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Evaluation of some natural oils and formic acid for controlling varroa mite (*Varroa destructor*) in honey bee colonies

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Abstract

Varroa destructor is a dangerous pest directly for beekeeping and indirectly for crops that require insect pollination. *V. destructor* spread from the Asian honey bee (*Apis cerana* Fabricius) to *Apis mellifera* L. (Hymenoptera : Apidae). Mites feed on haemolymph of brood and adult bees cause colony weakness, a decrease in brood and bees. The application of integrated pest management (IPM) techniques is more recent development in *V. destructor* control because its more effective than pesticides. This study was carried out to assess the efficacy of three natural oils (Camphor oil –mint oil – anise oil) and formic acid (65%) used at three concentrations (25%, 50% and 75%) against *V. destructor* in honey bee colonies (*A. mellifera*) during the period of January till September 2021 in Sidi Salem, Kafr El-Sheikh Governorate, Egypt. Data indicated that formic acid and the highest concentrations (75%) of tested essential oils caused effective control of varroa mites, whereas the infestation reduction percentage with formic acid, camphor oil recorded more than 80% after treatments on both brood and adult. while anise oil recorded the lowest one.

Introduction

The varroa mite (*Varroa destructor*) is an ectoparasitic mite on honey bee brood and adults .it considered one of the most pests in honey bee colonies (Sammataro *et al.*, 2000 and Anderson and Trueman, 2000). It causes big losses to honey bee , *Apis mellifera* L. (Hymenoptera : Apidae) and great economic loss to the worldwide beekeeping industry (Rashid *et al.*, 2012) and also, reduces the colony ability to pollinate plants (De Jong *et al.*, 1984), the varroa mite is considered as the parasite with the most pronounced economic impact on the beekeeping industry (Guzman-Novoa *et al.*,2010). There is current concern about contamination of bee products with synthetic substances against the varroa (Howis and Nowakowski, 2009). The mite is an ectoparasite, that transfers entomopathogens such as viruses, thus causing death of brood and adult bees in colonies (De Jong *et al.*,1982). Natural products such as essential oils and their components or organic acids, especially formic acid and citric acid were used for controlling varroa mites (Mutinelli *et al.*,1997).

Formic acid and thymol are effective in the control of varroa mites without any side effects (Soroker *et al.*, 2019). In a similar way, smoke from

plants has produced mixed success in increasing varroa reduction. Varroa mites need to be controlled because untreated colonies collapsed within a few years due to damage to both brood and adult bees (Elzen *et al*., 2000). In previous studies, plant essential oils have been examined and applied as alternatives to synthetic pesticides for varroa management (Rosenkranz *et al*., 2010 and Plettner *et al*., 2017). These circumstances allow for the development and testing of the effectiveness of new preparations (Gurgulova *et al* ., 2004). Little is known about the electrophysiological detection of essential oils and essential oil components by acarine (Soroker *et al*., 2019).

The aim of the present study is to evaluate some natural products for controlling varroa mite on honey bees, these natural materials generally have no side effects on honey bees and are less hazardous to beekeepers.

Materials and methods

1. Experimental site:

The experiment was carried out in an apiary at Sidi Salem district, Kafr El- Sheikh Governorate during the period from January to September 2021 to study the effect of some natural products for controlling *V. destructor* in honey bee colonies. Whereas the study required eighteen colonies of carniolan hybrid nearly of equal strength. The colonies have been divided into 6 groups (Each group 3 colonies).

2. Materials:

2.1. Camphor oil (25%-50% -75%)
2.2. Mint oil (25% -50% -75%)
2.3. Anise oil (25% -50% -75%)
2.4. Formic acid (65%)

The bottom board of the hive was covered with a plastic sheet coated with Vaseline to capture the fallen mites.

3. Determination of varroa infestation:

The percent infestations of varroa mite on adult before and after treatments were determined according to Korneili (1988), whereas the number of mites\100 was calculated and the fallen varroa on the plastic sheet was counted periodically every 3 days till the end of treatment. The percent infestations of varroa mites on brood cells was determined by square inch.

Reduction percentage in mite infestation was calculated according to Henderson and Tilton (1955)

$$\text{Reduction \%} = 100 \times \left(1 - \frac{\text{Treatment after}}{\text{Treatment before}} \times \frac{\text{Control before}}{\text{Control after}}\right)$$

4. Statistical analysis:

Data collected were statistically analyzed according to SAS Institute (1998) computer program.

Results and discussion

Three natural oils namely (Camphor oil, mint oil and anise oil) and formic acid were evaluated against *V. destructor* under field conditions. Data in Tables (1 and 2) showed that the reduction percentage of varroa mite infestation on adult was clearly reduced after the treatments in all tested oils and formic acid. In the colonies treated with essential oils and formic acid the reduction percentage of infestation with varroa on adult reduced gradually from the first treatment to the fourth (End of treatment) after the treatments. formic acid 65% and camphor oil caused a highly effective in controlling varroa mites, whereas the reduction percentage of infestation of Formic acid, camphor oil, mint oil and anise oil in January recorded (88.5%), (87.2%), (72.1%), (61.7%) after treatment on adult, respectively. Whereas, anise oil was the lowest percentage of infection reduction. The reduction percentage of infection of formic acid, camphor oil, mint oil and anise oil in September was recorded (94.5%), (89.6%), (65.3%),

(56%), respectively. The obtained data are in agreement with Allam *et al.* (2003) who found that formic acid killed 91.7% of varroa mites and Abd El-Wahab and Ebada (2006) and Hamaad *et al.* (2008) found that thyme oils resulted in 65.9% of varroa mite mortality for varroa control under Egyptian conditions. Data in Tables (1 and 2) showed that the highest number of varroa falling on the sheet was recorded after the first treatment and clearly decreased until the end of treatments.

Table (1): The reduction percentages of infection on adult in honey bee colonies treated with essential oils and formic acid in January 2021.

Date	Treatment	Control		Before treat-ment	Concentrations No of fallen of varroa			After treatm-ent	Reduction %
January		Before	After	Adult	%25	%50	%75	Adult	Adult
First treatment	Camphor oil	32	28	28	22a	28b	30c	7	71.4
Second		30	27	26	25b	26b	27b	5	78.6
Third		27	25	20	20a	20a	10a	3	83.8
Fourth		23	20	18	7a	5a	3a	2	87.2
First	Mint oil	32	28	30	23a	25b	28b	10	61.9
Second		30	27	28	20a	23a	25a	8	68.3
Third		27	25	26	15a	18a	16a	6	75.1
Fourth		23	20	21	13a	12a	11a	5	72.6
First	Anise oil	32	28	27	20a	21a	22a	12	49.2
Second		30	27	25	18a	20a	20a	10	55.6
Third		27	25	23	17a	18a	19a	8	62.4
Fourth		23	20	21	15a	14a	12a	7	61.7
First	Formic acid	32	28	24	30c	30c	30c	6	71.5
Second		30	27	22	28b	28b	28b	4	79.8
Third		27	25	20	15a	15a	15a	3	83.8
Fourth		23	20	20	2a	2a	2a	2	88.5

Table (2): The reduction percentages of infection on adult in honey bee colonies treated with essential oils and formic acid in September 2021.

Date	Treatment	Control		Before treatm-ent	Concentrations No of fallen of varroa			After treatm-ent	Reduction%
September		Before	After	Adult	%25	%50	%75	Adult	Adult
First treatment	Camphor oil	30	26	26	25b	27b	29c	6	73.4
Second		28	25	24	23a	26b	27b	4	81.4
Third		27	24	22	20a	24a	15a	3	84.7
Fourth		22	20	21	8a	6a	2a	2	89.6
First	Mint oil	30	26	28	24a	26b	28b	12	50.6
Second		28	25	24	22a	24a	26b	10	53.4
Third		27	24	22	17a	18a	14a	8	59.1
Fourth		22	20	19	14a	13a	10a	6	65.3
First	Anise oil	30	26	26	20a	23a	25b	13	42.4
Second		28	25	23	18a	20a	22a	11	46.5
Third		27	24	22	17a	19a	20a	10	48.9
Fourth		22	20	20	16a	14a	13a	8	56
First	Formic acid	30	26	27	29c	29c	29c	7	70.1
Second		28	25	25	28b	28b	28b	5	77.6
Third		27	24	23	12a	12a	12a	3	85.4
Fourth		22	20	24	2a	2a	2a	2	94.5

Data in Tables (3 and 4) showed that the reduction percentages of infection on brood in colonies treated with formic acid and essential oils in January recorded (86.3% formic acid), (81.5% camphor oil) , (65.7% mint oil)

,(56.7% anise oil) and recorded in September the reduction of infection of formic acid , camphor oil , mint oil and anise oil (86.9%), (82.1%) , (63.5 %) ,(56.2%) after treatment, respectively. Results showed that camphor oil is effective against *V. destructor* and safe for bees. Several authors have evaluated essential oils as control agents for varroa (Imdorf *et al.*, 1999; Ariana *et al.*,2002 and Ismail *et al*., 2006). Data agreement with May-Itza *et al*. (2007). Statistical analysis showed that highly significance between treatments.

Table (3): The reduction percentages of infection on brood in honey bee colonies treated with essential oils and formic acid in January 2021.

Date	Treatment	Control		Before Treatment	After Treatment	Reduction %
January		Before	After	Brood	Brood	Brood
First treatment	Camphor oil	33	30	25	11	51.6
Second		31	27	23	10	50.1
Third		28	25	22	6	59.3
Fourth		26	21	20	3	81.5
First	Mint oil	33	30	23	12	42.7
Second		31	27	22	10	47.9
Third		28	25	20	7	60.8
Fourth		26	21	18	5	65.7
First	Anise oil	33	30	27	14	43
Second		31	27	25	12	44.9
Third		28	25	23	10	51.4
Fourth		26	21	20	7	56.7
First	Formic acid	33	30	26	9	62
Second		31	27	23	7	65.1
Third		28	25	22	5	74.6
Fourth		26	21	18	2	86.3

Table (4): The reduction percentages of infection on brood in honey bee colonies treated with essential oils and formic acid in September 2021.

Date	Treatment	Control		Before Treatment	After Treatment	Reduction %
September		Before	After	Brood	Brood	Brood
First treatment	Camphor oil	30	27	28	10	60.4
Second		29	25	25	8	62.9
Third		27	23	24	6	70.7
Fourth		25	19	22	3	82.1
First	Mint oil	30	27	25	11	51.2
Second		29	25	22	9	52.6
Third		27	23	20	8	53.1
Fourth		25	19	18	5	63.5
First	Anise oil	30	27	27	13	46.6
Second		29	25	24	11	46.8
Third		27	23	23	9	54.1
Fourth		25	19	21	7	56.2
First	Formic acid	30	27	24	8	63
Second		29	25	23	6	69.8
Third		27	23	22	4	78.7
Fourth		25	19	20	2	86.9

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