



Study of the repellency and lethal effect of essential oils derived from *Heracleum persicum* and *Trachyspermum ammi* against *Panonychus ulmi* (Acari: Tetranychidae)

Sahar Taghizadeh^{1*} | Mohammad Bagheri^{1*} | Gholamhossein Gharekhani¹ | Samad Vojoudi² | Mohammad Reza Morshedloo³

1. Department of Plant Protection, Faculty of Agriculture, University of Maragheb, Maragheb, Iran; Emails: sahar.taghizadeh7844@gmail.com, mbagheri20022002@yahoo.com, qgharakhani@gmail.com

2. Department of Plant Protection, Agricultural Jihad Organization of East Azerbaijan Province, Iran; Email: svojoudi1@gmail.com

3. Department of Horticultural Science, Faculty of Agriculture, University of Maragheb, Iran; Email: morsbedoozeza@gmail.com

* Correspondence



sahar.taghizadeh7844@gmail.com
mbagheri20022002@yahoo.com

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ABSTRACT

The European red mite, *Panonychus ulmi* (Acari: Tetranychidae), is one of the main pests of apple trees worldwide. The main purpose of this research was to study the repellent and lethal effects of *Heracleum persicum* and *Trachyspermum ammi* (Apiaceae) essential oils (EOs) on the European red mite. The EOs of *H. persicum* and *T. ammi* were extracted using a Clevenger device and by the water distillation method. The mortality of the mites was evaluated after 24 hours, and the lethality of each EO was calculated for contact toxicity and fumigant toxicity in an incubator at 26 ± 2 °C, 16:8 h L:D, and $50 \pm 5\%$ RH. It was found that the LC_{50} values of EOs of *H. persicum* and *T. ammi* were 343.91 and 311.74 $\mu\text{L l}^{-1}$ for contact toxicity, and 2.54 and 2.85 $\mu\text{L l}^{-1}$ air for fumigant toxicity, respectively. With increasing the concentration of EOs, the death rate of mites increased. Three different concentrations of the EOs from *H. persicum* and *T. ammi* were tested for their repellent effects on the European red mite. Results of the present study revealed that the repellency rate increased with increasing concentration; meanwhile, the *T. ammi* EO had the highest repellency among the concentrations. Despite the growing interest in plant-based pest control, the specific acaricidal and repellent potential of these EOs against *P. ulmi* remains under-explored, particularly regarding their efficacy in integrated pest management systems. These findings suggest that *H. persicum* and *T. ammi* EOs represent promising, eco-friendly botanical alternatives for the management of the European red mite in apple orchards.

KEYWORDS

Apiaceae, botanical pesticides, lethal property, medicinal plants, pest control

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INTRODUCTION

Plant-feeding mites are among the most significant arthropod pests in perennial fruit production systems due to their capacity to cause substantial economic damage through direct feeding and physiological stress on host plants. The European red mite, *Panonychus ulmi* (Acari: Tetranychidae), is a major global pest of fruit orchards, where its activity leads to reduced photosynthetic capacity, leaf chlorosis, and premature defoliation, ultimately compromising fruit yield and quality (Cheng *et al.* 2023; IRAC 2024). The pest is particularly challenging due to its short life cycle and high reproductive rate, which allow for rapid population surges under favorable environmental conditions (IRAC 2024). For decades, the management of *P. ulmi* has relied heavily on synthetic acaricides; however, this approach has



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faced increasing failure due to the widespread development of resistance (IRAC 2024). Resistance has been documented against several major chemical groups, including organophosphates, pyrethroids, METI acaricides, and even abamectin, with resistance ratios reaching as high as 46× in certain populations (Crop Protection 2003; IRAC 2024). This escalating resistance necessitates the urgent exploration of alternative, sustainable pest management strategies that are compatible with Integrated Pest Management (IPM) programs. Botanical pesticides, specifically essential oils (EOs), have emerged as a promising alternative because they consist of complex bioactive mixtures that may offer multiple modes of action (Isman 2020). Such complexity can potentially mitigate the risk of rapid resistance development compared to conventional single-target synthetic chemicals (Isman 2020).

Among potential botanical candidates, *Heracleum persicum* Desf. & Fisch. and *Trachyspermum ammi* L. (Apiaceae) have shown significant biological potential, with *H. persicum* demonstrating notable antimicrobial and antioxidant properties (Imani Baran *et al.* 2020; Ghareh Bashlouei *et al.* 2022). Despite the potential of these plant-derived compounds, a significant knowledge gap exists regarding their efficacy against *P. ulmi*. Most recent research (2022–2026) in this field has prioritized other mite species, such as *Tetranychus urticae* (Acari: Tetranychidae) (Nascimento *et al.* 2012; Zhu *et al.* 2024), or has focused on the impact of botanical extracts on beneficial insects (Kamanga *et al.* 2025). Furthermore, while the bioactive properties of *H. persicum* are known, direct studies on its acaricidal potential against *P. ulmi* are scarce, and recent findings suggest its efficacy may vary compared to related species like *Trachyspermum copticum* (Isman 2020). Therefore, the objective of this study was to evaluate the repellent and lethal effects of *H. persicum* and *T. ammi* EOs against *P. ulmi*. This research aims to determine the mortality rates across different concentrations and assess the repellent activity of these oils under laboratory conditions. By investigating these specific EOs, this study provides novel insights into their potential as eco-friendly components for the sustainable management of acaricide-resistant *P. ulmi* populations.

MATERIAL AND METHODS

This research was carried out during 2023–2024 in the greenhouse and entomology laboratory of the Department of Plant Protection, Faculty of Agriculture, University of Maragheh (East Azerbaijan Province, Iran). Apple seedlings were obtained from the orchards of Maragheh.

Mite colonies

The culture of the European red mite was started using the individuals collected from apple orchards in Maragheh, which were then transferred to a greenhouse. The leaves of the apple seedlings were subsequently infested with the pest mites. To prepare a laboratory colony, apple seedlings (yellow apple cultivar) were placed in a climate chamber at 26 ± 2 °C temperature, 16:8 h L:D photoperiod, and $50 \pm 5\%$ RH. Seedling leaves were infested with mites and were maintained for 60 days before starting the experiments.

Plant material and preparation of essential oils

Heracleum persicum and *Trachyspermum ammi* samples were collected from Talesh, Guilan Province (37.5 – 38.0° N, 48.5 – 49.0° E; 600–2500 m a.s.l.) and Tabriz, East Azerbaijan Province (38.0 – 38.2° N, 46.2 – 46.5° E; 1300–1800 m a.s.l.), respectively. Following their identification, the specimens were subjected to a drying process within a controlled laboratory setting maintained under 25 ± 1 °C temperature conditions. To extract EOs from the dried plants, 300 grams of each plant were powdered using an electric mill. Then, 50 grams of the powdered plants were mixed with 600 mL of distilled water and extracted using a Clevenger-type apparatus with a distillation method, employing water for three hours. The EOs were dried over anhydrous sodium sulfate. Plant EOs were kept in 1.5 mL containers, covered using aluminum foil, at 4 °C temperature until use, then stored in a refrigerator (Gulluce *et al.* 2007).

Analysis of essential oil samples

EOs components were identified using an Agilent GC-MS instrument (Agilent 5975C) at the University of Maragheh according to the procedure explained by Morshedloo *et al.* (2018). An HP5-MS column type with a length of 30 meters and an inner diameter of 0.25 micrometers was used for the separation of the components. The oven temperature was programmed for 5 min at 60 °C and then

ramped from 60 to 240 °C at 3 °C/min, and then held isothermally for 10 min at 240 °C; carrier gas was He (flow rate of 1 mL/min); split ratio 1:24; acquisition mass range 40–400 m/z; ionization voltage, 70 eV.

Laboratory bioassay of essential oils

To check the contact toxicity of each EO separately in the preliminary tests, concentrations of 50, 100, 200, 400, 600, 800, and 1000 $\mu\text{L L}^{-1}$ were prepared for each EO. Two hundred mL of distilled water and 20 mL of ethanol were added for the prepared concentration of 1000 $\mu\text{L L}^{-1}$. For the control treatment, only ethanol and distilled water were used, and the concentrations that caused between 10–90% losses were selected and used in the final test. Leaf-dip method or residual bioassays were carried out using the immersion method (Roh *et al.* 2011). In such a way that after preparing the concentrations, apple leaves were placed in Petri dishes with dimensions of 2×9 cm and a volume of 40 mL, containing different concentrations of EOs, and after 5 seconds, the leaves were removed from the solution and kept for a period of 20 minutes to dry. After that, they were put into Petri dishes lined with moist pads. Twenty female adult mites of the same age were placed on the leaves with a fine brush in Petri dishes. All Petri dishes were kept at 26 ± 2 °C temperature, 16:8 h L:D photoperiod, and $50 \pm 5\%$ RH. Four replicates were performed for each concentration, and after 24 hours, the mite mortality rate was calculated.

In preliminary tests to evaluate fumigant toxicity separately, concentrations of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, and 1 $\mu\text{L L}^{-1}$ air, or 2.5, 5, 7.5, 10, 12.5, 15, 17.5, 20, 22.5, and 25 $\mu\text{L L}^{-1}$ air, were used. Only the concentrations that resulted in mortality rates between 10% and 90% were selected for the final test. To achieve this, 15 adult female mites were placed on apple leaf discs under controlled conditions, without exposure to any treatments, as well as in the presence of *H. persicum* and *T. ammi* EOs at concentrations of 2.5, 2.88, 3.31, 3.80, 4.37 and 5 $\mu\text{L L}^{-1}$ air were introduced using a Hamilton syringe onto filter paper measuring 2 square centimeters in diameter, which was then positioned within a 40 mL glass container to minimize the potential loss of EO vapors. From inside the containers, the doors were completely blocked by parafilm and placed in an incubator at 26 ± 2 °C temperature, 16:8 h L:D, and $50 \pm 5\%$ RH. Four replicates were performed for each concentration, and after 24 hours, the mortality rate of mites was calculated. Mites that showed no movement at all when touched with the brush were considered dead (Roh *et al.* 2011).

Repellence assay

To investigate the repellent effect of plant EOs, concentrations of 10, 100 and 1000 $\mu\text{L L}^{-1}$ were prepared for each EO. Apple leaves were cut into two halves. The concentrations prepared by the micro-sampler and leaf staining method were placed on one-half of the apple leaf as a treatment. The other half of the leaf was considered the control and received only ethanol solvent. Both halves of the leaf were exposed to ambient air for five minutes. Then both halves of the leaf were placed on wet pads at the bottom of Petri dishes with dimensions of 2×9 cm. Twenty adult mites were placed in the center of the leaf halves, and after two hours, the number of mites in both halves was counted. Four replicates were performed for each concentration. The following formula was used to calculate the percentage of repellent. In this formula, N_C is the number of mites in the control half of the leaf, N_T is the number of mites in the treated half of the leaf, and $E_o P_R$ is also the percentage of repellency (Nerio *et al.* 2009; Lim *et al.* 2012; Motazedian *et al.* 2011; Araújo *et al.* 2012).

$$P_R = [(N_C - N_T) / (N_C + N_T)] \times 100$$

Statistical analysis

All the bioassay data were analyzed to calculate the LC_{50} value with 95% confidence limits using the Probit procedure of the SAS program (SAS Institute 2020), and mean comparisons were carried out using the LSD test ($p \leq 0.05$). Abbott's formula (Abbott 1925) was used for corrections in relation to blank control mortality. The figures were prepared using Sigma Plot software.

RESULTS

Lethal effect of essential oil on the European red mite

Although the effect of the abovementioned EOs on the European red mite has not been studied,

studies of their EOs on other mites, including *T. urticae* Koch, have shown that these compounds have had a variety of effects, such as increasing mortality of the various mite stages (Bakkali *et al.* 2008; Abd-Elhady *et al.* 2011; Amer *et al.* 2011; Laborda *et al.* 2013). In this research, it was found that the LC₅₀ values of EOs of *H. persicum* and *T. ammi* for contact toxicity were 343.91 and 311.74 $\mu\text{L l}^{-1}$, and for fumigant toxicity were 2.54 and 2.85 $\mu\text{L l}^{-1}$ air, respectively (Table 1). The slopes of the logarithmic concentration response lines of EOs of *H. persicum* and *T. ammi* for contact toxicity were 3.42 and 1.99, and for fumigant toxicity were 0.4 and 0.19, respectively. The slope of the line of *H. persicum* EO was greater than that of *T. ammi* EO, meaning that with increasing the concentration of *H. persicum* EO, the mortality rate of adult female mites will show greater changes than with the same increase in concentration in *T. ammi* EO. One of the related issues of the slope of the line in pest control is that it is attempted to create a more effective control with a smaller increase in concentration, which is why the LC₅₀ index becomes important. Therefore, compounds that can kill more than 90% of pests with a small increase in concentration instead of 50% are more desirable (Table 1). With the increase in the concentration of EOs, the death rate of mites increased. Due to the lack of overlap, the 95% confidence interval values for the toxicity of EOs of *H. persicum* and *T. ammi* were significantly different at 5% significance level. While both EOs had low LC₅₀ values, they showed high toxicity against the European red mite.

Table 1. LC₅₀ for contact and fumigant toxicity of *Heracleum persicum* and *Trachyspermum ammi* EOs on adult *P. ulmi*.

Essential oils	Methods	N	Df	χ^2	Slope $\pm$ SE	LC ₅₀
<i>H. persicum</i>	contact toxicity	560	4	13.68	3.42 $\pm$ 0.008	343.91 (233.19–557.81)
<i>T. ammi</i>	contact toxicity	560	4	7.96	0.092 $\pm$ 1.99	311.74 (259.66–390.43)
<i>H. persicum</i>	fumigant toxicity	420	3	0.40	0.40 $\pm$ 0.327	2.548 (2.443–2.625)
<i>T. ammi</i>	fumigant toxicity	420	3	0.59	0.19 $\pm$ 0.897	2.858 (2.615–3.040)

Chemical components of essential oils

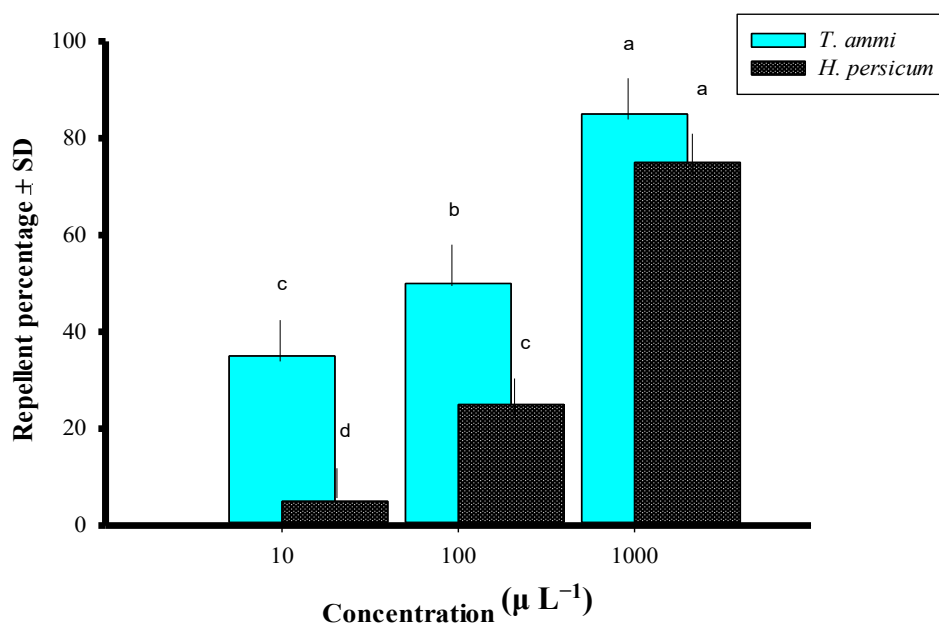
Identification of EO compounds was carried out by GC-MS chromatography. Thus, 68 compounds were identified in *H. persicum* EO, while the majority of the compounds include thymol, octyl acetate, butyl butanoate, and hexyl butyrate. In Comparison, 29 compounds were identified for *T. ammi* EO, while its main compounds were identified as thymol, γ -terpinene, carvacrol, and p-cymene (Table 2). The chemical profile of *H. persicum* EO in the present study, characterized by a predominance of octyl acetate and hexyl butyrate, is consistent with previous phytochemical investigations (e.g., Sefidkon *et al.* 2004; Mahboubi *et al.* 2011). While our results corroborate the dominance of these aliphatic esters, slight variations in the relative concentrations of minor compounds compared to earlier studies may be attributed to differences in the geographic origin, harvest period, and the specific phenological stage of the plant material (Moghaddam *et al.* 2015). Similarly, the composition of *T. ammi* EO, with thymol, γ -terpinene, and p-cymene as the major constituents, aligns with the findings of various studies identifying *T. ammi* as a thymol-chemotype plant (Boskabady *et al.* 2014; Dutta *et al.* 2020). The high content of thymol (41.3%) and γ -terpinene (17.57%) observed in our samples falls within the reported ranges for this species. Discrepancies in the quantitative ratios of these monoterpenes, when compared to other literature (e.g., Khorshidi *et al.* 2010), are typical in EO studies and often reflect the plasticity of the secondary metabolism of *T. ammi* in response to environmental conditions and post-harvest drying processes.

Table 2. The main components of *Heracleum persicum* and *Trachyspermum ammi* EOs were identified using GC-MS analysis.

No	RI	RI Reference	Components	<i>H. persicum</i> (%)	<i>T. ammi</i> (%)
1	951	955	Butyl isobutyrate	0.28	-
2	954	953	Isobutyl butanoate	0.04	-
3	985	985	Isobutyl 2-methylbutyrate	1.16	-
4	994	993	Butyl butanoate	4.18	-
5	1009	1007	Hexyl acetate	0.89	-
6	1022	1020	R-Cymene	1.22	-
7	1024	1022	Limonene 1024 1022	0.29	-

Table 2. Continued.

No	RI	RI Reference	Components	<i>H. persicum</i> (%)	<i>T. ammi</i> (%)
8	1033	1032	Ocimene <(Z)-β>	0.39	-
9	1043	1044	Butyl 2-methyl butyrate	0.45	-
10	1045	1047	Butyl isovalerate	0.32	-
11	1056	1054	γ-Terpinene	0.84	17.57
12	1058	1058	2-Methylbutyl butyrate	0.32	-
13	1066	1063	N-Octanol	1.73	-
14	1096	1095	Linalool	1.6	0.18
15	1148	1147	Hexyl isobutyrate	4.91	-
16	1191	1191	Hexyl butyrate	33.4	-
17	1197	1190	(3Z)-3-octenol acetate	3.84	-
18	1212	1214	Octyl acetate	14.76	-
19	1236	1233	Hexyl 2-methyl butyrate	4.66	-
20	1289	1287	Thymol	6	41.3
21	1344	1344	Octyl isobutyrate	1.32	-
22	1385	1382	Hexyl hexanoate	0.29	-
23	1388	1394	Octyl butyrate	3.1	-
24	1298	1302	Carvacrol	-	1.94
25	924	925	α-Thujene	-	0.52
26	930	932	α-Pinene	-	0.36
27	974	975	β-Pinene	-	1.48
28	988	989	β-Myrcene	-	0.82
29	1002	1002	α-Phellandrene	-	0.16
30	1020	1024	P-Cymene	-	30.57
31	1025	1026	β-Phellandrene	-	0.81
Total				85.99	95.71

Figure 1. The repellency of *Heracleum persicum* and *Trachyspermum ammi* EOs on adult *P. ulmi* after two hours.

DISCUSSION

EOs from plants, including *H. persicum* and *T. ammi*, demonstrate both fumigant and contact

toxicities against insects and mites. These effects not only directly increase mortality but also contribute to secondary impacts such as repellency and antifeedant properties (Motazedian *et al.* 2011; Gholamzadeh Chitgar *et al.* 2013).

Shafiee *et al.* (2015) studied the combined effect of orange peel EO with two chemical acaricides, spiroticlofen and propargite, against adult female spider mites *T. urticae*. In this study, the fumigant and contact toxicity of Citrus sinensis orange peel EO and the contact effect of a mixture of EOs with two acaricides, spiroticlofen and propargite, against two-spotted spider mites *T. urticae* were investigated. The EO was extracted from fresh Dezful orange peel by steam distillation. The median lethal concentration (LC₅₀) values of orange peel EO for fumigant and contact were estimated to be 48.75 $\mu\text{L l}^{-1}$ air and 48.48 $\mu\text{g/cm}^2$, respectively. Fumigant toxicity of plant EOs is much higher than their contact toxicity. Since plant EOs have a nervous mechanism of action in the mortality of the terminal section (Enan 2001), the high fumigant toxicity compared to contact toxicity may be because in fumigant toxicity, the EO compounds easily enter the body of insects and mites through the respiratory pores and directly affect nerve cells, while in the contact state, it must travel through the cuticle and hemolymph and then reach the nerve cells, during which a small amount of the EO enters the body of the insect and some of the EO is metabolized and loses its lethal effect. However, given that there is no closed space in orchard and field ecosystems, and that when plant EOs are employed as pesticides they will never reach a vapor pressure high enough to cause fumigant toxicity, despite the use of high concentrations of EOs in contact toxicity, research on the contact effects of EOs is more useful than fumigant toxicity (Negahban 2010). A key contribution of this research is the specific demonstration of both repellent and lethal effects of these EOs against *P. ulmi*. The significant contact toxicity observed in this study is of paramount importance for the practical management of *P. ulmi*. Unlike fumigant toxicity, which relies on the volatile movement of molecules through air spaces, contact toxicity ensures that the active constituents of *H. persicum* and *T. ammi* EOs directly penetrate the mite's cuticle upon physical contact with the leaf surface or the pest itself. Given that *P. ulmi* often resides in protected microhabitats, such as the undersides of leaves or within silken webs, a potent contact action is essential to ensure that the botanical acaricide reaches the target population effectively. Furthermore, the ability of these EOs to cause mortality through contact reduces the risk of 'escape' by the mites during volatile fluctuations, thereby providing a more reliable and consistent control mechanism in orchard environments (Smith *et al.* 2024).

Our determined LC₅₀ values for contact toxicity of *H. persicum* and *T. ammi* EOs were 343.91 and 311.74 $\mu\text{L l}^{-1}$, respectively. For fumigant toxicity, the LC₅₀ values were 2.54 and 2.85 $\mu\text{L l}^{-1}$ air, respectively. These findings align with and extend previous research on other mite species, such as *T. urticae* (Lim *et al.* 2012; Govindarajan *et al.* 2016; Reddy *et al.* 2016; Salehi Amiri *et al.* 2019), suggesting that the complex chemical composition of these EOs, particularly their high concentrations of monoterpenes and sesquiterpenes, plays a critical role in their bioactivity against mite populations. Monoterpenes and sesquiterpenes are known for their diverse biological activities, including insecticidal and acaricidal properties. Their modes of action are varied and can include disruption of the nervous system, interference with energy metabolism, and damage to the cuticle (Amiri *et al.* 2022; Djoumessi *et al.* 2023). For instance, compounds like pulegone, a monoterpene found in some EOs, have been shown to act as acetylcholinesterase inhibitors, leading to paralysis and death in insects (Kato *et al.* 2023). Sesquiterpenes, such as farnesol, have demonstrated effects on insect growth regulation and membrane integrity (Lee *et al.* 2004). While previous research has explored the insecticidal activities of various plant-derived compounds, extending this understanding to the specific efficacy of mono-terpene and sesquiterpene-rich EOs from *H. persicum* and *T. ammi* against *P. ulmi* is a significant advancement. Furthermore, research on the repellent effects of plant EOs against insects and mites has been well-documented (Sarraf-Moayeri *et al.* 2013; Faraji *et al.* 2015; Ebadollahi 2011).

Our repellency tests confirmed that *H. persicum* and *T. ammi* EOs exhibit a concentration-dependent repellent effect on *P. ulmi*, with higher concentrations leading to increased repellency rates. This multimodal approach, encompassing both lethal and repellent actions, underscores the potential of EOs to reduce reliance on conventional chemicals and integrate into safer orchard management programs (Zhang *et al.* 2025). The observed strong toxicity of these EOs is consistent with findings in other studies

focusing on the Tetranychidae family. For instance, research on similar volatile compositions has demonstrated that the synergistic interaction of monoterpenes and sesquiterpenes provides superior acaricidal efficacy by disrupting the delicate physiological balance of mite populations (Athanasios *et al.* 2022; Mossa *et al.* 2019). Our results, specifically regarding the high susceptibility of *P. ulmi* to the tested EOs, corroborate this trend, indicating that the chemical profile of *H. persicum* and *T. ammi* acts effectively across various species within the Acari subclass. This reinforces the broader applicability of these botanical acaricides as a robust alternative to synthetic compounds, ensuring consistent control efficacy despite the inherent interspecific variations among mites. Our study, focusing on the European red mite, provides specific data on the contact and fumigant toxicity of *T. ammi* EO, reinforcing the consistency of EO efficacy across different arthropod pests and highlighting the importance of chemical constituents (Imani Baran *et al.* 2020). A primary knowledge gap addressed by this study is the historical skew of EO efficacy research towards species like *T. urticae*. By expanding these evaluations to the *P. ulmi*, we provide a more comprehensive understanding of botanical acaricide performance across different species within the Tetranychidae family (Mossa *et al.* 2019). This broader perspective is crucial for developing effective and targeted pest management strategies. To further enhance the efficacy and durability of these EOs, future research could explore methods such as nanoencapsulation or investigate synergistic effects when EOs are combined with conventional acaricides. Such approaches could potentially increase the toxicity and longevity of EO action against *P. ulmi*, reduce the required dosage of chemical pesticides, and consequently mitigate the environmental impact of chemical pest control (Senthil-Nathan *et al.* 2023; Liu *et al.* 2026).

CONCLUSIONS

The results of this research showed that both tested EOs have repellent and lethal effects on the European red mite under laboratory conditions. In the contact toxicity assay, *T. ammi* exhibited higher efficacy with an LC_{50} value of $311.74 \mu\text{L l}^{-1}$ compared with $343.91 \mu\text{L l}^{-1}$ for *H. persicum*. Conversely, in the fumigant toxicity assay, *H. persicum* demonstrated greater lethality with an LC_{50} of $2.548 \mu\text{L l}^{-1}$ air, compared with $2.858 \mu\text{L l}^{-1}$ air for *T. ammi*. Overall, the results indicate that both EOs, particularly through the fumigant method, possess significant potential for use in the management of the targeted pest. Also, the results indicated that *T. ammi* EO had the highest percentage of repellency in all three concentrations used. Therefore, these EOs can be proposed for application in the management of the European red mite after field tests and further studies.

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REFERENCES

- Abd-Elhady, H.K. & El-Zahi, E.-Z.S. (2011) Composition and acaricidal activities of *Rosmarinus officinalis* essential oil against *Tetranychus urticae* and its predatory mite *Phytoseiulus persimilis*. *Alexandria Science Exchange Journal*, 32(3): 337–345. <https://doi.org/10.21608/asejaqjsae.2011.2637>
- Abbott, W.S. (1925) A method of computing the effectiveness of an insecticide. *Journal of Economic Entomology*, 18: 265–267. <https://doi.org/10.1093/jee/18.2.265a>
- Amer, S.A.A., Mohamed, F.S.A., Kamel, A.M., Zakeya, E.A.D., Huda, E.H. & Eldesouley, M.E. (2011) Acaricidal activity of some Lamiaceae plant essential oils against *Tetranychus urticae* Koch (Acari: Tetranychidae). *Acarines*, 5 (1): 11–17. <https://doi.org/10.21608/ajesa.2011.163601>
- Amiri, R., Guesmi, F., Saidi, I., Bouzenna, H., Khaled, I., Ben Ali, M., Hedfi, A., Alghamdi, A.S., Hfaiedh, N., Allagui, M.S. & Landoulsi, A. (2022) Insecticidal and antimicrobial potential of the volatile oils of the aerial parts of *Teucrium ramosissimum* and *Thymus hirtus* subsp. *algeriensis* growing in the south-west of Tunisia. *Journal of Essential Oil Bearing Plants*, 25(6): 1185–1207. <https://doi.org/10.1080/0972060X.2022.2150008>
- Araújo, M.J.C., Camara, C.A.G., Born, F.S., Moraes, M.M. & Badji, C.A. (2012) Acaricidal activity and repellency of essential oil from *Piper aduncum* L. and its components against *Tetranychus urticae* Koch (Acari: Tetranychidae). *Experimental Applied Acarology* 57: 139–155. <https://doi.org/10.1007/s10493-012-9545-x>
- Athanassiou, C.G., Kavallieratos, N.G. & Benelli, G. (2022) Essential oils and their constituents as potential botanical acaricides: A review on the recent literature. *Journal of Pest Management Science*, 78(4): 1234–1250.
- Bakkali, F., Averbeck, S., Averbeck, D. & Idaomar, M. (2008) Biological effects of essential oils A review. *Food and Chemical Toxicology*, 46: 446–475. <https://doi.org/10.1016/j.fct.2007.09.106>
- Boskabady, M.H., Alitaneh, S. & Alavinezhad, A. (2014) *Trachyspermum ammi* L. Spreng. (Ajwain): A review of its traditional uses, phytochemistry and pharmacology. *Journal of Ethnopharmacology*, 151(1): 1–14.
- Cheng, X., Wang, L. & Zhang, Y. (2023) Comparative analysis of botanical acaricides in managing *Panonychus ulmi* populations. *Pest Management Science*, 79(4): 1245–1256. <https://doi.org/10.1002/ps.7342>
- Djoumessi, A.K., Nono, R.N., Neumann, B., Stammler, H.-G., Bitchagno, G.T.M., Efange, N.M., Nkenfou, C.N., Ayong, L., Lenta, B.N., Sewald, N., Nkeng-Efouet-Alango, P. & Chouna, J.R. (2023) Constituents of the stem bark of *Trichilia monadelpha* (Thonn.) J. J. De Wilde (Meliaceae) and Their Antibacterial and Antiplasmodial Activities. *Metabolites*, 13(2): 298. <https://doi.org/10.3390/metabo13020298>
- Dutta, S., Kundu, A., Saha, S., Prabhakaran, P. & Mandal, A. (2020) Characterization, antifungal properties and in silico modelling perspectives of *Trachyspermum ammi* essential oil. *LWT-Food Science and Technology*, 131: 109786. <https://doi.org/10.1016/j.lwt.2020.109786>
- Ebadollahi, A. (2011) Iranian plant essential oils as sources of natural insecticide agents. *International Journal of Biological Chemistry*, 5(5): 266–290.
- Enan, E. (2001) Insecticidal activity of essential oils: octopaminergic sites of action. *Comparative Biochemistry and Physiology Part C: Toxicology and Pharmacology*, 130(3): 325–337. [https://doi.org/10.1016/S1532-0456\(01\)00255-1](https://doi.org/10.1016/S1532-0456(01)00255-1)
- Faraji, N., Siraj, A.A., Rajabpur, A. & Yarahmadi, F. (2015) Investigation of the repellent and anti-oviposition effects of essential oils of two plant species on the spider mite *Tetranychus turkestanii* and its predatory *Orius albidipennis*. *Journal Agriculture Science and Technology*, 38(1): 113–122. <https://doi.org/10.22055/ppr.2015.11979>
- Ghareh Bashlouei, S., Karimi, E., Zareian, M., Oskoueian, E. & Shakeri, M. (2022) *Heracleum persicum* essential oil nanoemulsion: A nanocarrier system for the delivery of promising anticancer and antioxidant bioactive agents. *Antioxidants*, 11(5): 831. <https://doi.org/10.3390/antiox11050831>
- Gholamzadeh Chitgar, M., Khosravi, R., JalaliSendi, J. & Ghadamyari, M. (2013). Sublethal effects of *Thymus vulgaris* essential oil on life-table parameters of two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae). *Archives of Phytopathology and Plant Protection*, 46: 781–788.

<http://dx.doi.org/10.1080/03235408.2012.752143>

- Govindarajan, M., Rajeswary, M., Hoti, S.L. & Benell, I. G. (2016) Larvicidal potential of carvacrol and terpinen-4-ol from the essential oil of *Origanum vulgare* (Lamiaceae) against *Anopheles stephensi*, *Anopheles subpictus*, *Culex quinquefasciatus* and *Culex tritaeniorhynchus* (Diptera: culicidae). *Research in Veterinary Science*, 104: 77–82. <https://doi.org/10.1016/j.rvsc.2015.11.011>
- Gulluce, M., Sahin, F., Sokmen, M., Ozer, H., Daferera, D., Sokmen, A., Polissiou, M., Adiguzel, A. & Ozkan, H. (2007) Antimicrobial and antioxidant properties of the essential oils and methanol extract from *Mentha longifolia* L. *Food Chemistry*, 103(4): 1449–1456. <https://doi.org/10.1016/j.foodchem.2006.10.061>
- Imani Baran, A., Jahanghiri, F., Hajipour, N., Sparagano, O. A. E., Norouzi, R., & Moharramnejad, S. (2020) In vitro acaricidal activity of essential oil and alcoholic extract of *Trachyspermum ammi* against *Dermanyssus gallinae*. *Veterinary Parasitology*, 278: 109030. <https://doi.org/10.1016/j.vetpar.2020.109030>
- Insecticide Resistance Action Committee (IRAC) (2024) *Panonychus ulmi: Pest profile and resistance management*. Available from: <https://irac-online.org/pests/panonychus-ulmi/> (Accessed on 15 October 2026)
- Isman, M.B. (2020) Bioinsecticides based on plant essential oils: a short overview. *Zeitschrift fur Naturforschung. C, Journal of biosciences*, 75(7–8): 179–182. <https://doi.org/10.1515/znc-2020-0038>
- Jankowska, M., Rogalska, J., Wyszowska, J. & Stankiewicz, M. (2018) Molecular targets for components of essential oils in the insect nervous system—A review. *Molecules*, 23(1): 34. <https://doi.org/10.3390/molecules23010034>
- Kamanga, R.M., Bhikha, S., Kamala, F.D., Mwale, V.M., Tembo, Y. & Ndakidemi, P.A. (2025) Neem and gliricidia plant leaf extracts improve yield and quality of leaf mustard by managing insect pests' abundance without harming beneficial insects and some sensory attributes. *Insects*, 16(2): 156. <https://doi.org/10.3390/insects16020156>
- Laborda, R., Manzano, I., Gamónb, M., Gavidia, I., Pérez-Berúdez, P. & Boluda, R. (2013) Effects of *Rosmarinus officinalis* and *Salvia officinalis* essential oils on *Tetranychus urticae* Koch (Acari: Tetranychidae). *Industrial Crops Products*, 48: 106–110. <https://doi.org/10.1016/j.indcrop.2013.04.011>
- Lee, B.H., Annis, P.C., Tumaalii, D. & Choi, W.S. (2004) Fumigant toxicity of essential oils from the Myrtaceae family and 1,8-cineole against three major stored-grain insects. *Journal of Stored Products Research*, 40(6): 553–564. <https://doi.org/10.1016/j.jspr.2003.09.001>
- Lim, E., Lee, B.H. & Park, C.G. (2012) Fumigant activity of essential oils and their components from *Eucalyptus codonocarpa* and *Eucalyptus dives* against *Tetranychus urticae* Koch (Acari: Tetranychidae) at three temperatures. *Journal of Applied Entomology* 136: 698–703. <https://doi.org/10.1111/j.1439-0418.2011.01700.x>
- Liu, X., Zhang, Y. & Zhao, Q. (2026) Climate change impacts on stored product insect populations. *Stored Product Research*, 45: 212–214.
- Mahboubi, M., Bidgoli, F. G., & Farzin, N. (2011) Chemical composition and antimicrobial activity of *Chenopodium botrys* L. essential oil. *Journal of Essential Oil Bearing Plants*, 14(4): 498–503. <https://doi.org/10.1080/0972060X.2011.10643608>
- Moghaddam, M., Esmaeili, A. & Ahmadi, M. (2015) Variations in the chemical composition of essential oils from Apiaceae species due to environmental factors. *Phytochemistry Letters*, 10: 45–52.
- Morshedloo, M.R., Maggi, F., Neko, H.T. & Aghdam, M.S. (2018) Sumac (*Rhus coriaria* L.) fruit: Essential oil variability in Iranian populations. *Industrial Crops and Products*, 111: 1–7. <https://doi.org/10.1016/j.indcrop.2017.10.002>
- Mossa, A.-T.H., Afia, S.I., Mohafrash, S.M.M. & Abou-Awad, B.A. (2019) Rosemary essential oil nanoemulsion, formulation, characterization and acaricidal activity against the two-spotted spider mite *Tetranychus urticae* Koch (Acari: Tetranychidae). *Journal of Plant Protection Research*, 59(1): 102–112. <https://doi.org/10.24425/jppr.2019.126039>

- Motazedian, N., Ravan, S. & Bandani, A. (2011) Toxicity and repellency effects of three essential oils against *Tetranychus urticae* Koch (Acari: Tetranychidae). *Journal of Agricultural Science and Technology*, 14: 275–284.
- Nascimento, A.F., da Camara, C.A. G., de Moraes, M.M. & Ramos, C.S. (2012) Essential oil composition and acaricidal activity of *Schinus terebinthifolius* from Atlantic Forest of Pernambuco, Brazil against *Tetranychus urticae*. *Natural Product Communications*, 7(1): 129–132.
<https://doi.org/10.1177/1934578X1200700141>
- Negahban, M. (2010) *Insecticidal activity of essential oil from Artemisia sieberi Besser on Tribolium castaneum and Plutella xylostella*. Ph.D. Thesis, Tarbiat Modares University, Tehran, Iran, 123pp.
- Nerio, L.S., Olivero-Verbel, J. & Stashenko, E.E. (2009) Repellent activity of essential oils from seven aromatic plants grown in Colombia against *Sitophilus zeamais* Motschulsky (Coleoptera). *Journal Stored Products Research*, 45: 212–214. <https://doi.org/10.1016/j.jspr.2009.01.002>
- Reddy, S.G.E., Dolma, S.K., Koundal, R. & Singh, B. (2016) Chemical composition and insecticidal activities of essential oils against diamondback moth, *Plutella xylostella* (Lepidoptera: Yponomeutidae). *Natural Product Research*, 30: 1834–1838.
<https://doi.org/10.1080/14786419.2015.1068772>
- Roh, H.S., Lim, E.G., Kim, J. & Park, C.G. (2011) Acaricidal and oviposition deterring effects of santalol identified in Sandal wood oil against two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae). *Journal of Pest Science*, 84(4): 495–501. <https://doi.org/10.1007/s10340-011-0377-y>
- Salehi Amiri, S., Mohammadi Sharif, M. & Hadizadeh, A. (2019) Biological effects of *Sambucus ebulus* L., *Urtica dioica* L., *Rubus fruticosus* Boiss. and *Pteridium aquilinum* L. Kuhn extracts against two-spotted spider mite. *Iranian Journal of Medicinal and Aromatic Plants*, 35(4): 565–576.
<https://doi.org/10.22092/ijmapr.2019.124763.2464>
- Sarraf Moayeri, H.R., Pirayeshfar, F. & Kaws, O. (2013) The repellent essential oils on the two-spotted spider mite *Tetranychus urticae* Koch (Acari: Tetranychidae). *Iranian Journal of Plant Protection Science*, 44(1): 103–112. <https://doi.org/10.22059/ijpps.2013.35627>
- SAS Institute (2020) SAS/STAT Software: changes and enhancements though release 8. SAS. SAS institute Inc., Cary, North Carolina.
- Sefidkon, F., Dabiri, M. & Mohammad, N. (2004) Analysis of the oil of *Heracleum persicum* L. (seeds and stems). *Journal of Essential Oil Research*, 16(4): 296–298.
<https://doi.org/10.1080/10412905.2004.9698725>
- Senthil-Nathan, S. (2015) A review of biopesticides and their mode of action against insect pests. In: Thangavel, P. & Sridevi, G. (Eds.), *Environmental Sustainability*, Springer, pp. 49–63.
https://doi.org/10.1007/978-81-322-2056-5_3
- Shafiee, E., Talebi Jahromi, K., & Sabahi, Q. (2016) Effects of mixture orange peel essential oil with two chemical acaricides, spirodiclofen and propargite against adult females of spider mites *Tetranychus urticae* (Acari: Tetranychidae). *Plant Pest Research*, 5(4): 39–50.
- Smith, R.J., Chen, Y., Lafleur, C.I., Kaur, D. & Bede, J.C. (2024) Effect of sublethal concentrations of the bioinsecticide spinosyn treatment of *Trichoplusia ni* eggs on the caterpillar and its parasitoid, *Trichogramma brassicae*. *Pest Management Science*, 80(6): 2965–2975.
<https://doi.org/10.1002/ps.8004>
- Toth, A. & Smith, B. (2003) Resistance mechanisms in *Panonychus ulmi* to synthetic acaricides. *Crop Protection*, 22(5): 345–352. [https://doi.org/10.1016/S0261-2194\(03\)00136-4](https://doi.org/10.1016/S0261-2194(03)00136-4)
- Zhang, Z.-Q. (2003) *Mites of greenhouses, identification, biology and control*. CABI Publishing, Wallingford, 244 pp.
- Zhang, S., Gao, Z., Wang, H., Gao, J., Guo, F., Wang, R., Xing, W., Liu, J., Zhang, X. & Yang, X. (2025) Acaricidal bioactivity and molecular target analysis of *Origanum onites* and *Ocimum gratissimum* essential oils against *Haemaphysalis doenitzi* ticks. *Parasites and Vectors*, 18: 401.
<https://doi.org/10.1186/s13071-025-07031-3>
- Zhu, Y., Wu, T., Hu, Q., He, W., Zheng, Y., Xie, Y., Rao, Q. & Liu, X. (2024) Plant essential oils: Dual action of toxicity and egg-laying inhibition on *Tetranychus urticae* (Acari: Tetranychidae), unveiling their potential as botanical pesticides. *Plants*, 13(6): 763. <https://doi.org/10.3390/plants13060763>

بررسی اثرهای دورکنندگی و کشندگی اسانس‌های استخراج شده از گلپر و زنیان کنه قرمز اروپایی (*Panonychus ulmi* (Acari: Tetranychidae)

سحر تقی‌زاده^{۱*} | محمد باقری^{۱*} | غلامحسین قره‌خانی^۱ | صمد وجودی^۲ | محمدرضا مرشدلو^۳

۱. گروه گیاه‌پزشکی، دانشکده کشاورزی، دانشگاه مراغه، مراغه، ایران؛ رایانامه‌ها: sabar.taghizadeh7844@gmail.com | mbagheri20022002@yahoo.com | qgharakbani@gmail.com
 ۲. اداره حفظ نباتات، جهادکشاورزی، استان آذربایجان شرقی، ایران؛ رایانامه: svojoudi1@gmail.com
 ۳. گروه باغبانی، دانشکده کشاورزی، دانشگاه مراغه، مراغه، ایران؛ رایانامه: morshedoorazga@gmail.com

*نویسندگان مسئول



sabar.taghizadeh7844@gmail.com
mbagheri20022002@yahoo.com

چکیده

کنه قرمز اروپایی (*Panonychus ulmi* (Acari: Tetranychidae) یکی از آفات اصلی درختان سیب در سراسر جهان است. هدف اصلی این پژوهش مطالعه اثر دورکنندگی و کشندگی اسانس گیاهان گلپر (*Heracleum persicum*) و زنیان (*Trachyspermum ammi*) روی کنه قرمز اروپایی است. اسانس گیاهان گلپر و زنیان با استفاده از دستگاه کلونجر و با روش تقطیر با آب استخراج شدند. مرگ‌ومیر کنه‌ها پس از گذشت ۲۴ ساعت ارزیابی شد و میزان کشندگی هر اسانس در سمیت تماسی و تدخینی در انکوباتور با دمای 26 ± 2 درجه سلسیوس، دوره نوری ۱۶ ساعت روشنایی و ۸ ساعت تاریکی و رطوبت نسبی 50 ± 10 درصد محاسبه شد. در این پژوهش مشخص شد که LC_{50} اسانس گیاهان گلپر و زنیان به ترتیب در سمیت تماسی $343/91$ و $311/74$ میکرولیتر بر لیتر و در سمیت تدخینی $2/54$ و $2/85$ میکرولیتر بر لیتر هوا است. با افزایش غلظت اسانس‌ها میزان مرگ‌ومیر کنه‌ها افزایش یافت. سه غلظت مختلف از اسانس گیاهان گلپر و زنیان برای بررسی اثر دورکنندگی آن‌ها بر روی کنه قرمز اروپایی آزمایش شدند. نتایج مطالعه حاضر نشان داد که میزان دورکنندگی با افزایش غلظت افزایش می‌یابد، همچنین اسانس زنیان بیش‌ترین درصد دورکنندگی را در بین غلظت‌ها داشت. با وجود افزایش علاقه به مبارزه با آفات با استفاده از ترکیب‌های گیاهی، پتانسیل اختصاصی کنه‌کشی و دورکنندگی این اسانس‌ها علیه *P. ulmi*، به‌ویژه از نظر کارایی آن‌ها در سیستم‌های مدیریت تلفیقی آفات، همچنان کمتر مورد بررسی قرار گرفته است. یافته‌های این پژوهش نشان می‌دهد که اسانس‌های *T. ammi* و *H. persicum* به‌عنوان جایگزین‌های گیاهی امیدوارکننده و سازگار با محیط‌زیست برای مدیریت کنه قرمز اروپایی مطرح هستند.

واژگان کلیدی: تیره چتریان، آفت‌کش‌های گیاهی، خاصیت کشندگی، گیاهان دارویی، کنترل آفت

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دریافت

۲۶ خرداد ۱۴۰۵

پذیرش

۲۹ تیر ۱۴۰۵

انتشار

۲۳ مهر ۱۴۰۵

دبیر تخصصی

ا. ترابی

