Lang, X., Liu, L., Casper, D. P., Wang, C., & Zhang, L. (2020). Effects of oregano essential oil on in vitro ruminal fermentation , methane production , and ruminal microbial community. Journal of Dairy Science. https://doi.org/10.3168/jds.2019-16611

Zhou, R., Wu, J., Zhang, L., Liu, L., Casper, D. P., Jiao, T., Liu, T., Wang, J., Lang, X., Song, S., & Gong, X. (2019). Effects of oregano essential oil on the ruminal pH and microbial population of sheep. PLoS ONE.14(5): 1–14. https://doi.org/10.1371/journal.pone.0217054

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