

**Evaluation of essential coriander (*Coriandrum sativum* L.) oil against the red poultry mite (*Dermanyssus gallinae*) (De Geer, 1778) (Acari: Dermanyssidae) under laboratory conditions**

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## Abstract

The red mite *Dermanyssus gallinae* affects poultry production mainly of laying hens by feeding on its blood. Its control is carried out using chemical acaricides, toward which its resistance increases. The aim of this study was to evaluate the acaricidal activity of essential oil (EO) of coriander (*Coriandrum sativum*) at concentrations of 1, 2 and 3 mg/cm<sup>2</sup> through contact bioassays on adults of *D. gallinae*, compared to a chemical acaricide (Neguvón®). The mites were collected from backyard hens (*Gallus gallus* L.). Six replicates were performed per treatment. Statistically, mortality percentages were established and an ANOVA was carried out. The lethal activity percentage was established. Additionally, the median lethal concentration (LC<sub>50</sub>) and the median lethal time (TL<sub>50</sub>) were estimated. Coriander EO caused 100 % mortality on *D. gallinae* population 25 min after contact with a concentration of 2 and 3 mg/cm<sup>2</sup> and after 30 min with a lower concentration of 1 mg/cm<sup>2</sup>. The LC<sub>50</sub> of the coriander EO was 1.3 mg/cm<sup>2</sup>, with a 13 min TL<sub>50</sub> on the *D. gallinae* population. The EO of coriander is suggested as an alternative to be used instead of the chemical acaricides for the control of the red poultry mite *D. gallinae*.

**Key words:** acaricides, Apiaceae, aviculture, haematophagy, pest control, repellents

## Introduction [T2]

The red poultry mite *Dermanyssus gallinae* (De Geer, 1778) belongs to the Arachnida (De Geer, 1778) class and to the Dermanyssidae family. Further, it is the most abundant species within this group (Walter & Proctor, 2013). It is an hematophagous ectoparasite that causes important damage in poultry production systems (Rodríguez-Vivas & Cob-Galera, 2005), especially in breeding operations of laying hens, in which egg production can fall up to 25 %, decreasing its quality and causing weight loss, anemia and mortality in birds (Green, Sparling, & Sperling, 2007). Moreover, this pest is commonly found worldwide (Kim, Na, Yi, Kim, & Ahn, 2007).

Synthetic acaricides are used for its control but there are populations that have developed resistance to pesticides such as carbamates and pyrethroids (George et al., 2015), increasing the problem (George, Callaghan, Guy, & Sparagano, 2008). Alternative substances have been assessed for its control, including essential oils of coriander (*Coriandrum sativum*), lavender (*Lavandula angustifolia*), thyme (*Thymus vulgaris*), manuka (*Leptospermum scoparium*), pennyroyal (*Mentha pulegium*), sweet basil (*Ocimum basilicum*), mint (*Mentha spicata*), garden savory (*Satureja hortensis*), cinnamon (*Cinnamomum zeylanicum*) and eucalyptus (*Eucalyptus globulus*), with toxic results on *D. gallinae* through contact trials (Kim, Yi, Tak, & Ahn, 2004; Kim et al. al., 2007; George, Smith, Shiel, Sparagano, & Guy, 2009; Magdaş, Cernea, Baciú, & Şuteu, 2010; Nechita, Poirel, Cozma, & Zenner, 2015). Likewise, entomopathogenic fungi such as *Beauveria bassiana* and *Metharhizium anisopliae* with high mortality rates have been studied (Steenber & Kilpinen, 2003; Tavassoli, Ownag, Porseyed,

& Mardani, 2008). However, other alternatives must be evaluated, because the final control solution has not been determined.

Pesticides based on natural products have been used as an alternative to mitigate the attack of mites, both hematophagous as well as phytophagous. Such is the case of essential oils (EO) whose use is viable thanks to their low toxicity for mammals and due to their biodegradability (Toloza, Zygadlo, Biurrun, Rotman, & Picollo, 2010). EOs with insecticidal properties have been successfully marketed in specific agricultural applications and meet minimum risk criteria as pesticides (United States Environmental Protection Agency [US EPA], 2004). According to Toloza (2010), natural insecticides such as EO are a viable option and should be taken into account for the development of new environmentally friendly products.

On the other hand, coriander (*Coriandrum sativum* L.) is an annual herbaceous plant, which belongs to the family Apiaceae (Mahendra & Bisht, 2011) and contains EO in leaves, stems, flowers, fruits, seeds, roots and bark (Mandal & Mandal, 2015). EO yield of *C. sativum* and its chemical composition undergo changes during ontogenesis (Bhuiyan, Begum, & Sultana, 2009), but its major constituent is linalool; in addition, it also contains limonene,  $\alpha$ -pinene, camphene, geranyl acetate, linalyl acetate, geraniol, terpin-4-ol,  $\alpha$ -terpineol, c-terpenepinene, myrcene and camphor (Zeb, 2016). These compounds have a broad spectrum of biological activities, including their insecticidal (Pavela & Vrchotová, 2013) and acaricide (Song, Yang, Suh, & Lee, 2011) functions. The activity of EOs depends on their composition, which is affected by factors such as their genetic structure, climate and agricultural practices (Telci, Toncer, & Sahbaz, 2006).

According to the aforementioned, the aim of this study was to evaluate the acaricidal activity of the coriander (*C. sativum*) EO against the red poultry mite (*D. gallinae*), under controlled laboratory conditions.

## Materials and methods [T2]

### *Dermanyssus gallinae* breeding [T3]

Colonies of *D. gallinae* mites were collected under the feathers and chest of *Gallus gallus* hens (L., 1758) (Birds: Galliformes: Phasianidae), and from slits in the poultry houses in a backyard production located in Finca Samaría, in Duitama (department of Boyacá, Colombia). The specimens of *D. gallinae* were immediately transferred to polyethylene containers (4.8 cm × 8.4 cm) and covered. The mites were transported to the Plant Health Laboratory of Fundación Universitaria Juan de Castellanos in the city of Tunja (Department of Boyacá, Colombia). In the laboratory, the mites were placed in a Petri dish on filter paper and a piece of wet cotton and sealed with Parafilm®; they were maintained at a temperature between  $20 \pm 9$  °C and a relative humidity of 60-90 %, with cycles of 16: 8 light-dark hours. Tests were carried out within 2 days after the mites were collected. These specimens were not fed because they can survive up to eight months away from poultry without feeding and they also resist desiccation (Chauve, 1998).

## Bioassays **T3**

For this type of test, parameters of established and standardized methodologies were followed with some modifications due to laboratory conditions, such as those published by Kim et al. (2004) and George et al. (2009).

Coriander EO was purchased at Bioryz Biovegetal (Bogota, Colombia). In order to evaluate their acaricidal activity, contact bioassays were carried out with filter paper on *D. gallinae* adults. To do this, concentrations of 1.0, 2.0 and 3.0 mg/cm<sup>2</sup> of *C. sativum* EO were applied on filter paper (Whatman No. 2, and 4.25 cm of diameter) in 50 µl of ethanol 70 %. The control treatment was carried out with 50 µl of ethanol and using the commercial acaricide (Neguvón®) as a standard, whose active ingredient is trichlorfon, in order to compare the toxicity tests. The filter paper was dried in an extractor hood for 2 minutes; later, the filter paper was placed in the lower part of a Petri dish (4.8 cm in diameter x 1.2 cm in height). Ten adult mites were placed in each box together with a piece of cotton (5 mm x 5 mm) impregnated with 100 µl of distilled water. Then, each Petri dish was covered with a lid and sealed with Parafilm®. Each treatment was repeated six times.

Finally, mortality was determined every 5 min after exposure to treatments, for which a Motic® SMZ-168 stereomicroscope was used. Adults were considered dead if their appendages did not move when they were punctured with a fine pin. Twenty-four hours later, residuality tests were carried out.

## Statistical analysis [T3]

Mortality percentage was established with the equation of Henderson and Tilton (1995), meanwhile, the lethal activity was classified according to Kim et al. (2007) as follows. Strong mortality is > 80 %; moderate i 80-61 %; weak is 60-40 %; and little or no activity is < 40 %. The analysis of variance (ANOVA) was carried out and a nonparametric analysis was performed, using the Shapiro-Wilk test ( $n < 30$ ). In addition, significant differences were analyzed through the Kruskal-Wallis test, and with the Tukey test, significant differences were evaluated between the treatments and the exposure time. The median lethal concentration (LC50) was estimated with the Probit analysis using the BioStat program (2009). Likewise, the median lethal time (TL50) for each concentration was determined with the slope of the line containing 50 % of the mortality value and the X and Y values in the equation ( $Y = A + BX$ ) were replaced to find A for each treatment.

## Results and Discussion [T2]

The acaricidal activity of coriander (*C. sativum*) on adult red poultry mites (*D. gallinae*) through contact bioassays, according to different doses and exposure times is presented in table 1.

**Table 1.** Acaricide activity of coriander (*C. sativum*) EO against adult red poultry mites (*D. gallinae*) through contact bioassays



Dose mg/cm <sup>2</sup>	Mortality (mean ± S.E. [%]) <sup>a</sup>					
	5 min	10 min	15 min	20 min	25 min	30 min
1	5.0 ± 3.4c	31.6 ± 7.4ab	60.0 ± 8.1a	81.7 ± 4.01b	93.3 ± 2.1b	100 ± 0.0
2	1.7 ± 1.6c	23.3 ± 4.9b	53.33 ± 9.5a	88.3 ± 6.0ab	100 ± 0.0a	
3	18.3 ± 1.7b	43.3 ± 5.5a	70 ± 7.3a	90.0 ± 4.4ab	100 ± 0.0a	
control	0c	0c	0b	0c	0c	0
CA	100 ± 0.0a					

<sup>a</sup>data with the same letter in each column expresses that there are no significant differences at  $p = 0.05$ . CA:

Commercial acaricide Neguvón®, chemical control treatment.

Source: Elaborated by the authors

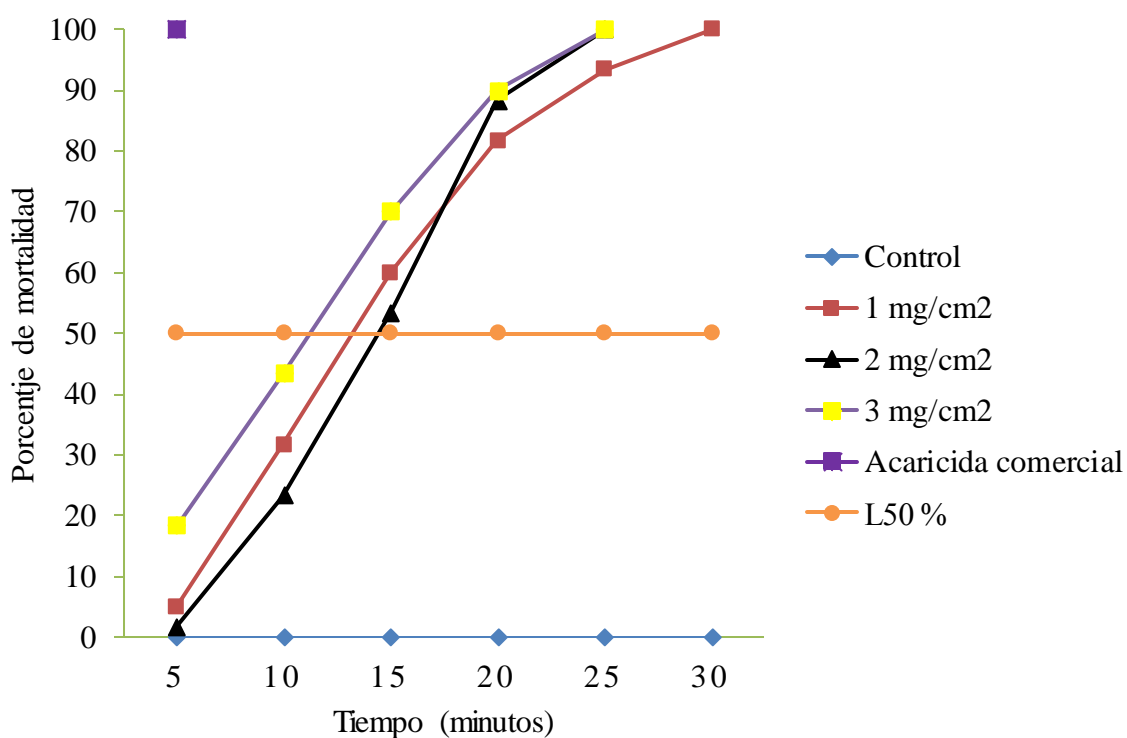
According to the data reported in table 1, it can be established that the dose of 3 mg/cm<sup>2</sup> is the one that offers the highest mortality at any time (5, 10, 15, 25 and 30 minutes). The efficacy of the evaluated doses of coriander EO (1, 2 and 3 mg/cm<sup>2</sup>) showed strong mortality (100% mortality) after 30 min of contact. In the control group, all individuals survived, meanwhile the chemical control group, from the first moment there was contact with the mites the mortality was 100%. The mean and standard error is reported with the untransformed data. The times and treatments are compared with the Kruskal-Wallis test and there were significant differences  $p < 0.05$  according to the dose applied and the exposure time.

Kim et al. (2004) reported 100% mortality in *D. gallinae* after 24 hours of contact with coriander EO at 0.07 mg/cm<sup>2</sup>. In the current study, coriander EO caused 100% mortality on

the population of *D. gallinae* 25 min after contact with a concentration of 2 and 3 mg/cm<sup>2</sup>, and after 30 min with a lower concentration of 1 mg/cm<sup>2</sup>. Magdaş et al. (2010) reported 100 % mortality after 24, 48 and 72 hours of contact of *D. gallinae* with coriander EO at 0.4 and 0.6 mg/cm<sup>2</sup> in *in vitro* tests, using the direct contact method. When comparing previous works with the current study, the effect of coriander EO on *D. gallinae* is faster, reaching 100 % mortality with the three concentrations evaluated after 30 minutes of exposure.

The doses of coriander EO in ethanol evaluated (1.0, 2.0 and 3.0 mg/cm<sup>2</sup>) on *D. gallinae*, are relatively high compared to the results published by other authors (Kim et al., 2004; Magdaş et al., 2010; Nechita et al., 2015), which demonstrates a faster way to eliminate the target pest with a low residual toxicity, as proposed by George, Olatunji, Guy and Sparagano (2010). In this case, no residual activity of coriander EO was recorded on *D. gallinae* 24 hours after application and 100 % mortality was reached after 30 min of exposure. According to Isman (2000), the lack of residual toxicity of volatile compounds could be considered beneficial, because the environmental persistence of bioactive compounds will be low. On the other hand, according to George et al. (2008), essential oils are very volatile in nature, so the effect is of short duration, and if they are used as acaricides, they act in the vapor phase. In addition, according to the results of Kim et al. (2004, 2007), coriander EO was more effective on *D. gallinae* in closed containers, indicating that the route of action of essential oils is largely in the vapor phase through the respiratory system; although the authors do not know its mode of action.

The LC<sub>50</sub> of the coriander EO was 1.301 mg/cm<sup>2</sup> and it was reached in a TL<sub>50</sub> of 13 min, which reduced 50% of the population of *D. gallinae* (figure 1). For the control group, no values were recorded, because they were null (zero) from 5 min to 30 min after exposure; similarly, there are no values for the commercial acaricide, as mortality was 100% after 5 min (figure 1).



**Figure 1.** Lethal concentration time of *C. sativum* EO on *D. gallinae* established from the slope of the line with 50% mortality; X and Y values were replaced in the equation ( $Y = A + BX$ ).

Source: Elaborated by the authors

It could be considered that the lethality of the coriander EO on *D. gallinae* is due to the presence of linalool. According to Khani and Rahdari (2012) and Chung et al. (2012), approximately 70% of the chemical composition of this oil is linalool. Studies on the mode of action of EOs indicate that there is neurotoxic activity, including hyperactivity, convulsions, and tremors, followed by paralysis, symptoms similar to those produced by pyrethroid insecticides (Kostyukovsky, Rafaeli, Gileadi, Demchenko, & Shaaya 2002) and also by the behavior observed in *D. gallinae* in this study. On the other hand, Chung et al. (2012), with an LC<sub>50</sub> value of 21.5 ppm of the evaluated coriander EO, observed that it has significant toxic effects against the larvae of *Aedes aegypti* (L., in Hasselquist, 1762) (Diptera: Culicidae), acting as an immunotoxin for the insect. It has been recognized that EOs are potent neurotoxins that affect, through the inhibition of the enzyme acetylcholinesterase, the central nervous system (Keane & Ryan, 1999).

In the current study, the potential of coriander essential oil varied according to the concentration and time of exposure. The results of this work show that the EO of *C. sativum* can play a controlling role on *D. gallinae* and reduces risks associated with the use of synthetic insecticides. The mode of action of the EO of *C. sativum* is of special interest, so other investigations should focus on the way they penetrate the cuticle of insects and their effects on mammals fed with the treated material. In addition, it should be noted that the leafy coriander EO has low cytotoxicity in human cells, considering it safe for human consumption (Mandal & Mandal, 2015).

## Conclusions [T2]

This study shows that the EO of *C. sativum* has acaricidal activity against *D. gallinae* through direct contact and has no residual activity. Therefore, it can be used as a natural acaricide for the management of adult individuals of *D. gallinae* and is considered as an interesting alternative to reduce the conventional use of chemical control.

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## Disclaimers [T2]

All the authors made significant contributions to the document agreeing in its publication, and state that there are no conflicts of interest in this study.

## References [T2]

Bhuiyan M. I., Begum, J., &Sultana, M. (2009). Chemical composition of leaf and seed essential oil of *Coriandrum sativum* L. from Bangladesh. *Bangladesh European Journal of Pharmacology*, 4, 150-153. doi:10.3329/bjp.v4i2.2800.

- Chauve, C. (1998). The poultry red mite *Dermanyssus gallinae* (De Geer, 1778): current situation and future prospects for control. *Veterinary Parasitology*, 79(3), 239-245. doi:10.1016/S0304-4017(98)00167-8.
- Chung, I. M., Ahmad, A., Kim, E. H., Kim, S. H., Jung, W. S., Kim, J. H., ... Nagella, P. (2012). Immunotoxicity activity from the essential oils of coriander (*Coriandrum sativum*) seeds. *Immunopharmacology and Immunotoxicology*, 34(3), 499-503. doi:10.3109/08923973.2011.637500.
- George, D. R., Finn, R. D., Graham, K. M., Mul, M. F., Maurer, V., Moro, C. V., & Sparagano, O. A. (2015). Should the poultry red mite *Dermanyssus gallinae* be of wider concern for veterinary and medical science? *Parasites and Vectors*, 8(1), 178. doi:10.1186/s13071-015-0768-7.
- George, D. R., Olatunji, G., Guy, J. H., & Sparagano, O. A. E. (2010). Effect of plant essential oils as acaricides against the poultry red mite, *Dermanyssus gallinae*, with special focus on exposure time. *Veterinary Parasitology*, 169(1), 222-225. doi:10.1016/j.vetpar.2009.12.038.
- George, D. R., Smith, T. J., Shiel, R. S., Sparagano, O. A. E., & Guy, J. H. (2009). Mode of action and variability in efficacy of plant essential oils showing toxicity against the poultry red mite, *Dermanyssus gallinae*. *Veterinary Parasitology*, 161(3), 276-282. doi: 10.1016/j.vetpar.2009.01.010.
- George, D. R., Callaghan, K., Guy, J. H., & Sparagano, O. A. E. (2008). Lack of prolonged activity of lavender essential oils as acaricides against the poultry red mite (*Dermanyssus gallinae*) under laboratory conditions. *Research in Veterinary Science*, 85(3), 540-542. doi:10.1016/j.rvsc.2008.02.001.

- Green, B., Sparling, J., & Sperling, M. B. (2007). What's eating you? Pigeon mite (*Dermanyssus gallinae*). *Cutis*, 80, 461-462. Retrieved from <https://www.mdedge.com/sites/default/files/Document/September-2017/080060461.pdf>.
- Henderson C. F., & Tilton, E. W. (1955). Acaricides tested against the brown wheat mite. *Journal of Economic Entomology*, 48, 157-161.
- Isman, M. B. (2000). Plant essential oils for pest and disease management. *Crop Protection*, 19(8-9), 603-608. doi:10.1016/S0261-2194(00)00079-X.
- Keane, S., & Ryan, M. F. (1999). Purification, characterisation, and inhibition by monoterpenes of acetylcholinesterase from the waxmoth, *Galleria mellonella* (L.). *Insect Biochemistry and Molecular Biology*, 29(12), 1097-1104. doi:10.1016/S0965-1748(99)00088-0.
- Khani, A., & Rahdari, T. (2012). Chemical composition and insecticidal activity of essential oil from *Coriandrum sativum* seeds against *Tribolium confusum* and *Callosobruchus maculatus*. *ISRN Pharmaceutics*, Article ID 263517. doi:10.5402/2012/263517.
- Kim, S. I., Na, Y. E., Yi, J. H., Kim, B. S., & Ahn, Y. J. (2007). Contact and fumigant toxicity of oriental medicinal plant extracts against *Dermanyssus gallinae* (Acari: Dermanyssidae). *Veterinary Parasitology*, 145(3), 377-382. doi:10.1016/j.vetpar.2006.12.021.
- Kim, S. I., Yi, J. H., Tak, J. H., & Ahn, Y. J. (2004). Acaricidal activity of plant essential oils against *Dermanyssus gallinae* (Acari: Dermanyssidae). *Veterinary Parasitology*, 120(4), 297-304. doi:10.1016/j.vetpar.2003.12.016.

- Kostyukovsky, M., Rafaeli, A., Gileadi, C., Demchenko, N., & Shaaya, E. (2002). Activation of octopaminergic receptors by essential oil constituents isolated from aromatic plants: possible mode of action against insect pests. *Pest Management Science*, 58(11), 1101-1106. doi:10.1002/ps.548.
- Magdaş, C., Cernea, M., Baciú, H., & Şuteu, E. (2010). Acaricidal effect of eleven essential oils against the poultry red mite *Dermanyssus gallinae* (Acari: Dermanyssidae). *Science of Parasitology*, 11(2), 71-75. Retrieved from file:///C:/Users/Ultra%20Book/Downloads/Acaricidal\_effect\_of\_eleven\_essential\_oils\_against%20(1).pdf.
- Mahendra, P., & Bisht, S. (2011). *Coriandrum sativum*: A daily use spice with great medicinal effect. *Pharmacognosy Journal*, 3(21), 84-88. doi:10.5530/pj.2011.21.16.
- Mandal, S., & Mandal, M. (2015). Coriander (*Coriandrum sativum* L.) essential oil: Chemistry and biological activity. *Asian Pacific Journal of Tropical Biomedicine*, 5(6), 421-428. doi:10.1016/j.apjtb.2015.04.001.
- Nechita, I. S., Poirel, M. T., Cozma, V., & Zenner, L. (2015). The repellent and persistent toxic effects of essential oils against the poultry red mite, *Dermanyssus gallinae*. *Veterinary Parasitology*, 214(3), 348-352. doi:10.1016/j.vetpar.2015.10.014.
- Pavela, R., & Vrchotová, N. (2013). Insecticidal effect of furanocoumarins from fruits of *Angelica archangelica* L. against larvae *Spodoptera littoralis* Boisd. *Industrial Crops and Products*, 43, 33-39. doi:10.1016/j.indcrop.2012.06.044.
- Rodríguez-Vivas R. I., & Cob-Galera L. A. (2005). *Técnicas diagnósticas en parasitología veterinaria* (2<sup>nd</sup> ed.). Mérida, México: Universidad Autónoma de Yucatán.



- Song, H. Y., Yang, J. Y., Suh, J. W., & Lee, H. S. (2011). Acaricidal activities of apiol and its derivatives from *Petroselinum sativum* seeds against *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, and *Tyrophagus putrescentiae*. *Journal of Agricultural and Food Chemistry*, 59(14), 7759-7764. doi:10.1021/jf201945y.
- Steenberg, T., & Kilpinen, O. (2003). Fungus infection of the chicken mite *Dermanyssus gallinae*. *IOBC WPRS Bulletin*, 26(1), 23-26.
- Tavassoli, M., Ownag, A., Pourseyed, S. H., & Mardani, K. (2008). Laboratory evaluation of three strains of the entomopathogenic fungus *Metarhizium anisopliae* for controlling *Dermanyssus gallinae*. *Avian Pathology*, 37(3), 259-263. doi:10.1080/03079450802043718.
- Telci, I., Toncer, O., & Sahbaz, N. (2006). Yield essential oil content and composition of *Coriandrum sativum* varieties (var. *vulgare* Alef and var. *microcarpum* DC.) grown in two different locations. *Journal Essential Oil Research*, 18, 189-193. doi:10.1080/10412905.2006.9699063.
- Toloza, A. (2010). *Bioactividad y toxicidad de componentes de aceites esenciales vegetales, en Pediculus humanus capitis (Phthiraptera: Pediculidae) resistentes a insecticidas piretroides* (doctoral thesis). Universidad de Buenos Aires. Buenos Aires, Argentina. Retrieved from [http://digital.bl.fcen.uba.ar/download/tesis/tesis\\_n4665\\_Toloza.pdf](http://digital.bl.fcen.uba.ar/download/tesis/tesis_n4665_Toloza.pdf).
- Toloza, A., Zygadlo, J., Biurrun, F., Rotman, A., & Picollo, M. (2010). Bioactivity of Argentinean essential oils against permethrin – resistant head lice, *Pediculus humanus capitis*. *Journal of Insect Science*, 10, 185. doi:10.1673 / 031.010.14145.

United States Environmental Protection Agency (US EPA). (2004). *Biopesticides—25b Minimum risk pesticides*. Retrieved from [http://www.epa.gov/oppbppd1/biopesticides/regtools/25b\\_list.htm](http://www.epa.gov/oppbppd1/biopesticides/regtools/25b_list.htm).

Walter, D. E., & Proctor, H. C. (2013). *Mites-ecology, evolution and behaviour: life at a microscale* (2<sup>nd</sup> ed.). Amsterdam, Netherlands: Springer. doi:10.1007/978-94-007-7164-2.

Zeb, A. (2016). Coriander (*Coriandrum sativum*) oils. In V. Preedy (Ed.), *Essential Oils in Food Preservation, Flavor and Safety* (pp. 359-364). London, United Kingdom: Elsevier. doi:10.1016/B978-0-12-416641-7.00040-7.