*Jordan Journal of Agricultural Sciences,* Volume **20**, No.**3** **2024**
DOI :https://doi.org/10.35516/jjas.v20i3.1045

# Analysis of Essential Oils Extracted from Algerian Medicinal Plants and Their Aphicidal Effect Against the Melon Aphid *Aphis Gossypii* Glover (Homoptera: Aphididae)

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Received on 22/3/2023 and Accepted for Publication on 9/10/2023.

## ABSTRACT

Chemical insecticides are decisive in controlling insect pests, but they harm the environment. Reducing the use of chemical insecticides has become the main goal for ensuring healthy produce. However, research focusing on plant-based compounds has recently increased. The present study was carried out to analyze essential oils extracted from Algerian medicinal plants by gas chromatography coupled with mass spectrometry (GC-MS) to determine the insecticidal activity of essential oils from *Juniperus phoenicea, Rosmarinus officinalis, Lavandula stoechas, Mentha pulegium and Pinus sylvestris*, against *Aphis gossypii* Glover The main components constituting each essential oil were: α-pinene, β-Pinene 1,8- cineol, Linalool, Linalyl acetate, Fenchone, Pulegone, and Camphor. The toxicity of tested essential oils against Aphis gossypii was different and dependent on the concentration used (1000, 10000, and 100000 ppm), the duration of exposure (24, 48, and 72 h), and the chemical composition of the oil. The highest toxicity was for *J. phoenicea, M. pulegium, and L. stoechas* which were toxic as Actara® insecticide.

**Keywords**: *Aphis gossypii* Glover , biocontrol, bioinsecticides, essential oils, and plant extracts.

## INTRODUCTION

The melon aphids, *Aphis gossypii* Glover (Homoptera: Aphididae), have an extensive host range (over 600 species), including cotton, cucurbits, Solanaceae, and citrus. Throughout the world, this aphid species transmits more than 50 plant viruses and causes extensive quantitative and qualitative damage to plants (Blackman and Eastop, 2006). Chemical aphicides are widely used in agriculture as neurotoxins that cause different effects on all living organisms (Jayakumar *et al.*, 2008), resulting in serious problems such as pollution of the environment, health hazards, and insect resistance (Sahayaraj and Paulraj, 1999; Yadav *et al.*, 2008; Sánchez-Bayo, 2021). The development of insecticide resistance in aphids necessitates the development of new control methods. The most effective approach to

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resistance management is to minimize insecticide use by following appropriate threshold guidance and using integrated pest management (IPM) programs. Plant-based pesticides (also known as botanical pesticides) are an alternative to pest control based on plant extracts (Ateyyat and Abu- Darwish 2009). Phytochemicals are usually less environmentally harmful than synthetic agrochemicals. Plant essential oils obtained from plants may have the potential to be an alternative to synthetic pesticides, so they are receiving increased attention as sources of useful pest-active compounds because of the necessity of finding safer control methods (Zhou *et al.* 2004). Their value within the control of aphids has been detailed and explained (Hori, 1998; Munneke *et al.*, 2004; Ahmed *et al.*, 2021). Essential oils displayed great potential movement to control insects and have effectiveness by fumigation (Mahmoodi *et al.*, 2015), topical application (Sharma and Vidyarthi, 2010; Hakimi *et al.*, 2015), anti-feedant and repellent properties (Hiromi *et al.*, 2012) and can significantly reduce pest's reproduction potential (Isik and Gorur, 2009). Recent? investigations confirmed various essential oils were efficient against aphids including *A. gossypii* (Akbar *et al.*, 2010; Kassimi and El-Wafik, 2012; Bokobana *et al.*, 2014; Mohmed, 2018).

Botanical pesticides based on essential oils become more interesting and important in recent years. Therefore, the current study was carried out to evaluate the aphidicidal effect of essential oils extracted from Algerian medicinal plants namely: *Mentha pulegium, Pinus sylvestris, Lavandula stoechas, Rosmarinus officinalis,* and *Juniperus phoenicea* against *A. gossypii*. These plants are abundant in the Mediterranean region and North Africa, known for their richness of essential oils and are characterized by complex chemical composition and compounds that have toxic or repellent action against pests (Go´rski and Tomczak, 2010), antimicrobial, anti-inflammation, and antiviral activities (Flamini *et al.*, 2002; Caillard, 2003; Bouyahiaoui, 2016).

Essential oils, which are for the most part composed of complex blends of monoterpenes, phenols, and sesquiterpenes, have demonstrated insecticidal activity, so the determination of the chemical composition of an essential oil supports the potency of the results of biological activities of certain essential oil and its secondary metabolites. Thus, research continued to find more potential plant-based compounds, considering the safety of the environment (Isman, 2006).

## Materials and methods

### Aphid source

The laboratory colonies of *A. gossypii* were started with aphids collected from fresh leaves derived from a stock culture maintained continuously at laboratory conditions; 23 °C, photoperiod of 11/13 h, and 60% relative humidity on squash (*Cucurbita pepo* L. cv. Scarlette) grown in pots. All aphid cultures were maintained continuously at the Department of Plant Protection, Faculty of Agriculture, The University of Jordan, Amman, Jordan.

### -Essential oil extraction

Oils were extracted from aerial parts of five medicinal plants: *R. officinalis*, *L. stoechas*, *M. pulegium*, *J. phoenicea*, and *P. sylvestris* by distillation using a Clevenger-type, The EOs of all dried samples were isolated by hydro-distillation for 3 h using a Clevenger-type apparatus according to the method recommended by the British Pharmacopoeia (British pharmacopeia, 1988). The distilled oils were dried over anhydrous sodium sulfate and put in tightly closed dark vials for further investigations (Ashraf *et al.*, 2020)). These plants were reputed to perform important biological functions as conventional medicines, and then they became more widely available in the entire world for treating ailments (Lai and Roy, 2004; Falodon, 2010).

### -Chemical analysis

The main components constituting each essential oil have been identified and quantified using gas chromatography combined with mass spectroscopy (GC/MS) in the chemistry laboratory of Shankiri University (Turkey).

Experiments were carried out at the laboratory of the Plant Production Department at the University of Jordan, to evaluate the efficacy of those extracts against melon aphid. Three concentrations (1,000, 10,000, and 100,000 ppm) of each extract were prepared by dissolving the oil extract in 0.01 (v/v) dimethyl sulfoxide (DMSO) solution.

DMSO and Actara® (Thiamethoxam) were used as negative and positive controls, respectively. Apterous virginoparae were carefully placed on the lower surface of host plant leaves inside 9-cm petri dishes. Sprays were made using Potter Spray Tower (Burkard Scientific Ltd). Each treatment was replicated 5 times. Mortalities were recorded after 24 h, 48 h and 72 h.

**-Statistical analysis**

Arcsine-transformed percentage data were subjected to a one-way ANOVA, followed by a Least Significant Differences test at a 95 % confidence level (SAS Institute, 2012).

## Results and discussion

### Chemical composition of the essential oils

Phytochemical screening of *J. phoenicea* essential oils led to the finding of at least 15 different compounds. α-Pinene is the major compound (78.26%) followed by β-Phellandrene (6.31%) (Table 1). Many studies indicated that the chemical composition of juniper differs from one region to another, and between the same plant species, meaning that it is characterized by multiple chemo-types, this difference could be quantitative or qualitative (Cavaleiro *et al.*, 2001). According to Bouzabata and Hadef (2009) and Mazari *et al.* (2010) studies in Batna, α-Pinene was the main component. Also, the results of Ramdani *et al.* (2013) in Setif (Algeria) were characterized by the dominance of α-Pinene and β-Phellandrene, but in different proportions. These compounds were also reported in studies on *J. phoenicea's* essential oil from Portugal (Ait-Ouazzou *et al.*, 2012).

Chemical analysis of *P. sylvestris* detected 24 compounds, it was also rich in α-pinene (26.76%) followed by β-pinene (Nopinene) (15.23%) and caryophylene (10.77%) (Table 2). In another study, α-pinene, 3-carene, camphene, and β-pinene were the main components of this essential oil (Komenda and Kopmann, 2002). The same components as those identified in the present study were detected but in different proportions, especially α-Pinene and β-pinene in Turkey (Ustun *et al.*, 2006); (Zafra and Garcia-Peregrin, 2009; Ibáñez and Blázquez, 2019), but results of (Fayemiwo *et al.*, 2014) were quite different from ours.

Regarding *R. officinalis*, it contains 24 compounds of which 1,8-cineol (Eucatolyptol) makes up to half of these compounds (49.58%), but with less value of α-Pinene and, Camphor (11.75%) and (10.82%), respectively (Table 3). According to Lawrence (1997) in his numerous studies on rosemary, α-Pinene, cineol, and camphor are present in close proportions in France, Spain, Italy, Greece, and Bulgaria. In Biban and Tlemcen (Algeria) the same components as those identified in our work were detected, but in different proportions (Boutekedjiret et al., 1999; Benkkara *et al.*, 2007).

**Table 1**: Chemical composition of essential oils extracted from *Juniperus phoenicea* and its retention time (RT), retention index (RI), and percentage (%)

| Component | RT (min) | RI | % |
|---|---|---|---|
| α-Pinene | 12.13 | 920 | **78.26** |
| Camphene | 12.60 | 936 | 0.81 |
| β-Pinene | 13.51 | 964 | 0.90 |
| β-Pinene | 13.69 | 970 | 1.69 |
| α-Phellandrene | 14.31 | 988 | 0.51 |
| 3-Carene | 14.526 | 995 | **3.34** |
| m-Cymene | 14.98 | 1008 | 0.85 |
| β-Phellandrene | 15.20 | 1015 | **6.31** |
| β-Linalool | 17.41 | 1080 | 1.25 |
| α-Terpineol acetate | 26.10 | 1332 | 1.45 |
| Caryophyllene | 28.69 | 1413 | 0.74 |
| Cedrelanol | 30.24 | 1463 | 0.70 |
| 2-Isopropyl-5-methyl-9-methylenebicyclo[4.4.0]dec-1- ene | 30.55 | 1473 | 0.62 |
| 4-epi-cubedol | 30.92 | 1485 | 1.10 |
| δ-Cadinene | 31.67 | 1509 | 1.49 |

**Table 2**: Chemical composition of essential oils extracted from *Pinus sylvestris* and its retention time (RT), retention index (RI), and percentage (%)

| Component | RT (min) | RI | % |
|---|---|---|---|
| α-Thujene | 11.78 | 908 | 1.17 |
| α-Pinene | 12.10 | 918 | **26.76** |
| β-Phellandrene | 13.28 | 957 | 1.23 |
| β-Pinene | 13.48 | 964 | 1.62 |
| Nopinene | 13.66 | 969 | **15.23** |
| Cyclofenchene | 14.51 | 994 | 0.90 |
| m-Cymene | 14.95 | 1007 | 3.26 |
| Eucalyptol | 15.25 | 1017 | 4.89 |
| β-Ocimene | 15.58 | 1027 | 0.74 |
| Terpinolene | 17.15 | 1073 | 1.66 |
| β-Linalool | 17.39 | 1079 | 7.98 |
| Camphor | 19.32 | 1135 | 1.48 |
| Borneol | 20.02 | 1155 | 0.99 |
| 4-terpineol | 20.36 | 1165 | 2.44 |
| p-Cymen-8-ol | 20.53 | 1169 | 1.19 |
| α-Terpineol | 20.77 | 1176 | 0.59 |
| Linalyl acetate | 22.72 | 1233 | 4.18 |
| Caryophyllene | 28.66 | 1412 | **10.77** |
| Humulene | 29.71 | 1447 | 2.35 |
| β-Phenylethyl isovalerate | 30.52 | 1472 | 5.51 |
| δ-Cadinene | 31.64 | 1508 | 0.45 |
| Caryophyllene epoxide | 33.68 | 1578 | 3.67 |
| Humulene epoxide | 34.43 | 1603 | 0.56 |
| 7-Hexadecenal | 34.69 | 1612 | 0.37 |

**Table 3:** Chemical composition of essential oils extracted from *Rosmarinus Officinalis* and its retention time (RT), retention index (RI), and percentage (%)

| Component | RT (min) | RI | % |
|---|---|---|---|
| Tricyclene | 11.82 | 0.30 | 0.30 |
| α-Pinene | 12.14 | 11.76 | **11.76** |
| Camphene | 12.65 | 4.54 | 4.54 |
| β-Pinene | 13.55 | 5.68 | 5.68 |
| Sabinene | 13.71 | 0.94 | 0.94 |
| α-Phellandrene | 14.36 | 0.19 | 0.19 |
| γ-Terpinene | 14.57 | 0.18 | 0.18 |
| α-Terpinene | 14.75 | 0.55 | 0.55 |
| p-Cymene | 15.03 | 1.76 | 1.76 |
| Eucalyptol | 15.43 | 49.58 | **49.58** |
| γ-Terpinene | 16.16 | 0.91 | 0.91 |
| Terpinolene | 17.22 | 0.39 | 0.39 |
| β-Ocimene | 17.44 | 0.39 | 0.39 |
| Camphor | 19.44 | 10.83 | **10.83** |
| Borneol | 20.09 | 3.42 | 3.42 |
| α-Phellandrene | 20.42 | 0.26 | 0.26 |
| α-Terpineol | 20.86 | 2.27 | 2.27 |
| Bornyl acetate | 24.08 | 0.74 | 0.74 |
| alfa-Copaene | 27.20 | 0.24 | 0.24 |
| Caryophyllene | 28.73 | 3.94 | 3.94 |
| Humulene | 29.78 | 0.40 | 0.40 |
| γ-Muurolene | 30.33 | 0.22 | 0.22 |
| epi-Bicyclosesquiphellandrene | 31.51 | 0.11 | 0.11 |
| δ-Cadinene | 31.70 | 0.42 | 0.42 |

*M. pulegium* contains 16 compounds, the most important of which were p-Menthane-1-ol (45.21%), Pulegone (33.03%), and Eucalyptol (9.45%) (Table 4). The chemical composition of *M. pulegium* varied in different regions, whether in Algeria or abroad, but it is generally agreed that Pulegone is one of the basic components. Our results are consistent with the findings of Boukhebti *et al.* (2011); and Razik *et al*. (2015) and being the closest to ours.

**Table 4:** Chemical composition of essential oils extracted from *Mentha Pulegium* and its retention time (RT), retention index (RI), and percentage (%)

| Component | RT (min) | RI | % |
|---|---|---|---|
| α-Pinene | 12.11 | 919 | 0.84 |
| m-Cymene | 14.99 | 1008 | 0.39 |
| Limonene | 15.15 | 1014 | 0.94 |
| Eucalyptol | 15.30 | 1018 | **9.45** |
| γ-Terpinene | 16.13 | 1044 | 0.18 |
| Camphor | 19.36 | 1136 | 0.48 |
| Menthone | 19.57 | 1142 | 0.49 |
| p-Menthan-3-one | 19.97 | 1154 | 2.63 |
| p-Menthan-1-ol | 20.36 | 1165 | **45.21** |
| Isoneomenthol | 20.66 | 1173 | 0.97 |
| Pulegone Oxide | 21.83 | 1205 | 0.60 |
| Pulegone | 22.70 | 1232 | **33.03** |
| Piperitone | 23.08 | 1244 | 0.33 |
| Borneol. acetate | 24.17 | 1275 | 3.58 |
| Verbenone | 26.01 | 1331 | 0.71 |
| Caryophyllene | 29.74 | 1447 | 0.18 |

Analysis of essential oil from *L. stoechas* revealed 28 compounds. The predominant compounds were Fenchone (23.84%) with the highest value followed by β-Linalol (16.79%). Camphor (14.52%) and Linalyl acetate (13.34%) (Table 5). The basic components of lavender oil show significant quantitative differences related to biological and genetic diversity, as the genus *Lavandula* sometimes consisted of α-Pinene, fenchone, and camphor, while at other times it was fenchone/comfort, or cineole/ fenchone (Skoula *et al.,* 1996), while our results are close to those of Mohammedi and Atik (2011).

**Table 5:** Chemical composition of essential oils extracted from *Lavandula Stoechas* and its retention time (RT), retention index (RI), and percentage (%)

| Component | RT (min) | RI | % |
|---|---|---|---|
| Tricyclene | 11.8 | 909 | 0.23 |
| α-Pinene | 12.12 | 920 | 4.24 |
| Camphene | 12.64 | 937 | 3.70 |
| β-Linalool | 13.535 | 965 | 0.57 |
| β-Myrcene | 13.71 | 970 | 0.52 |
| m-Cymene | 15.01 | 1009 | 0.40 |
| β-Terpinyl acetate | 15.17 | 1014 | 1.78 |
| Eucalyptol | 15.31 | 1019 | 7.27 |
| alpha-Ocimene | 15.64 | 1029 | 0.46 |
| Linalool oxide | 16.64 | 1058 | 0.20 |
| Fenchone | 17.38 | 1079 | **23.84** |
| β-Linalool | 17.53 | 1083 | **16.79** |
| Fenchyl alcohol | 18.21 | 1101 | 0.38 |
| allo-Ocimene | 18.47 | 1109 | 0.66 |
| Camphor | 19.43 | 1138 | **14.52** |
| 7-Hexadecenal | 19.82 | 1149 | 0.25 |
| Borneol | 20.08 | 1157 | 3.66 |
| 4-Terpineol | 20.42 | 1166 | 0.47 |
| Ascaridole epoxide | 20.55 | 1170 | 0.36 |
| α-Terpineol | 20.84 | 1178 | 0.82 |
| Dipentene diepoxide | 21.08 | 1185 | 0.39 |
| 1. 3.3- Trimethylbicyclo [2.2.1]hept-2-yl acetate | 21.82 | 1205 | 0.35 |
| Linalyl acetate | 22.82 | 1236 | **13.34** |
| lavandulyl acetate | 23.90 | 1268 | 0.47 |
| Bornyl acetate | 24.09 | 1273 | 2.44 |
| 2.4-Decadienal | 24.92 | 1296 | 0.78 |
| Pinocarvyl acetate | 25.34 | 1309 | 0.98 |

This variability in essential oil compositions for the same plant led to remark that the difference is due to overlapping factors such as geographic variation, stage of plant growth, the method of analysis used, extraction conditions, the plant part used, age of the plant, type of soil, duration of exposure to sunlight, as well as the duration and how the oil is preserved (Khan *et al,* 2023). In addition, other ecological factors such as heat, humidity, and rain, pollution may influence the constituents of the EOs in either a quantitative or qualitative manner (Bruneton, 1999; Smallfield, 2001; Boutekedjiret *et al.,* 2005; Ennajar *et al.,* 2010; Taalbi, 2016; Khan *et al,* 2023).

**Toxicity of essential oil against *Aphis gossypii***

Individual responses of *A. gossypii* exposed to different concentrations of essential oils are presented in survival curves (Fig. 1). At a concentration of 1000 ppm, *M. pulegium* and *J. phoenicea* resulted in mortality of aphids over 50 %; (59.29%) and 56.43%, respectively, after 24 h of treatment compared to the negative control (DMSO solution). However, the mortality rate was lower for *P. sylvestris* (49.29%) and *L. stoechas* (40.71%) (Table 6). After 48 h of treatment, all oils reached more than 50 %, with the highest death rate reached (71.43%) for *J. phoenicea*, followed by *M. pulegium* (68.50%), then *P. sylvestris* (64.29%), but none of them was as toxic as Actara® insecticide after 48 h of treatment. After 72 h of treatment, each of the five essential oils reported high mortality rates of over (70%), for *J. phoenicea* (75.00%), *P. sylvestris* (74.29%), and *M. pulegium* (72.86%). These results are still very significant but none of them was as toxic as Actara® insecticide (97.10%). It is obvious that with increasing time, the death rate increased.

When the concentration of extracted oils was increased to 10.000 ppm, the mortality rate increased in all treatments, which exceeded 60% (Table 7). *J. phoenicea* (76.43%), *M. pulegium* (74.29%) and *P. sylvestris* (73.57%) resulted in mortalities above 70 % after 24 h of treatment. After 48 and 72 h of treatment with oils, the death rate reached 90.0% and 90.71% for *P.*

*sylvestris* and *J. phoenicea*, respectively, which was close to the toxicity of the pesticide, Actara® (97.10%).

By increasing the concentration of oils to 100000 ppm, a significant increase in the death rate of aphids by the five oils was noticed, which exceeded 83% after 24 hours (Table 8), and reached its maximum after 48 and 72 h of treatment with a rate of 98.57% for *J. phoenicea*, and both *M. pulegium* and *L. stoechas* resulted in mortalities above (96.43%), followed by *R. officinalis* (94.29%) and *P. sylvestris* (92.14%).

These results demonstrated the effectiveness of the five essential oils against *A. gossypii*, especially with high concentrations that gave the same efficacy as the insecticide, Actara® (97.14%).

All tested essential oils caused higher aphid mortalities compared to the control. Indeed, different tested concentrations against this insect have shown various effects on aphids. Also, the death rate increased gradually over time from 24 to 72 h for tested oils. So, they exerted toxicity levels in which the intensity increased gradually as the oil concentration increased. However, this toxicity could be caused by volatile substances emitted by the studied essential oils.

*J. phoenicea* essential oil gave the best results in all tested concentrations. The insecticide properties of this extract have long been known and well-documented against various insect pests (Dane *et al.*, 2016), especially for stored grain insects. Birgücü *et al.* (2015) evaluated the effect of various plant extracts that affected the development of *A. gossypii* and *Bemisia tabaci* (Gennadius). Zhou *et al.* (2004) and Roh *et al.* (2015) also observed that volatile oils had distinct repelling effects and significantly higher control on *A. gossypii*. Our results match those of (Harmouzi *et al.*, 2016), who concluded that essential oils of *J. phoenicea* caused significantly higher mortalities than those of the controls, different concentrations tested against *Aphis citricola* Goot levels in which the intensity increased gradually as concentration increased and the aphid survival period was shortened when the exposure time became longer.

**Table 6:** Percentage mortality of *Aphis gossypii* exposed to different plant oil extracts of Algerian medicinal plants at a concentration of 1.000 ppm±SEM

| Medicinal plant extract | % Mortality of A.gossypii at a concentration of 1000 ppm±SEM | | |
|---|---|---|---|
| | After 24 h | After 48 h | After 72 h |
| Rosmarinus officinalis | 31.43d*± 3.73 (33.86) | 52.14d±4.06 (46.29) | 62.14c±5.10 (52.71) |
| Lavandula stoechas | 40.71c±6.11 (39.49) | 57.86cd±6.71 (49.71) | 69.29bc±4.55 (56.71) |
| Mentha pulegium | 59.29b±2.97 (50.57) | 68.57bc±3.03 (56.14) | 72.86b±3.75 (58.86) |
| Juniperus phoenicea | 56.43b±3.22 (48.86) | 71.43b±4.04 (57.86) | 75.00b±2.88 (60.00) |
| Pinus sylvestris | 49.29bc±2.02 (44.57) | 64.29bc±4.28 (53.57) | 74.29b±2.97 (59.71) |
| DMSO solution | 0.71e±0.71 (1.86) | 3. 57e±1.42 (8.14) | 6.43d ±1.79 (12.14) |
| Actara® | 88.57a±4.04 (73.71) | 95.71a±2.02 (82.29) | 97.14a±1.84 (84.86) |

***Means in the same column with the sharing the same letter are not significantly different** (P = 0.05)

# Arcsin-transformed percentages were analyzed by ANOVA and the means were separated by LSD.

**Table 7:** Percentage mortality of *Aphis gossypii* exposed to different plant oil extracts of Algerian medicinal plants at a concentration of 10000 ppm±SEM.

| Medicinal plant extract | % Mortality of A.gossypii At a concentration of 10000 ppm±SEM | | |
|---|---|---|---|
| | After 24 h | After 48 h | After 72 h |
| Rosmarinus officinalis | 65.71bc*± 3.16 (54.43#) | 77.86c±4.20 (62.71) | 82.86bc±3.75 (66.43) |
| Lavandula stoechas | 60.00c±4.08 (51.00) | 77.86c±2.40 (61.86) | 82.14bc±2.40 (65.29) |
| Mentha pulegium | 74.29b±5.28 (60.00) | 80.00bc±4.22 (64.14) | 80.71bc±4.42 (64.86) |
| Juniperus phoenicea | 76.43b±4.18 (61.71) | 87.14ab±3.05 (70.71) | 90.71ab±2.97 (75.14) |
| Pinus sylvestris | 73.57b±4.32 (59.29) | 85.29bc± 3.08 (68.86) | 90.00b±3.61 (74.86) |
| DMSO solution | 0.71e±0.71 (1.86) | 3. 57e±1.42 (8.14) | 6.43d ±1.79 (12.14) |
| Actara® | 88.57a±4.04 (73.71) | 95.71a±2.02 (82.29) | 97.14a±1.84 (84.86) |

***Means in the same column with the sharing the same letter are not significantly different** (P = 0.05)

# Arcsin-transformed percentages were analyzed by ANOVA and the means were separated by LSD.

**Table 8:** Percentage mortality of *Aphis gossypii* exposed to different plant oil extracts of Algerian medicinal plants at a concentration of 100000 ppm±SEM.

| Medicinal plant extract | % Mortality of A.gossypii At a concentration of 100000 ppm±SEM | | |
|---|---|---|---|
| | After 24 h | After 48 h | After 72 h |
| Rosmarinus officinalis | 83.57a*± 3.40 (66.86#) | 90.71a±3.99 (75.71) | 94.29a±3.52 (81.29) |
| Lavandula stoechas | 87.86a±4.08 (70.00) | 94.29a±2.02 (78.57) | 96.43a±2.10 (83.00) |
| Mentha pulegium | 89.29a±2.97 (72.71) | 90.71a±2.54 (74.00) | 94.43a±1.42 (81.86) |
| Juniperus phoenicea | 84.25a±3.84 (68.71) | 95.00a±1.54 (79.29) | 98.57a±1.42 (60.00) |
| Pinus sylvestris | 83.57a±3.40 (67.86) | 90.71a± 2.54 (74.00) | 92.514a±2.87 (76.57) |
| DMSO solution | 0.71d±0.71 (1.86) | 3. 57e±1.42 (8.14) | 6.43b ±1.79 (12.14) |
| Actara® | 88.57a±4.04 (73.71) | 95.71a±2.02 (82.29) | 97.14a±1.84 (84.86) |

***Means in the same column with the sharing the same letter are not significantly different** (P = 0.05)

# Arcsin-transformed percentages were analyzed by ANOVA and the means were separated by LSD.

*M. pulegium* and *L. stoechas* created significantly higher mortality rates. Our results are in agreement with those of Ebadollahi *et al.* (2017) who showed that *M. pulegium* oil has a significant anti-toxic activity against *A. gossypii*. Furthermore, (Zekri *et al.*, 2016) found that *M. pulegium* has a high insecticidal effect on brown citrus aphid *Aphis auranti* Boyer de Fonscolombe (previously *Toxoptera auranti*). In general, mint is a plant that has been used since ancient times, known for its destructive activity and its effectiveness against fleas (Munneke *et al.*, 2004). Saheb and Mouhouche (2016) found that the lavender oil was effective against *A. gossypii* with mortality reaching up to 90.8%.

Rosemary oil has a strong lethal effect against many insects (Zoubiri and Baaliouamer, 2011). Our results are in agreement with the results of other researchers, such as Hori (1998, 1999) who proved that rosemary oil is strong repellent to peach aphids, and it impedes the taste and smell process, thus it is a strong inhibitor of the nutrition and toxic too. Koorki *et al*. (2018) also showed that rosemary oil affects the larval and adult stages of *A. gossypii* and works to drive it away. In addition, the fumes of mint, lavender, and rosemary were toxic to this insect and other insects at concentrations ranging between 10 and 15 µl/ ml, and a mortality rate of 100% (Shaaya *et al.*, 1997).

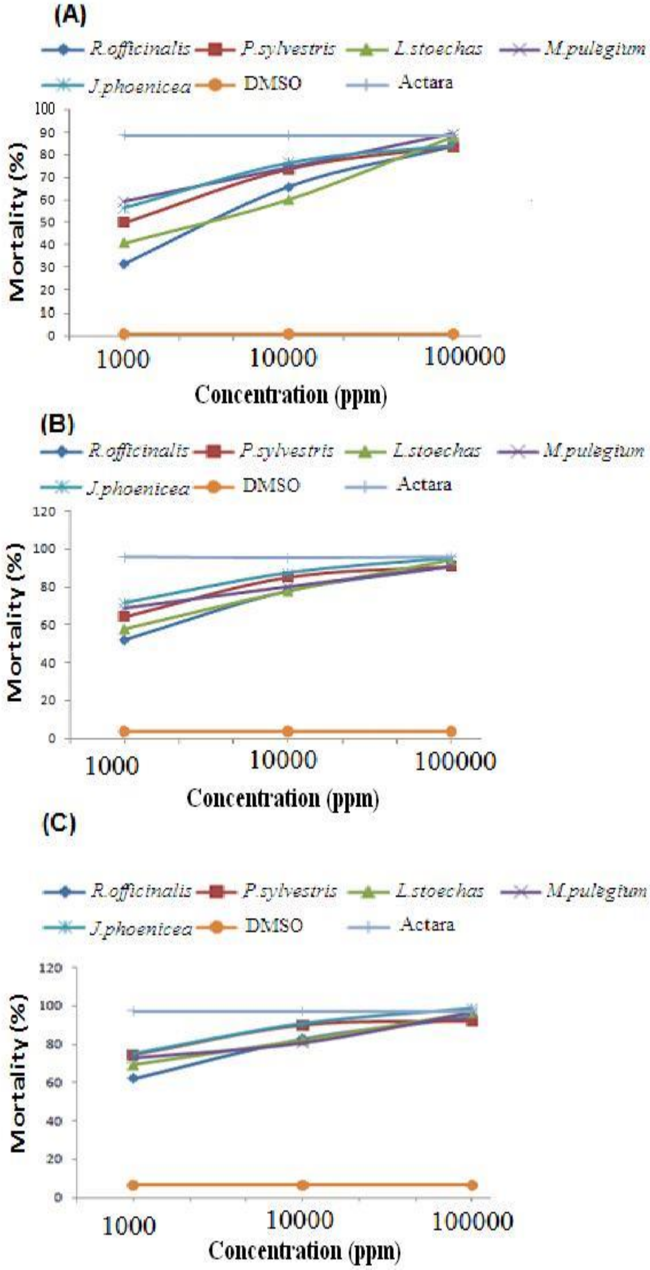


**Figure 1:** Mortality of *Aphis gossypii* exposed to different plant oil extracts of Algerian medicinal plants at three different concentrations after A) 24 h, B) 48 h, and C) 72 h.

Generally, EOs from Lamiaceous plants like mint, lavender, and rosemary have potent insecticidal properties. On the other hand, Fayemiwo *et al.* (2014), found that pine oil was efficient in controlling *Aedes aegypti* (L.) mosquitoes. Furthermore, Elefterios *et al.* (2014) discovered that pine oil had decreased peach aphid fertility and its life expectancy.

Essential oil toxicity against a pest is mainly related to its chemical composition, such as phenolic compounds that are also known to have ovicidal, larvicidal, nymphocidal, and adulticidal properties against different insect species. Toxicity may also be due to its oxygenated monoterpene content (Akono *et al*, 2012). Similar results were obtained with oxygenated monoterpenes such as 1,8-cineole, menthone, eugenol, linalool, isosafrol, and terpinene-4-ol, which were toxic against *Sitophilus oryzae* (L.) (Lee *et al.,* 2001).

Essential oil used in our experiment is characterized by the presence complex mixture of components, such as monoterpenes and sesquiterpene (major constituents of aromatic essential oils), known for their insecticidal, anti-appetizing, and repellents properties such as α-pinene, β-Pinene 1,8- cineol, Linalool, Linalyl acetate, Fenchone, Pulegone and Camphor (Mueller and Haufe, 1991). According to Hamraoui and Regnault-Roger (2013), different monoterpenes show inhalation toxicity to *Rhopalosiphum padi* (L.) and *Ceratitis capitate* (Wied.). The degree of susceptibility of these two species is very variable. These differences may result from genetic polymorphism, but also structural conformations of monoterpenes. Regarding the specificity of EOs in aphids, Santana *et al.* (2012) reported that *Thymus vulgaris* L. and *Lavandula latifolia* Medik. containing linalool, cineol, or linalyl acetate as main compounds were active on both *R. padi* and *Myzus persicae* Sulzer.

The toxic activity of some characteristic monoterpenoids: α-pinene, camphor, linalool, and others had a reproductive inhibition. It involved female fecundity, oviposition, and the development of neonate and intracotyledonal larvae (Wojtunik-Kulesza, 2022). The effects of monoterpenes on oviposition, larval penetration inside the seeds, and emergence were determined. All monoterpenes revealed more or less pronounced vapor toxicity and significantly inhibited beetle reproduction (Hamraoui and Regnault-Roger, 1995). Results of Isman *et al.* (2011) confirmed synergy among constituents of rosemary oil, including apparent synergy between apparently ‘‘inert’’ or inactive constituents and the ‘‘active’’ ones. Compounds exert their activities on insects through neurotoxic effects involving several mechanisms, notably through Gamma-aminobutyric acid (GABA) octopamine synapses, and the inhibition of acetylcholinesterase (Regnault-Roger *et al.*, 2012; Ulusoy *et al.,* 2019).

## Conclusion

It appears that aromatic plants contain a veritable molecular arsenal of insect-repellent substances capable of inducing plant protection. The toxic activity of the essential oils is different and depends on the concentration used the duration of exposure, and the typical chemical composition of the oil, which includes various active molecules that work together to affect these insects. These changes may also be related to the mechanics and mechanism of entry of these compounds and their toxicity removal by insects, the degree of insect response, and sensitivity. The major compounds of tested oils belonging to different chemical classes revealed a toxic activity in the confined environment on *A. gossypii*. The use of essential oils from *J. phoenicea, R. officinalis, L. stoechas, M. pulegium,* and *P. sylvestris* is recommended as an alternative to synthetic pesticides. In this context, the use of biopesticides has been clarified, and it is important as an alternative effective, economically and ecologically reliable control.

## Acknowledgment

We wish to thank the Department of Biology and Animal Physiology, Faculty of Life and Natural Sciences, University Ferhat Abbas, Setif1, Algeria for providing the place and materials for this project. We also thank the Department of Plant Protection, Faculty of Agriculture, The University of Jordan, Amman, Jordan., for providing a place and needed materials for aphid bioassay tests. We wish to thank the Department of Chemistry, Faculty of Science, Cankiri Karatekin University, Cankiri, Turkey, for the analysis of essential oils

## REFERENCES

Ahmed, Q., Agarwal, M., Al-Obaidi, R., Wang, P., & Ren, Y. (2021). Evaluation of the aphicidal effect of essential oils and their synergistic effect against *Myzus persicae* (Sulzer) (Hemiptera: Aphididae). *Molecules, 26*(10), 3055. https://doi.org/10.3390/molecules26103055

Ait-Ouazzou, A., Loran, S., Arakrak, A., Laglaoui, A., Rota, C., Herrera, A., Pagan, R., & Conchello, P. (2012). Evaluation of the chemical composition and antimicrobial activity of *Mentha pulegium* L., *Juniperus phoenicea* L., and *Cyperus longus* L. from Morocco. *Food Research International, 45*, 313–319. https://doi.org/10.1016/j.foodres.2011.10.020

Akbar, M. F., Haq, M. A., Parveen, F., Yasmin, N., Farhan, M., & Khan, U. (2010). Comparative management of cabbage aphid (*Myzus persicae* (Sulzer) (Aphididae: Hemiptera)) through bio- and synthetic insecticides. *Pakistan Entomologist, 32*(1), 12-17.

Akono, N. P., Belong, P., Tchoumbougnang, F., Bakwo fils, E., & Fankem, H. (2012). Composition chimique et effets insecticides des huiles essentielles des feuilles fraîches d'*Ocimum canum* Sims et d'*Ocimum basilicum* L. sur les adultes d'*Anopheles funestus* ss, vecteur du paludisme au Cameroun. *Journal of Applied Biosciences, 59*, 4340-4348.

Ateyyat, M., & Abu-Darwish, M. (2009). Insecticidal activity of different extracts of *Rhamnus dispermus* (Rhamnaceae) against peach trunk aphid, *Pterochloroides persicae* (Homoptera: Lachnidae). *Spanish Journal of Agricultural Research, 7*(1), 160-164. https://doi.org/10.5424/sjar/2009071-1228

Ashraf, R., Ghufran, S., Akram, S., Mushtaq, M., & Sultana, B. (2020). Cold pressed coriander (*Coriandrum sativum* L.) seed oil. In M. F. Ramadan (Ed.), *Cold Pressed Oils* (pp. 345-356). Academic Press. https://doi.org/10.1016/B978-0-12-818188-1.00031-1

Base SAS 9.3. (2011). *Procedures guide: Statistical procedures* (2nd ed.). SAS Institute Inc.

Benkkara, A., Bousmaha, F., Bendiab, T. S. A., Boti, J. B., & Casanova, A. (2007). Composition chimique de l'huile essentielle de *Rosmarinus officinalis* L. poussant à l'état spontané et cultivé de la région de Tlemcen. *Biologie et Santé, 7*, 6-11.

Birgücü, A. K., Satar, S., & Karaca, I. (2015). Effects of some plant extracts on *Aphis gossypii* Glover (Hemiptera: Aphididae) and *Bemisia tabaci* (Gennadius) Takahashi (Hemiptera: Aleyrodidae). *Asian Journal of Agricultural and Food Sciences, 3*(2), 149-154.

Blackman, R. L., & Eastop, V. F. (2006). *Aphids on the world's herbaceous plants and shrubs*. Wiley & Sons.

Bokobana, E. M. K., Koba, E. M., Poutouli, W. P., Akantetou, P. K., Nadio, B., Laba, N. A., Tozou, P., Raynaud, C., & Sanda, K. (2014). Evaluation du potentiel insecticide et repulsif de l'huile essentielle de *Cymbopogon schoenanthus* (L.) Spreng sur *Aphis gossypii* Glover (Aphididae: Homoptera), ravageur du cotonnier au Togo. *Revue CAMES, 2*(2), 48-55.

Boukhebti, H., Chaker, A. N., Belhadj, H., Sahli, F., Ramdhani, M., Laouer, H., & Harzallah, D. (2011). Chemical composition and antibacterial activity of *Mentha pulegium* L. and *Mentha spicata* L. essential oils. *Der Pharmacia Lettre, 3*(4), 267-275.

Boutekedjiret, C., Belabbes, R., Bentahar, F., & Bessière, J. M. (1999). Study of *Rosmarinus officinalis* L. essential oil and composition as a function of the plant life cycle. *Journal of Essential Oil Research, 11*, 238-240.

Boutekedjiret, C., Buatois, B., & Bessiere, J. M. (2005). Characterization of rosemary essential oil of different areas of Algeria. *Journal of Essential Oil Bearing Plants, 8*(1), 65-70.

Bouyahiaoui, A. (2016). *Contribution à la valorisation des substances naturelles: Etude des huiles essentielles des cupressacées de la région de l'Atlas algérien* (Doctoral dissertation). Université Abdelhamid Ibn Badis de Mostaganem.

Bouzabata, A., & Hadef, Y. (2009). Variability of the yield and the chemical composition of essential oils of *Juniperus phoenicea* L. coming from two regions of Algeria. *TJMPNP, 2*, 1-9.

British Pharmacopoeia. (1988). *British pharmacopoeia*. HMSO Publication.

Bruneton, J. (1999). *Pharmacognosie, phytochimie, plantes medicinales*. Techniques et documentation, Lavoisier.

Caillard, J. (2003). *Les plantes des usines chimiques*. Dossiers de ressource documentaires. CRDP Midi-Pyrénées.

Cavaleiro, C., Rezzi, S., Salgueiro, L., Bighelli, A., Casanova, J., & da Cunha, P. A. (2001). Infraspecific chemical variability of the leaf essential oil of *Juniperus phoenicea* var. *Turbinate* from Portugal. *Biochemical Systematics and Ecology, 29*(11), 1175-1183. https://doi.org/10.1016/S0305-1978(00)00056-0

Dane, Y., Mouhouche, F., Canela-Garayoa, R., & Delpino-Rius, A. (2016). Phytochemical analysis of methanolic extracts of *Artemisia absinthium* L. 1753 (Asteraceae), *Juniperus phoenicea* L., and *Tetraclinis articulata* (Vahl) Mast, 1892 (Cupressaceae) and evaluation of their biological activity for stored grain protection. *Arabian Journal of Science and Engineering, 41*(6), 2147-2158.

Ebadollahi, A., Davari, M., Razmjou, J., & Naceri, B. (2017). Separate and combined effects of *Mentha piperita* and *Mentha pulegium* essential oils and a pathogenic fungus *Lecanicillium muscarium* against *Aphis gossypii* (Hemiptera: Aphididae). *Journal of Economic Entomology, 110*, 1025-1030. https://doi.org/10.1093/jee/tox134

Elefterios, A. P., Antanasios, C. K., Dionysios, C. P., Dionysios, P. L., Petros, A. T., & Moschos, G. P. (2014). Responses of *M. persicae* Sulzer on three Lamiaceae essential oils obtained by microwave-assisted and conventional hydrodistillation. *Industrial Crops and Products, 62*, 272-279. https://doi.org/10.1016/j.indcrop.2014.08.047

Ennajar, M., Bouajila, J., Lebrihi, A., Mathieu, F., Savagnac, A., Abderraba, M., Raies, A., & Romdhane, M. (2010). The influence of organ, season, and drying method on chemical composition and antioxidant and antimicrobial activities of *Juniperus phoenicea* L. essential oils. *Journal of the Science of Food and Agriculture, 90*(3), 462-470. https://doi.org/10.1002

Falodon, A. (2010). Herbal medicine in Africa-distribution standardization and prospects. *Research Journal of Phytochemistry, 4*(3), 154-161.

Fayemiwo, K. A., Adeleke, M. A., Okoro, O. P., Awojide, S. H., & Awoniyi, I. O. (2014). Larvicidal efficacies and chemical composition of essential oils of *Pinus sylvestris* and *Syzygium aromaticum* against mosquitoes. *Asian Pacific Journal of Tropical Biomedicine, 4*(1), 30-34. https://doi.org/10.1016/S2221-1691(14)60116-0

Flamini, G., Gioni, P. L., Morelli, I., Macchia, M., & Ceccarini, L. (2002). Main agronomic productive characteristics of two ecotypes of *Rosmarinus officinalis* L. and chemical composition of their essential oils. *Journal of Agricultural and Food Chemistry, 50*, 3512-3517. https://doi.org/10.1021/jf0200926

Górski, R., & Tomczak, M. (2010). The usefulness of natural essential oil in the control of foxglove aphid (*Aulacorthum solani* Kalt.) occurring on eggplant (*Solanum melongena* L.). *Ecological Chemistry and Engineering, 17*(3), 345-349.

Hakimi, S., Ateyyat, M., & Bounechada, M. (2015). Insecticidal activity of five essential oils of Algerian medicinal plants on peach-potato aphid, *Myzus persicae* (Homoptera: Aphididae). *Advances in Environmental Biology, 9*(2), 89-94.

Hamraoui, A., & Regnault-Roger, C. (1995). Fumigant toxic activity and reproductive inhibition induced by monoterpenes on *Acanthoscelides obtectus* (Say) (Coleoptera), a Bruchid of kidney bean (*Phaseolus vulgaris* L.). *Journal of Stored Products Research, 31*(4), 291-299. https://doi.org/10.1016/0022-474X(94)00032-4

Hamraoui, A., & Regnault-Roger, C. (2013). Comparison des activités insecticides des monoterpènes sur deux espèces d'insectes ravageurs des cultures: *Ceratitis capitata* et *Rhopalosiphum padi*. *Acta Botanica Gallica, 144*(4), 413-417. https://doi.org/10.1080/12538078.1997.11015014

Harmouzi, A., Boughdad, A., El Ammari, Y., & Chaouch, A. (2016). Chemical composition and toxicity of Moroccan *Tetraclinis articulata* and *Juniperus phoenicea* essential oils against *Aphis citricola* Goot, 1912 (Homoptera, Aphididae). *Research on Chemical Intermediates, 42*, 7185-7197. https://doi.org/10.1007/s11164-015-2213-7

Hiromi, I., Higashimita, T., & Kawasaki, K. (2012). Repellent effect of herb extracts on the population of wingless green peach aphid, *Myzus persicae* Sulzer (Hemiptera: Aphididae). *Journal of Agricultural Science, 4*(5), 139-144. https://doi.org/10.5539/jas.v4n5p139

Hori, M. (1998). Repellency of rosemary oil against *Myzus persicae* in the laboratory and a screen house. *Journal of Chemical Ecology, 24*(9), 1425-1432. https://doi.org/10.1023/A:1022901710441

Hori, M. (1999). Antifeeding, settling inhibitory, and toxic activities of labiate essential oils against the green peach aphid, *Myzus persicae* (Sulzer) (Homoptera: Aphididae). *Applied Entomology and Zoology, 34*(1), 113-118. https://doi.org/10.1303/aez.1999.113

Ibáñez, M. D., & Blázquez, M. A. (2019). Phytotoxic effects of commercial *Eucalyptus citriodora*, *Lavandula angustifolia*, and *Pinus sylvestris* essential oils on weeds, crops, and invasive species. *Molecules, 24*(2847), 1-15. https://doi.org/10.3390/molecules24162847

Isik, M., & Gorur, G. (2009). Aphidicidal activity of seven essential oils against cabbage aphid, *Brevicoryne brassicae* L. (Hemiptera: Aphididae). *Munis Entomology & Zoology, 4*(2), 424-431.

Isman, M. (2006). Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. *Annual Review of Entomology, 51*, 45-66. https://doi.org/10.1146/annurev.ento.51.110304.151358

Isman, M. B., Miresmeli, S., & Machial, C. (2011). Commercial opportunities for pesticides based on plant essential oils in agriculture, industry, and consumer products. *Phytochemistry Reviews, 10*, 197-204. https://doi.org/10.1007/s11101-010-9207-6

Jayakumar, R., Naganagoud, K., & Rajashekarappa, K. (2008). Influence of indigenous components on natural enemies in okra ecosystem. *Annals of Plant Protection Sciences, 16*, 102-106.

Kassimi, A., & El-Wafik, L. (2012). Insecticide effect of plant extracts on aphids of watermelon. *Journal of Biology and Agriculture Healthcare, 2*(5), 20-28.

Komenda, M., & Kopmann, R. (2002). Monoterpene emissions from Scots pine (*Pinus sylvestris*): Field studies of emission rate variabilities. *Journal of Geophysical Research, 117*(13), 1-13. https://doi.org/10.1029/2002JD002744

Koorki, Z., Shahidi-Noghabi, S., Mahdian, K., & Pirmaoradi, M. (2018). Chemical composition and insecticidal properties of several plant essential oils on the melon aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae). *Journal of Essential Oil Bearing Plants, 21*(2), 1-10. https://doi.org/10.1080/0972060X.2018.1431798

Lai, P. K., & Roy, J. (2004). Antimicrobial and chemopreventive properties of herbs and spices. *Current Medicinal Chemistry, 11*(11), 1451-1460. https://doi.org/10.2174/0929867043388593

Lawrence, B. M. (1997). Progress in essential oils, rosemary oil. *Perfumery & Flavorist, 22*(5), 71-83.

Lee, S. E., Lee, B. H., Choi, W. S., Park, B. S., Kim, J. G., & Campbell, B. C. (2001). Fumigant toxicity of volatile natural products from Korean spices and medicinal plants towards the rice weevil, *Sitophilus oryzae* (L). *Pest Management Science, 57*(6), 548-553. https://doi.org/10.1002/ps.345

Mahmoodi, L., Valizadegan, O., & Mahdavi, V. (2015). Fumigant toxicity of *Carum copticum* (Apiaceae) essential oil against greenhouse aphids (*Aphis gossypii*) (Hemiptera: Aphididae) and an analysis of its constituents. *Acta Entomologica Sinica, 58*(2), 147-153. https://doi.org/10.1016/j.j.1618-5287.2015.03.001

Mazari, K., Bendimerad, N., Bekhechi, C., & Fernandez, X. (2010). Chemical composition and antimicrobial activity of essential oils isolated from Algerian *Juniperus phoenicea* L. and *Cupressus sempervirens* L. *Journal of Medicinal Plants Research, 4*, 959-964. https://doi.org/10.5897/JMPR10.066

Mohammedi, Z., & Atik, F. (2011). Pouvoir antifongique et antioxydant de l'huile essentielle de *Lavandula stoechas* L. *NATEC, 6*, 34-39.

Mohmed, A. S. (2018). Effect of some plant extracts in some aspects of the biological performance of *Aphis gossypii* Glov. (Aphididae: Homoptera). *Bulletin of the Jordanian Society for Biological Sciences, 11*, 77-89.

Mueller, M., & Haufe, G. (1991). The response of the large pine weevil, *Hylobius abietis* L., Coleoptera Curculionidae, to certain chemical compounds of its host plants. *Archives of Phytopathology and Plant Protection, 27*, 299-305. https://doi.org/10.1080/03235409109383494

Munneke, M. E., Schuurman-de Bruin, A., Moskal, J. R., & Van Tol, R. W. (2004). Repellence and toxicity of plant essential oils to the potato aphid, *Macrosiphum euphorbiae*. In *Proceedings of the Netherlands Entomological Society, 15*, 81-85.

Khan, M. H., Dar, N. A., Alie, B. A., Dar, S. A., Lone, A. A., Mir, G. H., Fayaz, U., Ali, S., Tyagi, A., El-Sheikh, M. A., & Alansi, S. (2023). Unraveling the variability of essential oil composition in different accessions of *Bunium persicum* collected from different temperate micro-climates. *Molecules, 28*(5), 2404. https://doi.org/10.3390/molecules28052404

Ramdani, M., Lograda, T., Silini, H., Zeraib, A., Chalard, P., Figueredo, G., Bouchaala, M., & Zerrar, S. (2013). Antibacterial activity of essential oils of *Juniperus phoenicea* from eastern Algeria. *Journal of Applied Pharmaceutical Science, 3*, 22-28. https://doi.org/10.7324/JAPS.2013.30203

Razik, A., Adly, F., Berhal, C., Moussaid, M., Elamrani, A., Moussaid, H., Bourhim, N., & Loutfi, M. (2015). Comparative study of the pharmaceutical activity of two plants of the Moroccan spontaneous flora: *Mentha pulegium* (L) and *Marrubium vulgare* (L.) (Lamiaceae). *International Journal of Scientific Research and Technology, 6*(1), 86-90.

Regnault-Roger, C., Vincent, C., & Thor Arnason, J. (2012). Essential oils in insect control: Low-risk products in a high-stakes world. *Annual Review of Entomology, 57*, 405-424. https://doi.org/10.1146/annurev-ento-120811-153644

Roh, S., Kim, J., Shin, E. S., Lee, D. W., Choo, H. Y., & Park, C. G. (2015). Bioactivity of sandalwood oil (*Santalum austrocaledonicum*) and its main components against the cotton aphid, *Aphis gossypii*. *Journal of Resource Science, 88*, 621-624. https://doi.org/10.1016/j.jrs.2015.08.007

Sahayaraj, K., & Paulraj, M. G. (1999). Toxicity of some plant extracts against life stages of a Reduviid predator, *Rhynocoris marginatus*. *Indian Journal of Entomology, 61*, 342-344.

Saheb, D., & Mouhouche, F. (2016). Chemical composition and comparative study of insecticidal activity by contact and vapor of four essential oils against *Sitophilus oryzae*

(L.) (Coleoptera: Curculionidae). *Advances in Environmental Biology*, *10*(11), 60-69.

Santana, O., Cabrera, R., Giménez, C., González-Coloma, A., Sánchez-Vioque, R., de los Mozos-Pascual, M., Rodríguez-Conde, M. F., Laserna-Ruiz, I., Usano-Alemany, J., & Herraiz, D. (2012). Perfil químico y biológico de aceites esenciales de plantas aromáticas de interés agro-industrial en Castilla-La Mancha (España). *Grasas y Aceites*, *63*(2), 214-222. https://doi.org/10.3989/gya.030912

Sánchez-Bayo, F. (2021). Indirect effect of pesticides on insects and other arthropods. *Toxics*, *9*(8), 177. https://doi.org/10.3390/toxics9080177

Shaaya, E., Kostjukovskim, M., Eilberg, J., & Sukprakarn, C. (1997). Plant oils as fumigants and contact insecticides for control of stored product insects. *Journal of Stored Products Research*, *33*, 7-15. https://doi.org/10.1016/S0022-474X(96)00027-0

Sharma, S., & Vidyarthi, K. (2010). Insecticidal activity of ethanolic extract of *Mentha piperita* leaves against cotton aphid *Aphis gossypii* Glover on okra crop (*Abelmoschus esculentus*). *Journal of Experimental Sciences, 1*(5), 11-13.

Skoula, M., Abidi, C., & Kokkalou, E. (1996). Essential oil variation of *Lavandula stoechas* L. ssp stoechas growing wild in Crete Greece. *Biochemical Systematics and Ecology*, *24*(3), 255-260. https://doi.org/10.1016/0305-1978(96)00038-2

Smallfield, B. M. (2001). Introduction to growing herbs for essential oils, medicinal and culinary purposes. New Zealand Institute for Crop & Food Research, Christchurch.

Taalbi, A. (2016). Chemical variability and economic interest of the essential oils of two wild mints: *Mentha pulegium* (Fliou) and *Mentha rotundifolia* (Domrane) from western Algeria. *Synthèse et Application Université, Tlemcen*.

Ulusoy, S., Özgür, O., & Alpkent, Y. (2019). Toxic and in vitro anti-acetylcholinesterase and anti-carboxylesterase effects of various plant extracts on *Aphis gossypii* Glover, 1877 (Hemiptera: Aphididae). *Turkish Journal of Entomology*, *43*(3), 339-346. https://doi.org/10.16970/entoted.600993

Ustun, O., Sezik, E., Kurkcuoglu, M., & Baser, K. H. C. (2006). Study of the essential oil composition of *Pinus sylvestris* from Turkey. *Chemistry of Natural Compounds*, *42*(1), 26-27. https://doi.org/10.1007/s11457-006-0028-x

Wojtunik-Kulesza, K. A. (2022). Toxicity of selected monoterpenes and essential oils rich in these compounds. *Molecules*, *27*(5), 1716. https://doi.org/10.3390/molecules27051716

Yadav, J. B., Singh, R. S., & Tripathi, R. A. (2008). Evaluation of biopesticides against pest complex of okra. *Annals of Plant Protection Sciences*, *16*, 58-61.

Zafra, M., & Garcia-Peregrin, E. (2009). Seasonal variations in the composition of *Pinus halepensis* and *Pinus sylvestris* twigs and needles essential oil. *Journal of Agricultural Science*, *86*(1), 1-6.

Zekri, N., Handaq, N., El-Caidi, A., & Touria, Z. (2016). Insecticidal effect of *Mentha pulegium* L. and *Mentha suaveolens* Ehrh. hydrosols against a pest of citrus, *Toxoptera aurantii* (Aphididae). *Research on Chemical Intermediates*, *42*(3), 1639-1649. https://doi.org/10.1007/s11164-015-2226-2

Zhou, Q. Q., Liang, G., Kong, C., & Huang, S. (2004). Repellent effect of volatile oils from whitefly (*Syngonium podophylum*) on aphid and its chemical constituents. *Ying Yong Sheng Tai Xue Bao*, *15*, 856-858.

Zoubiri, S., & Baaliouamer, A. (2011). Chemical composition and insecticidal properties of some aromatic herbs essential oils from Algeria. *Food Chemistry*, *29*(1), 179-182. https://doi.org/10.1016/j.foodchem.2011.05.059

# تحليل الزيوت الاساسية المستخرجة من النباتات الطبية الجزائرية وتأثيرها القاتل في القضاء على حشرة من البطيخ Glover (Homoptera: Aphididae) Aphis gossypii

تاريخ استلام البحث: 2023/3/22 وتاريخ قبوله: 2023/10/9.


## ملخص

تعتبر المبيدات الحشرية الكيميائية حاسمة في مكافحة الآفات الحشرية، ولكنها ضارة بالبيئة. أصبح الحد من استخدام المبيدات الحشرية الكيميائية الهدف الرئيسي لضمان الحصول على منتجات صحية. ومع ذلك، فقد زادت في الآونة الأخيرة الأبحاث التي تركز على المركبات النباتية. أجريت هذه الدراسة لتحليل الزيوت الاساسية المستخرجة من النباتات الطبية الجزائرية بواسطة كروماتوغرافيا الغاز مقرونة بمطياف الكتلة ( GC-MS)لتحديد نشاط الزيوت الاساسية المستخرجة من Juniperus phoenicea، Rosmarinus officinalis، Lavandula stoechas، Mentha pulegium و Pinus sylvestris.ضمن البطيخ . كانت المكونات الرئيسية التي تشكل كل زيت أساسي هي: : α-pinene، β-Pinene، 1 8- cineol1 ,، Linalool، Linalyl acetate، Fenchone، Pulegone، و . Camphorكانت سمية الزيوت الاساسية المختبرة ضد Aphis gossypii Glover مختلفة وتعتمد على التركيز المستخدم (1000، 10000، و100000 جزء في المليون)، ومدة التعرض (24، 48، و72 ساعة)، والتركيب الكيميائي للزيت. أعلى سمية كانت لـ J. phoenicea وM. pulegium و .stoechas L والتي كانت سامة مثل المبيد الحشري Actara.®


**الكلمات الدالة**: من البطيخ Glover، المكافحة الحيوية للمبيدات الحشرية الحيوية، الزيوت الاساسية، المستخلصات النباتية.

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