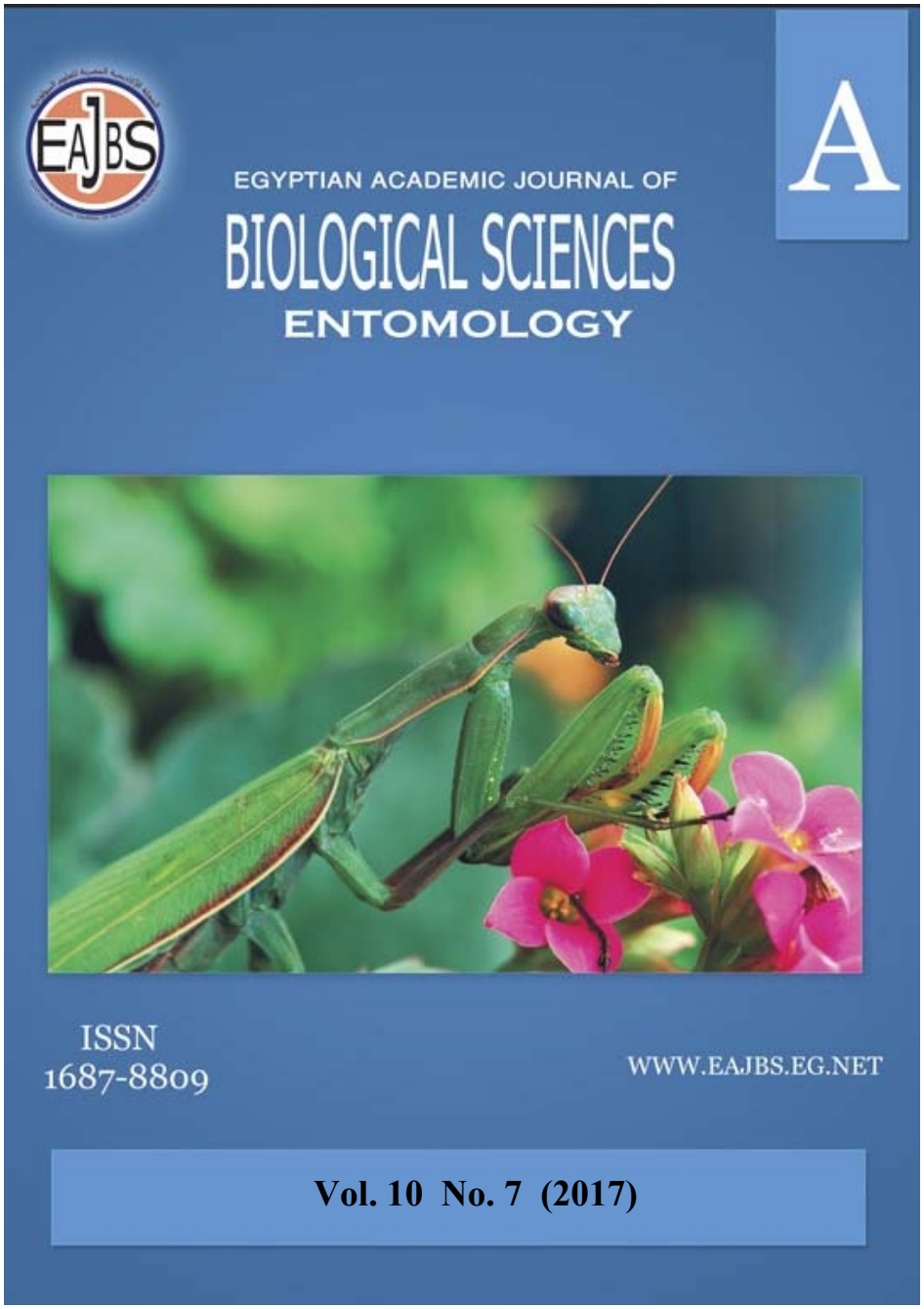

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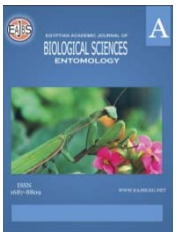

Efficiency of Some Plant Essential Oils Against the Two-Spotted Spider Mite, *Tetranychus urticae* Koch and the Two Predatory Mites *Phytoseiulus persimilis* (A.-H.), and *Neoseiulus californicus* (McGregor).

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ABSTRACT

Seven plant essential oils were tested for their toxicity against eggs and adults of *Tetranychus urticae* Koch as well as adults of the two predatory mites *Phytoseiulus persimilis* Athias-Henriot, *Neoseiulus californicus* (McGregor) under laboratory conditions. Essential oils were extracted with water distillation from lemon grass, spearmint, rosemary, marjoram herbs, fennel and coriander seeds and flower of chamomile, in five concentrations 4%, 3%, 2%, 1% and 0.5% were used for each essential oil. LC_{50} values for the adult females after 72h of *T. urticae* were 1.28, 0.85, 0.53, 1.61, 0.44, 3.11 and 0.46%, respectively. For these oils, LC_{50} values for eggs of *T. urticae* were 1.54, 6.44, 0.96, 1.72, 1.30, 14.67 and 0.95%, respectively. Chamomile, coriander, spearmint and rosemary proved to be the most efficient agent against eggs and adults of *T. urticae*. Results indicated that the mean number of laid eggs were highly decreased as concentration increased, the highest decreased was observed with *T. urticae* females treated with 4% conc. of coriander. It produced 4.7 eggs/female compared with 44.3 eggs/female in untreated females. On the other hand, there was no significant difference between seven essential oils against between *P. persimilis* and *N. californicus* after 48h. The LC_{50} values of the seven oils ranged between 7.09 and 9.63% for *P. persimilis*, where it ranged from 4.94 to 9.63 for *N. californicus*. The toxicity of all essential oils was lower to females of predacious mites than *T. urticae.* The data may suggest that essential oils of all seven plants have potential to be used for management of *T. urticae* and a good selectivity on the two predacious mites *P. persimilis* and *N. californicus*. The chemical composition of the essential oils was characterized by GC.

INTRODUCTION

The two-spotted spider mite, *Tetranychus urticae* Koch is one of the most important pests in many cropping systems worldwide and the most polyphagous species within the family of the Tetranychidae. Its host plants (nearly 800 plant species) comprise of vegetables, fruits, crops and a wide range of ornamentals (Migeon and Dorkeld, 2010). The greatest problem with this mite is its ability to rapidly evolve resistance to pesticides (Cranham and Helle 1985).

The host plant can be affected in different ways, including a decrease in photosynthesis or an injection of phytotoxic substances when feeding.

Moreover, the accumulation of faeces, webbing, and defoliation can affect the plant's appearance as well as its commercial value (Johnson and Lyon 1991). The control of spider mites has been based mainly on the use of acaricides, resulting in pesticide resistance and accumulation of pesticide residues on the harvested products (Attia *et al.* 2013).

To date, several reports have dealt with the use of essential oils and other extracts from plants to control phytophagous mites (Momen *et al.* 2001; Choi *et al.* 2004; Miresmailli and Isman 2006; Han *et al.* 2010 and Hussein *et al.* 2013).

However identifying selective pesticides for Integrated Pest Management programs is necessary to protect the natural beneficial arthropod fauna and at the same time reduce environmental pollutants. A low toxicity of these products to natural beneficial is very important. Members of the family Phytoseiidae are predatory mites and usually associated with phytophagous pest mites in fields; the extensive and long-term use of chemical pesticides has serious adverse effects on beneficial organisms, humans and the environment (Hoy and Ouyang, 1986).

The use of predatory mites of the family Phytoseiidae had proved effective control method in IPM programs for controlling pest mites especially the two spotted spider mite *T. urticae* (McMurtry *et al.* 2013). Also reported that the predatory mite *Neoseiulus californicus* (McGregor) has characteristics of both type II specialist predatory mite and type III generalist predatory mite. *N. californicus* prefers Tetranychid mites as food, but will also consume other phytophagous mites, small insects, such as thrips, and even pollen when the primary prey is unavailable. *Phytoseiulus persimilis* A.-H., is one of the most important predator of tetranychid mites and is widely found on various crops. It is considered one of the main predatory mites used in IPM in Egypt (El-Sharabasy, 2010).

Essential, mineral and plant oils are less disruptive to predatory mites than some commonly used synthetic miticides, and are generally much safer to use from an environmental and human health perspective than synthetic miticides (Momen *et al.* 2001; Momen and Amer, 2003).

The present work was carried out to study the direct effect of some plant oils extracts on the pest mite *T. urticae* which is very harmful to agriculture and two predacious mites (i.e. *P. persimilis* and *N. californicus*).

MATERIALS AND METHODS

Plant material:

Seven essential oils extracted from lemon grass (*Cymopogon citratus* (Dc.) Stapf), spearmint (*Mentha viridis* L.), rosemary (*Rosmarinus officinalis* L.) and marjoram (*Origanum majorana* L.) herbs and fennel (*Foeniculum vulgare* Mill.) and coriander (*Coriandrum sativum* L) fruits and chamomile (Matricaria recutita L.) flowers were tested. Plant materials were obtained from the medicinal and aromatic plants Department Farm, Horticulture Research Institute, Agriculture Research Center, El- Qanater El- Khayreya, Qualyubia, Egypt.

Extraction and analysis of volatile oil:

Volatile oil extraction:

The air dried plant was hydro distilled in a Clevenger-type apparatus for 4 h, according to the procedure described in the Egyptian Pharmacopeia (2005) to determine the volatile oil percentage (volume/weight). The obtained oils were dehydrated by filtration through anhydrous sodium sulfate and kept in a refrigerator in dark bottles for GC analysis. The Extraction of volatile oils and its components

were carried out at Medicinal and Aromatic Plants Research Department Laboratory, Horticulture Research Institute, Agriculture Research Center, Giza, Egypt.

Preparation of the emulsions:

Emulsions of the seven essential oils were prepared for different concentrations by mixing of Triton-x 100 with oils and completed with distilled water in exact volume.

Gas chromatography analysis (GC):

The GC analysis of the volatile oil samples was carried out using gas chromatography instrument at the Medicinal and Aromatic plants Dept. Laboratory, Horticulture Research Institute. DsChrom 6200 Gas Chromatograph is equipped with a flame ionization detector, Column: BPX-5, 5% phenyl (equiv.) polysillphenylene-siloxane 30 m x 0.25 mm ID x 0.25 µm film. Sample size: 1 µl, Temperature program ramp increase with a rate of 10 ºC/min from 70 to 200 ºC, Detector temperature (FID): 280 °C. Carrier gas: nitrogen. Flow rate: N_2 30 ml/min; H2 30 ml/min; air 300 ml/min. Main compounds of the volatile oils were identified by matching their retention times with those of the authentic samples injected under the same conditions. The relative percentage of each compound was calculated from the area of the peak corresponding to each compound.

Stock culture of the prey mite, *T. urticae*:

The stock colony of *T. urticae* was obtained from colonies that had been in greenhouse for about two years before the beginning of the study in the laboratory without exposure to any acaricide, at Qaha Agriculture Research Station (ARC), Qualyubia governorate. They were reared on plastic pots (15 cm in diameter) on bean plants, *Phaseolus vulgaris* L., adult mites were transferred to clean mulberry, *Morus alba* L. leaf with the lower surface up, placed on moistened cotton pads resting on sponges in the foam dish (15x20 cm). The colonies were maintained at room temperature under laboratory conditions. The mulberry leaves were examined every three days and replaced with fresh ones when over-crowding of mites and yellow leaves were observed. All bioassays were conducted and carried out under the same environmental conditions as the culture.

Stock cultures of the two predacious mites:

The two predatory mites *P. persimilis* and *N. californicus* were collected from different plants especially strawberry plants. The colonies were maintained at room temperature under laboratory conditions in large plastic boxes (70x30x40 cm), water as added when needed. Excised bean leaves highly infested with *T. urticae* were provided every day as food source for predatory mites. All bioassays were conducted and carried out under the same environmental conditions as the culture.

Experimental design:

An experimental foam dish (15x20 cm) consisted of a mulberry leaf disc (3 cm in diameter) kept upside down on moistened cotton pads resting on sponges. Water was replaced, as required to prevent the mites from escaping and to keep the culture healthy. A total of 40 experimental foam dishes were divided into seven treatments and a control, with six replicates in each treatment.

Treatment eggs of *T. urticae*:

Leaf discs of mulberry leaves were used as substrate to ovipositor. Six leaf discs were used for each treatment and ten mite females were transferred to each disc and left 24 h to lay eggs, then females were removed. Subsequently, six replicates leaf discs (20 eggs/replicate) were used per concentration (4%, 3%, 2%, 1% and 0.5%). Eggs were sprayed by a glass atomizer in each concentration for each essential oil and other in distilled water (control). Eggs were maintained at room

temperature under laboratory conditions for eight days till hatching. The numbers of hatching and non-hatching eggs were recorded. Corrected mortality counts according to Abbott's formula (1925) and LC_{50}, LC_{90} and slope values were estimated according to Finney (1971).

Treatment adult females of *T. urticae*:

Ten adult females of *T. urticae* were transferred to the lower surface to each disc of mulberry leaf discs (10 adult female/leaf discs) treated previously, using a fine camel hairbrush. Leaf discs were treated with one of previous treatments. Each treatment was replicated six times. Mortality was recorded after 24, 48 and 72 h post treatments under a binocular microscope. Mites were considered to be dead if their bodies or appendages did not move when prodded with fine camel hairbrush (Kim *et al.* 2004). The percentage reduction in the treatments was corrected in relation to the control (water) by Henderson and Tilton's formula (1955).

Effect of plant essential oils on fecundity and mortality of *T. urticae* females:

Leaf disks of Mulberry plants were painted with various concentrations of tested oils. Newly emerged females were transferred singly on painted leaf discs. Fifteen replicate leaf discs were used per each concentration and similar number of females on clean leaf disks was used as a control. The fecundity and mortality of females were recorded for 7 days. The oviposition deterrent indices (ODI) were calculated as reported by Lundgren (1975):

Direct effect of plant essential oils on adult females of two predacious mites:

Each newly adult females of two predatory mites (*P. persimilis* and *N. californicus*) were confined separately on the lower surfaces of mulberry leaves while the upper surfaces were placed on cotton saturated with water, tangle foot (Vaseline) was applied on the rim of leaf discs to prevent dispersal. A number of the preys, *T. urticae* were added as a food for the two predacious mites. Predacious mites were sprayed using a glass atomizer. Each test contained 5 concentrations and each concentration had 6 replicates (15 females/replicate). In every test, a water control was included. Mortality was recorded after 24 & 48 h after application.

Statistical analysis:

All data were analyzed using analysis of variance (ANOVA) and Least Significant Difference Test (LSD) was employed to compare the treatment means ($P = 0.05$), means were compared by Duncan's test using the SAS Program version 9.1 (SAS Institute, 2010). Data obtained from each dose-response bioassay were subjected to probit analysis (Finney, 1971) to estimate LC_{50} and LC_{90} values using Ldp line software. The terms of oviposition deterrent indices (ODI) as defined by (Lundgren, 1975) as ODI= (C-T/T+C)* 100%, C= number of eggs in control, T= number of eggs in treatment.

RESULTS AND DISCUSSION

Toxicity effect of seven essential oils on eggs of *T. urticae* after 7days:

The effect of seven plant extracts at different concentrations (0.5%, 1%, 2%, 3% and 4%) of aqueous extracts of lemon grass, spearmint, rosemary, fennel, flower of chamomile, marjoram and seeds of coriander were tested to evaluate their toxic effect after 7 days against eggs *T. urticae* and the obtained results have been obtained in Figure 1.

All essential oils tested had toxic effects against the eggs of *T. urticae*. Coriander and rosemary oils were the most potent oils tested eggs (LC_{50}= 0.95 and 0.96 & LC_{90}= 3.69 and 6.47) of *T. urticae* respectively, while spearmint and

marjoram oils were the least toxic oil tested on eggs (LC_{50}= 6.44 and 14.67 & LC_{90}= 31.52 and 427.63), respectively.

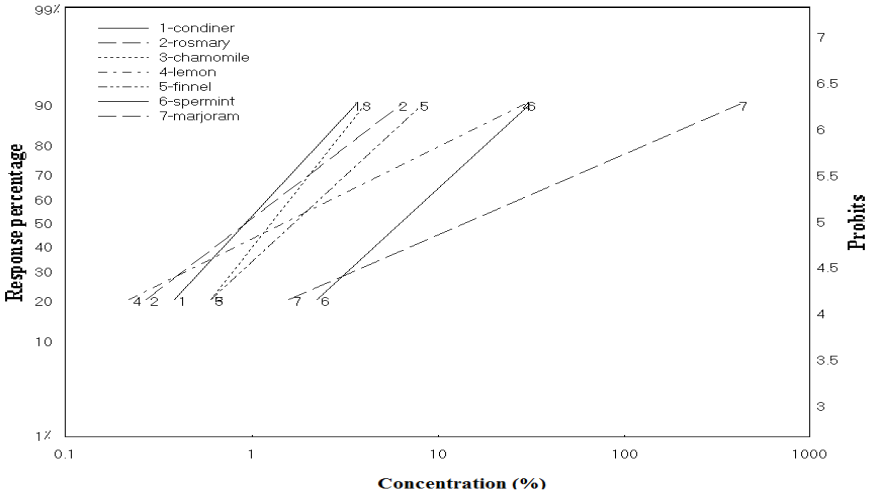

Fig. 1: Toxicity effect of seven essential oils on eggs of *T. urticae* after 7days.

The slopes for coriander, rosemary, chamomile, lemongrass, fennel, spearmint and marjoram are 2.17, 1.55, 2.56, 1.0, 1.86, 1.86 and .88, respectively. Thus, it is shown that chamomile essential oil became more effective with increase in the concentrations. Marjoram is of the lowest slope showing that its effectiveness on the mite is not as pronounced as coriander, rosemary and chamomile.

Toxicity effect of seven essential oils for adults of *T. urticae* :

Results from Table (1) indicated that, the corresponding LC_{50} values of chamomile, coriander, rosemary, spearmint, lemongrass, fennel and marjoram against the adult females of *T. urticae* after 24h of treated were 0.63, 0.62, 0.96, 1.3, 2.04, 2.88 and 5.75%, and the corresponding LC_{90} values were 8.37, 7.58, 23.45, 6.41, 22.29, 79.09 and 166.09%, respectively.

Table 1: Toxicity effect of seven essential oils for adults of *T. urticae* after 24, 48 and 72h.

Essential oils	Time (h)	LC_{50}	Lower limit %	Upper limit %	Slope	Toxicity index	LC_{90}	X^2
Chamomile	24	0.63	0.31	0.91	1.14	98.72	8.37	1.77
	48	0.51	0.25	0.75	1.25	100	5.38	2.21
	72	0.44	0.26	0.62	1.67	100	2.59	3.00
Coriander	24	0.62	0.31	0.89	1.18	100	7.58	1.77
	48	0.59	0.35	0.81	1.44	85.69	4.58	1.61
	72	0.46	0.28	0.63	1.75	95.69	2.50	5.49
Rosemary	24	0.96	0.49	1.39	0.92	64.35	23.45	2.02
	48	0.72	0.32	1.07	0.97	70.40	15.05	2.43
	72	0.53	0.23	0.79	1.13	84.41	7.16	3.19
Spearmint	24	1.30	1.04	1.57	1.85	47.73	6.41	3.14
	48	1.10	0.87	1.32	1.94	46.48	5.03	3.92
	72	0.85	0.67	1.02	2.25	52.24	3.15	6.01
Lemon grass	24	2.04	1.55	2.85	1.24	30.28	22.29	1.11
	48	1.72	1.25	2.39	1.13	29.56	23.41	0.67
	72	1.28	0.98	1.61	1.53	34.63	8.84	3.07
Fennel	24	2.88	1.97	6.05	0.89	21.49	79.09	0.21
	48	2.13	1.45	3.66	0.88	23.95	59.83	0.18
	72	1.61	1.07	2.39	0.94	27.60	37.38	0.17
Marjoram	24	2.88	1.97	6.05	0.89	21.49	79.09	0.21
	48	4.32	2.71	14.85	0.84	11.77	142.6	0.43
	72	3.11	2.06	7.65	0.84	14.28	105.6	0.27

While the corresponding LC_{50} values after 48h of treated against the adult females of *T. urticae* were 0.51, 0.59, 0.72, 1.1, 1.72, 2.13 and 4.32%, and the consequent LC_{90} values were 5.38, 4.58, 15.05, 5.03, 23.41, 59.83 and 142.57%, respectively. Spearmint recorded the highest slop value after 24 and 48 h 1.85& 1.94, respectively. Whereas the lowest slop value were 0.88 & 0.84 for marjoram oil after 24 and 48 h, respectively.

On the other hand, the corresponding LC_{50} values after 72 h for adults were 0.44, 0.46, 0.53, 0.85, 1.28, 1.61 and 3.11% and the consequent LC_{90} values were 2.59, 2.5, 7.16, 3.15, 8.84, 37.38 and 105.64%, respectively. The slop values of regression line were 1.67, 1.75, 1.13, 2.25, 1.53, 0.94 and 0.84 for chamomile, coriander, rosemary, spearmint, lemongrass, fennel and marjoram after 72 h for adults, respectively.

Effect of plant essential oils on fecundity and mortality of *T. urticae* females:

Data shown in Tables (2 & 3) clearly indicated that, potential effect of this extract. Reproduction of *T. urticae* was greatly affected by oils treatment. Significant reduction in the total number of eggs laid during 7 days period was found for all the concentrations tested. Statistically, control recorded the highest eggs laid per female/7day (41.33 eggs) with significant differences with all treatments, followed by fennel 15, 17.53 and 20.6 eggs/female/7 days at concentrations 4%, 3% & 2%, respectively whereas coriander occupied the lowest mean numbers of eggs/female/7 days by 4.73, 8.33, 14.2, 16.6 and 19.45 eggs at concentrations 4%, 3%, 2%, 1% & 0.5%, respectively.

Table 2: Effect of various concentrations of seven essential oils on reproduction of *T. urticae*.

Essential oils	Mean number of eggs deposited/ female/ 7days ± SD				
	4%	3%	2%	1%	0.5%
Lemon grass	8.80 ±2.18^{de}	17.40±2.53^{b}	19.27±2.66^{bc}	30.60±4.05^{b}	35.80±3.9^{b}
Spearmint	6.60±1.84^{fg}	9.60±2.59^{d}	14.07±2.25^{d}	22.47±4.72^{d}	24.87±3.18^{e}
Rosemary	7.53±2.03^{ef}	16.07±1.84^{b}	18.33±1.77^{c}	24.42±2.68^{c}	27.38±3.08^{de}
Fennel	15.00±2.14^{b}	17.53±3.09^{b}	20.60±3.56^{b}	28.00±3.05^{b}	31.20±2.76^{c}
Chamomile	10.53±2.72^{cd}	12.33±2.94^{c}	17.73±2.81^{c}	20.60±3.56^{d}	29.67±4.3^{cd}
Marjoram	12.00±3.32^{e}	12.33±2.99^{c}	14.07±2.25^{d}	24.87±3.18^{c}	26.27±4.37^{e}
Coriander	4.73±1.87^{g}	8.33±2.47^{d}	14.20±1.97^{d}	16.60±6.22^{e}	19.45±2.93^{f}
Control	41.33±5.39^{a}				
F	247.2	165.8	131.5	46.4	41.0
LSD at 0.05	2.09	2.27	2.2	3.08	2.95

Means followed in the same column by the same letter are not significantly different ($P \leq 0.05$).

Table 3: Effect of various concentrations of seven essential oils on oviposition deterrent indices (ODI) of *T. urticae*.

Essential oils	Oviposition deterrent indices (ODI) %				
	4%	3%	2%	1%	0.5%
Lemon grass	64.9	40.7	36.4	14.9	7.2
Spearmint	72.5	62.3	49.2	29.6	24.9
Rosemary	69.2	44.0	38.5	25.7	20.3
Fennel	46.7	40.4	33.5	19.2	14.0
Chamomile	59.4	54.0	40.0	33.5	16.4
Marjoram	55.0	54.0	49.2	24.9	22.3
Coriander	79.4	66.4	48.9	42.7	36.0

The depression in total number of eggs with high concentrations could be attributed to feeding inhibition and effects of the formulation, causing depression on reproduction activity. The oviposition deterrent indices (ODI) of tested oils was highest at 4% concentration varied between (46.7–79.4%), while the lowest values at

0.5% concentration varied from 7.2% on lemongrass and 36% on coriander oils.

Direct effect of plant extracts oils on adult females of two predacious mites:

The obtained results as shown in (Table 4 and 5) revealed that the relation between the percentage of mortality and concentrations of seven essential oils on female stages of *P. persimilis* and *N. californicus*. Fennel was more toxic to females of the predatory mite *P. persimilis* (LC_{50}=0.8.04& 7.09% and LC_{90}= 45.31& 62.61%) followed by chamomile oil (LC_{50}=10.02 & 7.37% and LC_{90}= 95.61& 90.25%) after 24 and 48h respectively, while rosemary has less activity against the females *P. persimilis* (LC_{50}=14.42& 10.71% and LC_{90}= 139.89& 143.15 %) after 24 and 48h respectively (Table 4). No significant differences were recorded between the seven essential oils against adult females of the predatory mite *P. persimilis*.

Table 4: Toxicity effect of seven essential oils for adults of the predatory mite *P. persimilis* after 24 and 48h.

Essential oils	Time (h)	LC_{50}	Lower limit %	Upper limit %	Slope	Toxicity index	LC_{90}	X^2	P
Fennel	24	8.04	5.27	20.65	1.71	100	45.31	0.06	1.00
	48	7.09	4.57	18.70	1.36	100	62.61	0.18	0.98
Chamomile	24	10.02	5.73	41.51	1.31	80.23	95.61	0.15	0.98
	48	7.37	4.50	23.95	1.18	96.19	90.25	0.36	0.95
Coriander	24	10.48	5.85	48.05	1.27	76.72	106.98	0.25	0.97
	48	8.69	4.82	44.57	1.03	81.55	154.34	0.15	0.98
Spearmint	24	12.66	6.40	92.77	1.15	63.49	164.29	1.40	0.71
	48	9.05	4.87	54.98	0.98	78.32	183.41	0.79	0.85
Marjoram	24	10.82	6.19	45.82	1.47	74.31	80.85	0.57	0.90
	48	9.47	5.43	39.07	1.23	74.85	103.76	0.12	0.99
Lemongrass	24	11.18	6.41	49.13	1.59	71.86	71.43	0.33	0.95
	48	9.63	5.60	37.13	1.33	73.62	89.03	0.21	0.98
Rosemary	24	14.42	7.15	117.9	1.30	55.75	139.89	0.26	0.97
	48	10.71	5.74	60.12	1.14	66.18	143.15	0.15	0.98

The results illustrated in Table (5) proved that, the Ldp-lines of toxicity effects of seven essential oils on adult females of *N. californicus*. When compare between the effects of essential oils of mortality percentage of females of *N. californicus* after 24 and 48h from treatment it can be conducted that spearmint was more toxic the LC_{50} values 4.94 and 6.85%; LC_{90} values 78.43 and 72.11% and the slope values gave 1.25 and 1.07 respectively, whereas marjoram was less toxic to adult of females of *N. californicus* LC_{50} values 11.39and 9.63%; LC_{90} values 125.88 and 222.43% and the slope values gave 1.23 and 0.94, respectively. Insignificant differences were recorded between the seven essential oils against adult females of the predatory mite *N. californicus.*

The present results are in agreement with the data cited by Kawka (2004) who studied the effect of chamomile extracts from fresh and dry on *T. urticae*. Rosemary oil was the most toxic to females of *Neoseiulus barkeri* (Hughes) and the least to *Neoseiulus* zaheri Yousef & El-Borolossy. In contrast, marjoram oil was relatively toxic to *Typhlodromus athiasae* Porath & Swirski, and slightly toxic to *N. barkeri*. Both essential oils, decreased the food consumption rate at the concentration used for *N. barkeri* and *N. zaheri* (Momen and Amer, 1999).

Based on direct contact toxicity, Melissacide was found to be 10 times more active on the pest *T. urticae* than the predator *Neoseiulus californicus* females, respectively. The formulation was extremely active on *T. urticae* eggs than predatory eggs.

Table 5: Toxicity effect of seven essential oils for adults of the predatory mite *N. californicu*s after 24 and 48h.

Essential oils	Time (h)	LC_{50}	Lower limit %	Upper limit %	Slope	Toxicity index	LC_{90}	X^2	P
Spearmint	24	6.85	4.36	19.02	1.25	100	72.11	0.38	0.94
	48	4.94	3.25	12.63	1.07	100	78.43	0.27	0.97
Coriander	24	9.19	5.24	39.13	1.18	74.50	113.24	0.11	0.99
	48	6.43	3.92	22.17	1.04	76.88	110.11	0.15	0.99
Rosemary	24	9.00	5.42	30.29	1.39	76.10	75.41	0.15	0.98
	48	6.61	4.23	18.08	1.24	74.75	72.13	0.33	0.95
Chamomile	24	8.97	5.16	36.95	1.18	76.36	110.49	0.02	1.00
	48	6.64	3.92	27.11	0.97	74.48	137.77	0.03	1.00
Fennel	24	9.98	5.97	35.75	1.59	68.63	64.18	0.30	0.96
	48	7.39	4.80	19.01	1.46	66.91	55.87	0.43	0.93
Lemongrass	24	9.92	5.73	39.49	1.34	69.02	89.70	0.57	0.90
	48	7.76	4.58	29.50	1.11	63.72	111.54	0.60	0.90
Marjoram	24	11.39	6.11	62.46	1.23	60.11	125.88	0.71	0.87
	48	9.63	4.99	72.95	0.94	51.35	222.43	0.26	0.97

Momen *et al.* 2001 showed that that mint is satisfactory as regards both high mortality and low reduction of fecundity for *T. urticae*. Mint was more toxic to *T. urticae* than to phytoseiid predators studied. In contrast, peppermint was more effective on most phytoseiid predators than mint, as well as it was considered to be less toxic to *T. urticae* than mint. In the next year, Amer and Momen 2002 found that the direct toxicity of four essential oils, marjoram, rosemary, peppermint and lavender to adult females of the predacious mite *Amblyseius swirskii* A.-H., were tested. Peppermint oil was the most toxic to females' *A. swiriskii* while the French lavender oil was the least toxic to the predator. All essential oils, at the two concentrations used, decreased the food consumption rate as well as egg laying.

Choi *et al*. 2004 reported that, among the 53 essential oils of caraway seed, citronella, lemon, eucalyptus, pennyroyal and peppermint were found to be highly toxic to mite species, *T. urticae* and *P. persimilis*.

Use of natural compounds from essential oils has been suggested as a viable source of alternative treatments for insect and mite control because many of such compounds have novel modes of action, no or low toxicity to non-target organisms and mammals, and are less harmful to the environment (Isman, 2006). In the same year, Momen *et al.* 2006 showed that, Sweet basil oil was the most toxic essential oil to females *Neoseiulus cucumeris* (Oudemans), while sweet marjoram oil was the least toxic one (LC_{50}=2.315 and 7.021%, respectively). In contrast, rosemary oil was toxic to eggs of *N. cucumeris*, while sweet basil oil was the least effective oil against predator eggs (LC_{50} = 2.695 and 11.950%, respectively). Also, rosemary and sweet marjoram oils seem to be slightly harmful to *N. cucumeris* at (LC_{50}) concentration of each oil. In addition, Miresmailli and Isman (2006) reported that, rosemary oil repels two spotted spider mite, *T. urticae* and can affect oviposition behavior. Also, the predatory mite *Phytoseiulus persimilis* is less susceptible to rosemary oil than two-spotted spider mite.

Han *et al.* 2010 found that spearmint and basil oils were significantly less toxic to *T. urticae* and *N. californicus*. Afifi *et al.* 2012 indicated that chamomile represented the most potent efficient acaricidal agent against *T. urticae* followed by marjoram and *Eucalyptus*. The LC_{50} values of chamomile, marjoram and *Eucalyptus* for adults were 0.65, 1.84 and 2.18, respectively and for eggs 1.17, 6.26 and 7.33, respectively. Mead 2012 found that, the lemongrass oil was more toxic against adults of *T. urticae* using spraying method than leaf dip technique method. A significantly reduced hatchability percentage of *T. urticae* eggs than control that recorded 85.33, 77.33, 57.33 and 33.33 % for concentration 0.25, 0.5, 1.0 and 2.0 %, respectively.

Momen *et al.* 2014 showed that the predator *Neoseiulus californicus* is extremely less sensitive to Melissa oil and Melissacide than the pest *T. urticae* in the laboratory. When *N. californicus* was sprayed with (LC_{50} and LC_{90} values reported on *T. urticae*), females mortalities ranged between 8.5–13%, respectively. In the next year, Salman *et al.* 2015 found that in all concentrations of the essential oils of lavandin, sage, rosemary and hyssop essential oils had high contact effect on *T. urticae* adults and nymphs.

Chemical constituents of essential oils:

The obtained results as shown in Tables (6 &7) and Figs (2, 3, 4& 5) clarified the gas chromatography analysis for selected four essential oils chamomile, spearmint, coriander and rosemary volatile oils which the most effective of *T. urticae* during this study.

Table 6: GC analysis report for rosemary and spearmint volatile oils.

Rosemary			Spearmint		
PK.NO.	Component	Pct. (%)	PK.NO.	Component	Pct. (%)
1	α-Pinene	3.05	1	α-Pinene	0.27
2	camphene	1.09	2	Sabinene	0.49
3	β - Pinene	0.50	3	Myrcene	1.26
4	Unknown	0.74	4	β - Pinene	1.28
5	Unknown	0.17	5	P-Cymene	1.17
6	Limonene	5.10	6	Unknown	0.70
7	1,8 cineole	1.86	7	limonene	11.23
8	Unknown	0.52	8	1,8 cineole	6.94
9	Unknown	0.66	9	β - ocimene	0.56
10	camphor	54.36	10	γ-terpineol	0.83
11	α-terpineol	1.38	11	α-terpineol	0.53
12	borneol	1.07	12	Dihydrocarveol	1.19
13	Bornyl acetate	4.66	13	Dihydrocarvone	0.48
14	Unknown	3.48	14	Trans- carveol	0.30
15	Eugenol	14.17	15	Pulegone	0.53
16	β-caryophyllene	4.30	16	Carvone	70.29
17	Unknown	2.22	17	Dihydrocarveol acetate	1.11
18	Unknown	0.67	18	β-caryophyllene	0.84
sum		100.00	19	Caryophyllene oxide	0.01
			sum		100.00

Table 7: GC analysis report for chamomile and coriander volatile oils.

Chamomile			Coriander		
PK.NO.	Component	Pct. (%)	PK.NO.	Component	Pct. (%)
1	α -Pinene	0.92	1	α-Pinene	2.44
2	α-Farnesene	1.41	2	Unknown	0.28
3	1,8-Cineol	1.67	3	Sabinene	0.32
4	β-Farnesene	2.57	4	Myrcene	0.99
5	Isofaurinone	1.82	5	β - Pinene	2.40
6	γ-Cadinene	1.58	6	P-Cymene	1.03
7	Caryophyllene oxide	1.91	7	Linalool	85.60
8	Bisabolol oxide b	16.40	8	Geraniol	0.86
9	α-Eudesmol	1.92	9	Unknown	0.55
10	β -Bisabolol	3.96	10	borneol	0.80
11	Spathylenol	1.26	11	Linalyl acetate	3.23
12	Unknown	1.44	12	Geranyl acetate	1.51
13	Bisabolene oxide a	9.01	sum		100.00
14	α-Bisabolol	6.09			
15	Chamazulene	1.24			
16	Bisabolol oxide a	44.34			
17	Trans - dicycloether	2.45			
sum		100.00			

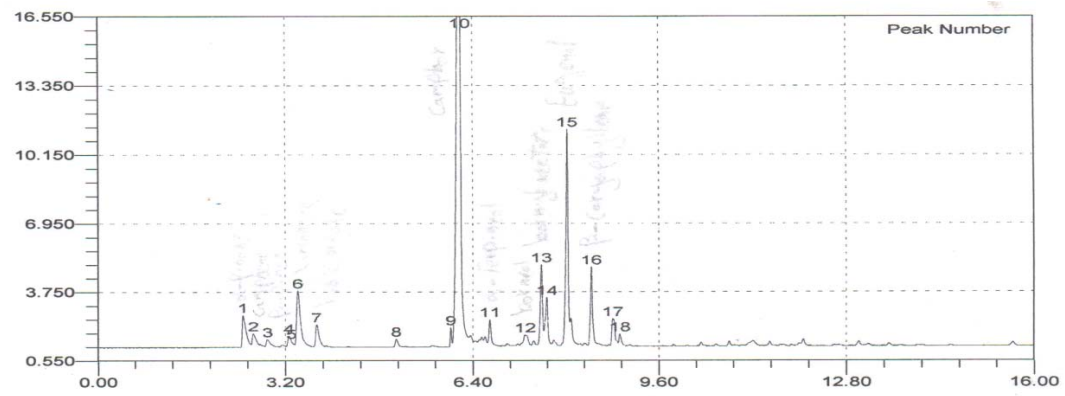

Fig. 2: GC analysis chromatogram for rosemary volatile oil.

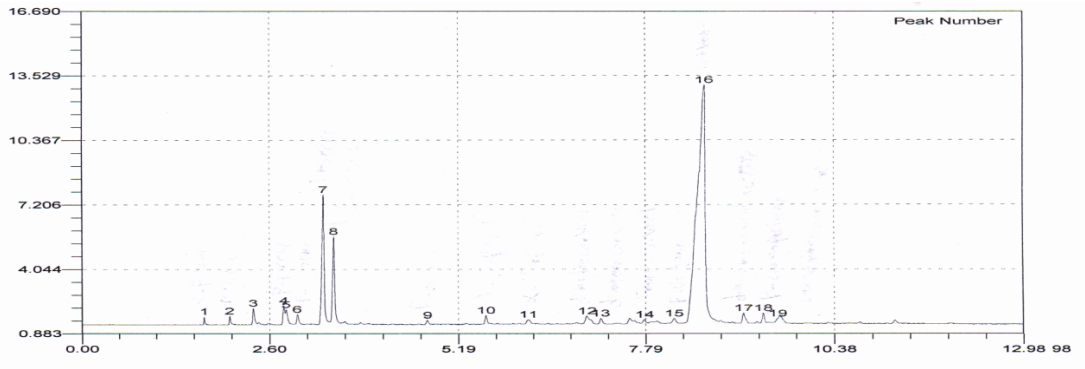

Fig. 3: GC analysis chromatogram for spearmint volatile oil.

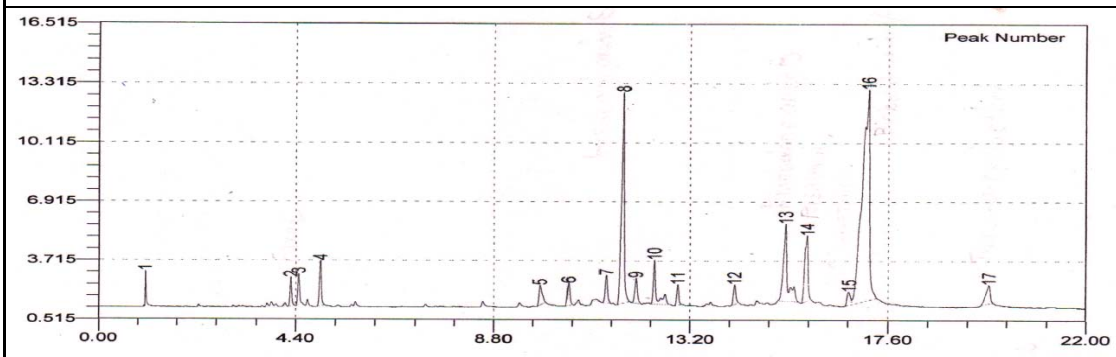

Fig. 4: GC analysis chromatogram for chamomile volatile oil.

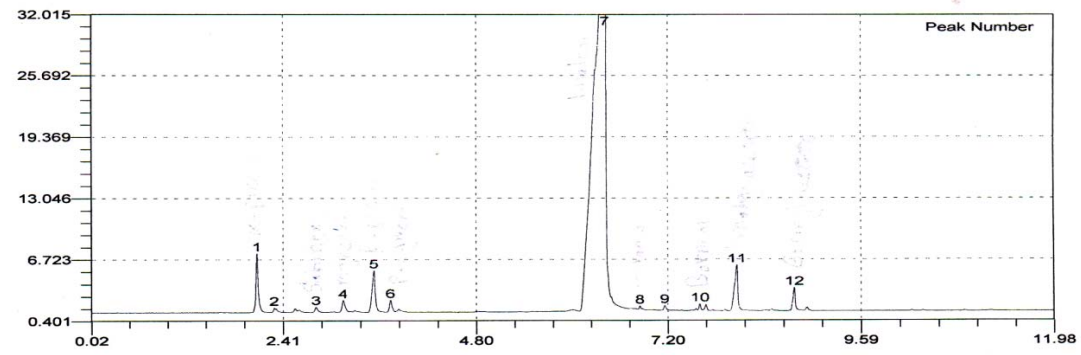

Fig. 5: GC analysis chromatogram for coriander volatile oil.

Gas chromatography analysis for volatile oils showed that, bisabolol oxide a (44.34%), carvone (70.29%), linalool (85.60%) and camphor (54.36%) were the main components of chamomile, spearmint, coriander and rosemary volatile oils respectively, which may be responsible for controlling *T. urticae*.

Comparable results were obtained by Momen *et al.* 2001 they showed that mint oil was mainly characterized by high concentration of carvone (57.351%), while menthone and menthol represented the main components in peppermint oil since they formed 25.145 and 21.633% of oil content, respectively. The essential oil extracted from *Foeniculum vulgare* was less toxic to adults of *T. urticae* than the eggs. The main compounds in *F. vulgare* oils are T-anethole, estragole, fenchone and limonene (Aprotosoaie *et al.* 2010; Amizadeh *et al.* 2013).

CONCLUSION

Present results indicated that the LC_{50} value of *T. urticae* of all essential oil and its formulation is essential to select the best one which can be effective to *T. urticae* and also safe when select the oil in IPM programme. This work offered here is based on laboratory data; care should be taken in translating results of laboratory to the field.

REFERENCES

Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. J. Econ. Entomol. 18: 265-267. doi.10.1093/jee/18.2.265a

Afify, A.M.; Ali, F.S. and Turky, A.F. 2012. Control of *Tetranychus urticae* Koch by extracts of three essential oils of chamomile, marjoram and *Eucalyptus*. Asian Pacific Journal of Tropical Biomedicine. 24-30. doi.10.1016/S2221-1691(11)60184-6

Amizadeh, M.; Hejazi, M. and Saryazdi, G.S. 2013. Fumigant toxicity of some essential oils on *Tetranychus urticae* (Acari: Tetranychidae) Inter. J. of Acarology, 39(4): 285–289. doi.10.1080/01647954.2013.777782

Amer, S.A. and Momen, F. 2002. Effect of some essential oils on the predacious mite *Amblyseius swirskii* A. H. (Acari: Phytoseiidae). Acta Phytopathol. Entomol. Hung. 37 (1–3):281–286. doi.10.1556/APhyt.37.2002.1-3.27

Aprotosoaie, A.C.; Spaci, A.; Hancianu, M.; Mironi, A.; Tanasescu, V.F.; Dorneanu, V. and Stanescu, U. 2010. The chemical profile of essential oils from fennel fruits (*Foeniculum vulgare* Mill.). Farmacia. 58:46–53.

Attia, S.; Grissa, K.L.; Lognay, G.; Bitume, E.; Hance, T. and Mailleux, C. 2013. A review of the major biological approaches to control the worldwide pest *Tetranychus urticae* (Acari: Tetranychidae) with special reference to natural pesticides. J Pest Sci., 86(3):361–386. doi.10.1007/s10340-013-0503-0

Baker, E.M. 2003. Phytochemical and toxicological studies on essential oils of aromatic plants against *Tetranychus urticae* Koch. Ph. D. Thesis, Fac. Agric., Cairo Univ., 150pp.

Choi, W.I.; Lee, S.G.; Park, H.M. and Ahn, Y.J. 2004. Toxicity of plant essential oils to *Tetranychus urticae* (Acari: Tetranychidae) and *Phytoseiulus persimilis* (Acari: Phytoseiidae). J. Econ. Entomol. 97(2): 553-558. http://dx.doi.org/10.1603/0022-0493-97.2.553

Cranham, J. E., and W. Helle. 1985. Pesticide resistance in the Tetranychidae, pp. 405–421. *In* Helle H. and Sabelis M. W. (eds.), World crop pests 1B. Spider mites: their biology, natural enemies and control. Elsevier, Amsterdam, The Netherlands.458pp.

Egyptian Pharmacopeia. 2005. 4thed, Central Administration of Pharmaceutical Affairs (CAPA), Cairo, Egypt, Ministry of Health and Population, 31-33.

El-Sharabasy, H. M. 2010. Acaricidal activities of *Artemisia judaica* L. extract against

Tetranychus urticae Koch and its predator *Phytoseiulus persimilis* Athias-Henriot (Tetranychidae: Phytoseiidae). J. Biopestcides 3: 514–519.

Finney, M. 1971. Probit Analysis. Cambridge Univ. Press, 3rd ed., London.

Han, J.; Choi, B.R.; Lee, S.G.; Kim, S.I. and Ahn Y.J. 2010. Toxicity of plant essential oils to acaricide-susceptible and -resistant *Tetranychus urticae* (Acari: Tetranychidae) and *Neoseiulus californicus* (Acari: Phytoseiidae). J. Econ. Entomol., 103:1293–1298. doi.10.1603/EC09222

Hassan, S. A. 1985. Standard method to test the side effects of pesticides on natural enemies of insect and mites developed by the IOBC/WPRS working group "Pesticides and Beneficial organisms". Eppo Bulletin 15, 214–255.

Henderson, C.F. and Tilton, E.W. 1955. Tests with acaricides against the brown wheat mite. J Econ Entomol. 48:157–161. doi.10.1093/jee/48.2.157

Hoy, M. A. and Ouyang, Y. L. 1986. Selectivity of the acaricides clofentezine and hexythiazox to the predator *Metaseiulus occidentalis* (Nesbitt) (Acari: Phytoseiidae). J. Econ. Entomol.79, 1377–1380. doi.10.1093/jee/79.5.1377

Hussein, H.; Reda, A.S. and Momen, F.M. 2013. Repellent, antifeedent and toxic effects of three essential oils on the two Spotted Spider Mite, Tetranychus urticae Koch (Acari: Tetranychidae). Acta Phytopathol. Entomol. Hung. 48 (1):177–186. doi.10.1556/APhyt.48.2013.1.17

Isman, M. B. 2006. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Ann. Rev. Entomol. 51, 45–66. doi.10.1146/annurev.ento.51.110104.151146

Johnson, W. T. and Lyon, H.H. 1991. *Insects that feed on trees and shrubs*. 2nd ed. rev. Ithaca, N.Y.: Cornell University Press. 560 pp.

Kawka B. 2004. Effect of chamomile extracts on biology of *Tetranychus urticae* Koch feeding on Algerian ivy (*Hedera canariensis* L.). Ann Warsaw Agric Univ Hortic Landsc Archit 2004; 25: 75-79.

Kim, Y. J.; Lee, H. S.; Lee, S. W. and Ahn, Y. J. 2004. Fenproximate resistance in *Tetranychus urticae* (Acari: Tetranychidae) cross-resistance and biochemical resistance mechanisms. Pest Manag. Sci. 60: 1001-1006. doi.10.1002/ps.909

Lundgren, L. 1975. Natural plant chemicals acting as oviposition deterrent on cabbage butterflies *Pieris brassica* (L.) and *Pieris rapi* (L.). Zool. Sci. 4, 253–258.

McMurtry, J. A., de Moraes, G. J. and Sourassou, N. F. 2013. Revision of the life styles of phytoseiid mites (Acari: Phytoseiidae) and implications for biological control strategies. Sys. Appl. Acarol. 184: 297–320.

Mead, H. M. 2012. Acaricidal activity of essential oil of lemongrass, *Chymbopogon citratus* (DC.) Stapf against *Tetranychus urticae* Koch. J. Plant Prot. and Path., Mansoura Univ., 3(1): 43 – 51.

Migeon, A. and Dorkeld, F. 2010. Spider mites web: a comprehensive database for the Tetranychidae. http://www.montpellier.inra.fr/CBGP/spmweb

Miresmailli, S. and Isman, M. 2006. Efficiency and persistence of rosemary oil as an acaricide against two spotted spider mite (Acari: Tetranychidae) on greenhouse tomato. J. Econ. Entomol., 99 (6): 2015 – 2023. doi:10.1603/0022-0493-99.6.2015

Momen, F.M. and Amer, S.A. 1999. Effect of rosemary and sweet marjoram on three predacious mites of the family Phytoseiidae (Acari: Phytoseiidae). Acta Phytopathol. Entomol. Hung. 34 (4):355–361. doi.10.1556/APhyt.34.1999.4.11

Momen, F. M. and Amer, S. A. 2003. Influence of the sweet basil, *Ocimum basilicum* L. on some predacious mites of the family Phytoseiidae (Acari: Phytoseiidae). Acta Phytopathol. Entomol. Hung. 38: 137–143. doi.10.1556/APhyt.38.2003.1-2.16

Momen, F.M.; Amer, S.A. and Refaat, A.M. 2001. Influence of mint and peppermint on *Tetranychus urticae* and some predacious mites of the family Phytoseiidae (Acari: Tetranychidae: Phytoseiidae). Acta Phytopathol. Entomol. Hung. 36 (1–2): 143–153. doi.10.1556/APhyt.36.2001.1-2.17

Momen, F.M.; Amer, S.A. and Saber, S.A. 2006. Acaricidal potentials of some essential, mineral and plant oils against the predacious mite *Neoseiulus cucumeris* (Oudemans)

(Acari: Phytoseiidae). Acta Phytopathol. Entomol. Hung. 41(3-4): 383–393. doi.10.1556/APhyt.41.2006.3-4.20

Momen, F. M.; Abdel Rahman, H. A.; Samour, E. A.; Aly, S. M. and Fahim, S. F. 2014. Acaricidal activity of *Melissa officinalis* oil and its formulation on *Tetranychus urticae* and the predatory mite *Neoseiulus californicus* (Acari: Tetranychidae and Phytoseiidae). Acta Phytopathol. Entomol. Hung. 49, 95–115. doi.10.1556/APhyt.49.2014.1.10

Overmeer, W. P. J. and van Zon, A. G. 1982. A standard method for testing the side effects of pesticides on the predacious mite *Amblyseius potentillae* (Acarina: Phytoseiidae). Entomophaga 27, 357–364. doi.10.1007/BF02372057

Salman, S.Y.; Saritas, S.; Kara, N.; Aydinli, F. and Ay, R. 2015. Contact, repellency and ovicidal effects of four Lamiaceae plant essential oils against *Tetranychus urticae* Koch (Acari: Tetranychidae), Journal of Essential Oil Bearing Plants, 18:4, 857-872, doi.10.1080/0972060X.2014.914856

SAS Institute. 2010. SAS Statistics and Graphics Guide, Release 9.1. SAS Institute, Cary, North Carolina, 27513, USA.

ARABIC SUMMARY

فعالية بعض الزيوت العطرية على العنكبوت الأحمر العادى *Tetranychus urticae* والمفترسين الأكاروسيين *Phytoseiulus persimilis* و *Neoseiulus californicus*

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تم اختبار سمية سبعة زيوت عطرية نباتية على البيض والأطوار الكاملة لكل من العنكبوت الأحمر العادى وكذلك الطور الكامل من المفترسيين الأكاروسيين *Phytoseiulus persimilis* ، *Neoseiulus californicus* تحت الظروف المعملية. تم استخلاص الزيوت العطرية من العشب الجاف لنباتات حشيشة الليمون، النعناع البلدى ، الحصالبان ، البردقوش و بذور الشمر والكزبرة ، وأزهار البابونج باستخدام التقطير المائى و تم تحضير خمسة تركيزات 4٪، 3٪، 2٪، 1٪ و 0.5٪ لكل زيت عطري. كانت قيم LC_{50} للإناث البالغة بعد 72 ساعة للعنكبوت الأحمر العادى 1.28، 0.85، 0.53، 1.61، 0.44، 3.11، 0.46٪ على التوالي. وبالنسبة لسمية هذه الزيوت على بيض العنكبوت الأحمر العادى كانت قيم LC_{50} 1.54 ، 6.44 ، 0.96 ، 1.72 ، 1.30 ، 14.67 ، 0.95٪ على التوالي. أثبتت النتائج ان زيت البابونج والكزبرة والحصالبان والنعناع البلدي أعطت أعلى كفاءة على كلا من البيض والأطوار الكاملة للعنكبوت الأحمر العادى . أشارت النتائج إلى أن متوسط عدد البيض الناتج من الإناث المعاملة كان منخفضا بدرجة كبيرة بزيادة التركيز، لوحظت أعلى نسبة انخفاض على إناث العنكبوت الأحمر العادى المعاملة بتركيز 4٪ من الكزبرة أعطت 4.7 بيضة / أنثى مقارنة ب 44.3 بيضة / أنثى في الإناث غير المعاملة. لم تسجل اى فروق معنوية بين سبعة زيوت عطرية على *P. persimilis* ، *N. californicus* بعد 48ساعة حيث تراوحت قيم LC_{50} للزيوت السبعة بين 7.09 و 9.63٪ لـ*P. persimilis* ، في حين تراوحت بين 4.94 و 9.63٪ لـ*N. californicus* . وكانت سمية جميع الزيوت العطرية أقل على إناث المفترسين الأكاروسيين من العنكبوت الأحمر العادى. ونستخلص من النتائج إلى أن الزيوت العطرية المختبرة لديها القدرة على خفض تعداد العنكبوت الأحمر العادى مع الحفاظ على تعداد المفترسين *P. persimilis*، *N. californicus*. وقد وصف التركيب الكيميائي للزيوت الأساسية بتحليل الغاز الكروماتوجرافى.

كلمات مفتاحية: زيوت عطرية، العنكبوت الأحمر العادى، فيتوسيدى، نعناع بلدى، حصالبان، البابونج، الكزبرة.