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USE OF SOME VOLATILE OILS AS ATTRACTIVE AGENTS TO INCREASE FOOD CONSUMPTION IN HONEYBEE COLONIES

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ABSTRACT

The present work aimed to investigate the stimulating and attractive effects of five volatile oils on honey bee colonies food consumption. These oils were added to sugar syrup and pollen substitutes. The consumption of sugar syrup and percentage of dead bees in caged honeybee workers were determined. Multi-choice test inside the honey bee colonies was carried out to determine the food consumption rate from different pollen substitutes. Positive effect was recorded by adding Coriander oil 0.03% followed by Fennel 0.15% and Spearmint oils 0.03% while nigella oil showed a repellent effect on honey bee workers. The mortality percentage was very low with no significant differences between treatments. Results indicated that addition of 5% pollen grains and three volatile oils increased significantly pollen substitute's consumption. The highest consumption rate was recorded with coriander oil 0.03%. Results obtained indicated that the consumption of diets that contain Coriander, Fennel, and Spearmint volatile oils was more successful than control.

INTRODUCTION

Honeybee colonies involve honey and pollen as their natural resources of food components. Both are highly nutritious food resources supplying bees with carbohydrates, proteins, vitamins, fats, and minerals. Carbohydrates come mainly from honey, whereas other components come from pollen. In addition to water, they are essential for energy, brood rearing, and activity of honeybee individuals leading to strong and productive colonies (**Loper and Berdel, 1980**).

Stability and efficiency of bee colonies can be restricted by shortage of food income. In Saudi Arabia, climatic factors are the main cause of deficiency in nectar and/or pollen resources. Artificial honeybee feeding during shortage of natural sources becomes very significant in order to sustain strong colonies throughout the season. Spring feeding with sugar syrup often used to stimulate brood rearing and pollen collection (**Johansson and Johansson, 1977**). Pollen supplements or substitutes frequently used to increase the number of foraging bees (**Stanger and Laidlow, 1974; Doull, 1980**) leading to high honey and pollen production.

Honeybee workers prefer natural pollen grains over pollen substitutes which were less beneficial to bees than pollen as a source for protein (**Haydak, 1967**). Protein-poor diets during larval and adult life stages resulted in small body mass and low level of ovary development in workers compared to those fed on protein-high diets (**Hoover *et al* 2006**). **Standifer *et al* (1973) and Erickson and Herbert (1980)** suggested that the addition of 5% pollen to protein ration significantly increased consumption of diet by honey bee colonies. Similar findings were reported by (**Alqarni, 2006**). **Hanna and Schmidt (2004)** reported that feeding behavior and bee survival were enhanced after addition of 1- 5% pollen extracts to the bee diet. It is well established that some natural products such as plant extracts are used to accelerate and increase consumption of artificial food by honey bee colonies (**Hussein and Omar, 1989**).

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The effect of adding volatile oils to honeybee artificial diets was studied by many investigators **(Waller *et al* 1970; Fathy *et al* 2001; Omran and Omar, 2003). Abdel-Rahman (1998)** used some volatile oils with sugar syrup as attractants for foraging workers. Plant volatile oils were also evaluated for their toxic effects on tracheal and varroa mites attacking honeybee colonies **(Imdorf *et al* 1999; Lindberg *et al* 2000; Ariana *et al* 2002 and Ali *et al* 2002)**.

In most of Saudi Arabia, especially in central regions, environmental conditions such as short spring season, low rain falls, high sun intensity and summer temperature play a limited factor in beekeeping activity. **Alqarni (1995) and Alghamdi (2002)** reported that pollen area was less than 10 inch^2/colony during summer season in central Saudi Arabia and supplementary feeding was very essential. Many beekeepers reported colony loss during summer, and bees were not attracted to sugar syrup and pollen substitutes.

This work aimed to study the attractiveness of five plant volatile oils to accelerate honeybee workers consumption of sugar syrup and pollen substitutes in central Saudi Arabia.

MATERIALS AND METHODS

Experimental work was carried out in the laboratory and apiary of the Bee Research Unit at King Saud University, Riyadh during Fall season of 2006.

The first experiment was carried out in the laboratory in small cages under controlled conditions. Five volatile oils from *Fennel Foeniculum vulgare, Spearmint Mentha viridis, Coriander Coriandrum sativum, Nigella Nigella sativa* and *Parsley Petroselinum crispum* were tested as attractive agents with sugar syrup. Two concentrations (0.03% and 0.15%) were made from each volatile oil and 250 ml from each concentration was prepared and kept in refrigerator for use. To homogenate the oils, drops from emulsion material was added to sugar syrup.

Experimental wooden cages of 15x15x5 cm dimensions with two sides of glass and black muslin were prepared. Every cage was provided with two hanged vials of tap water and sugar solution 1:1 (w/v) mixed with the volatile oil under test. Pieces of wax comb were attached to the top of each cage to encourage bees to dwell in. For each tested oil concentration, four cages (each contains fifty newly emerged honeybee workers) were used. Forty four cages in all treatments were used including four cages as control treatment. All cages were held in the dark in an incubator at 34±2°C and 70 R.H. Sugar syrup consumption by honey bee workers in each cage was calculated as ml/cage/3 days. In addition, the dead bees of each cage were counted each 3 days to calculate the percentage of mortality under the effect of oil type and concentration. Experiment was repeated three times at one week interval.

The second experiment was carried out in the apiary inside honeybee colonies to study the consumption rate of pollen substitutes mixed with volatile oils. In this experiment, the best treatments selected from laboratory test were used. The selected treatments were: Fennel (0.15%), Spearmint (0.03%), and Coriander (0.03%).

The traditional pollen substitute (3 parts soybean flour, 1 part Brower yeast, 1 part skimmed milk powder, 5 parts sugar powder) was used as a basic substitute. Oil percentage from every treatment was added during paste preparation to make 500 gm from every treatment. New treatment of pollen substitute (mixed with 5% natural pollen grain powder) was used for comparison. The paste was put into perforated polyethylene bag, and was divided into small pieces (approximately 50 gm/piece).

Four honey bee colonies at the same strength were selected for application. Five different pieces- one from every variant- were placed at random on the top of brood nest inside every colony under test. The consumption was calculated after 2 weeks for every treatment. This procedure was repeated four times at one week interval.

The F-test was used in order to calculate and test for significance within administered diets, whereas multiple scale of **Duncan (1955)** was used in order to compare the means.

RESULTS AND DISCUSSION

Effect of adding volatile oils to sugar syrup on honeybee consumption

Data presented in **Table (1)** show the consumption rates of sugar syrup mixed with plant volatile oils by honeybee workers during three days compared to sugar syrup only (control) under laboratory conditions. It is clear that hoarding behavior was affected positively and negatively by adding some plant volatile oils. Depending on the type of oil and concentration, positive effects were recorded with some treatments and were significantly different. The addition of Coriander,

Table 1. Consumption of sugar syrup mixed with volatile oils as attractive agents for honey bee workers

Volatile oil and concentration		Consumption rate (ml/50 bees/3 days)				Deviation from control
		1st application	2nd application	3rd application	General Mean*	
Fennel	0.03%	2.56	3.56	2.57	2.99 BC	+35.29%
	0.15%	2.40	3.50	3.40	3.10 B	+40.27%
Spearmint	0.03%	2.73	3.20	3.23	3.05 B	+38.00%
	0.15%	2.40	4.06	2.23	2.90 CD	+31.22%
Coriander	0.03%	4.03	6.47	4.33	4.94 A	+123.53%
	0.15%	2.57	2.46	2.53	2.52 F	+14.03%
Nigella	0.03%	1.83	2.03	2.43	2.10 G	-4.98%
	0.15%	1.33	1.46	2.06	1.62 H	-26.70%
Parsley	0.03%	2.17	3.10	3.03	2.77 DE	+25.3%
	0.15%	2.37	2.87	2.73	2.66 EF	+20.35%
Control (sugar syrup only)		1.60	2.30	2.73	2.21 G	

* Means followed by the same letter in the same column are not significantly differed according to Duncan's multiple range test at 0.05 level probability.

Fennel, and Spearmint oils significantly increased the consumption of sugar syrup by honeybee workers in laboratory conditions **(Fig. 1)**.

The highest percent deviation against control was recorded when Coriander oil 0.03% was added (+123.53%), followed by Fennel oil 0.15% and Spearmint oil 0.03% (+40.27% and +38.00%) respectively. The least percentages were recorded with parsley oil at both concentrations **(Table 1)**. Nigella oil gave a negative effect (repellent) to honeybee workers. **Hammoda (1987)** reported that repellent substances affect the susceptibility of some medicinal plant to visiting insects. **Nicodemo and Nogueira (2004)** found repellent effect for parsley plant extract towards bees visiting animal feeders with chopped sugar cane and prevent the cattle from eating. Alqarni (unpublished data) found that *Nigella sativa* flowers received the lowest foraging workers in comparison with five medicinal plants in Riyadh area. Further, seed weight produced from *N. sativa* was significantly lower than all seed weight produced from other plants.

Table (2) shows the percentages of dead bees during the three periods of application. The general means of three feeding applications with sugar syrup mixed with some volatile oils as attractive agents were calculated. The mortality percentage was very low and ranged between 4.34% (sugar syrup plus spearmint oil 0.15%) and 7.5% (sugar syrup plus nigella oil 0.15%). There were insignificant differences between treatments and control (5.33%).

The concentration of volatile oil used had no toxicological effect on honeybee workers. Results showed that honey bee colonies prefer to feed on diets with volatile oils. The lethal effect of numerous volatile oils on honeybee workers was studied by many investigators in search of their acaricidal act on varroa and tracheal mites. However, application methods in acaricidal effect studies included contact application, with worm air, and in combination with formic acid. **Omran and Omar (2003)** stated that the consumption of diets containing volatile oils was more successful than those free of volatile oils.

Effect of adding volatile oils to pollen substitutes on honeybee consumption

Data in **Table (3)** show the honeybee consumption of pollen substitutes provided with three types of volatile oils (fennel 0.15%, spearmint 0.03%, coriander 0.03%) and pollen grains (5%). The selection of these oils was based on their significant increase in sugar syrup consumption in the first experiment. Coriander oil 0.03% showed significant improvement in diet consumption

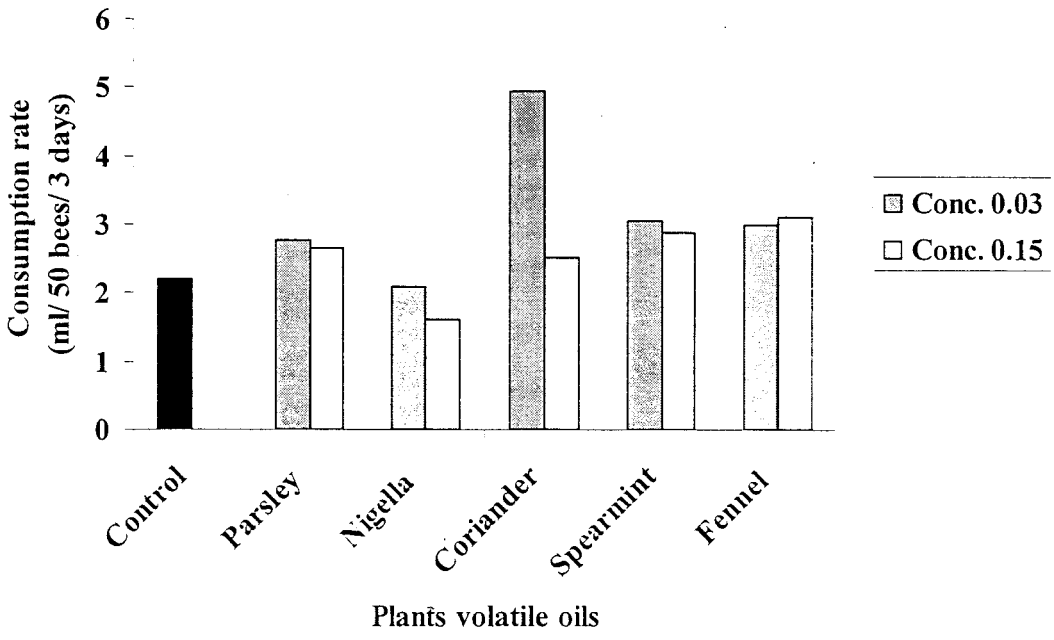

Figure 1. Means of worker bees' consumption rate of sugar syrup mixed with volatile oils of some medicinal plants

Table 2. Mortality percentages of honey bee workers fed on sugar syrup mixed with some volatile oils as attractive agents

Volatile oil used and concentration		Mean percentages of dead bees			
		First Application	Second application	Third application	General mean
Fennel	0.03%	6.00	5.50	5.00	5.50
	0.15%	7.00	7.00	5.75	6.59
Spearmint	0.03%	7.00	6.50	4.00	5.83
	0.15%	4.50	4.50	4.00	4.34
Coriander	0.03%	7.00	6.50	4.50	6.00
	0.15%	6.00	5.00	4.00	5.00
Nigella	0.03%	5.50	5.00	4.50	4.67
	0.15%	9.50	8.00	8.00	7.50
Parsley	0.03%	5.50	4.50	4.50	4.83
	0.15%	6.00	5.50	5.00	5.50
Control (sugar syrup only)		5.00	5.50	5.50	5.33

Table 3. Consumption of pollen substitutes mixed with some volatile oils and pollen as attractive agents for honey bee colonies

Volatile oil and concentration		Consumption rate (gm/colony/2 weeks)					Deviation from control
		1st application	2nd application	3rd application	4th application	General Mean*	
Fennel	0.15%	23.38a	33.20B	24.00Ab	26.22b	26.70 (B)	+57.43%
Spearmint	0.03%	18.57bc	27.11C	17.67C	21.29c	21.16 (C)	+24.76%
Coriander	0.03%	23.38a	38.69A	25.55A	33.40a	30.25 (A)	+78.36%
Pollen grains	5%	20.60ab	30.46Bc	20.89B	28.35b	25.07 (B)	+47.82%
Control (sugar syrup only)		15.98c	20.19D	15.52D	19.16c	16.96 (D)	

* Means followed by the same letter in the same column are not significantly differed according to Duncan's Multiple range test at 0.05 level probability

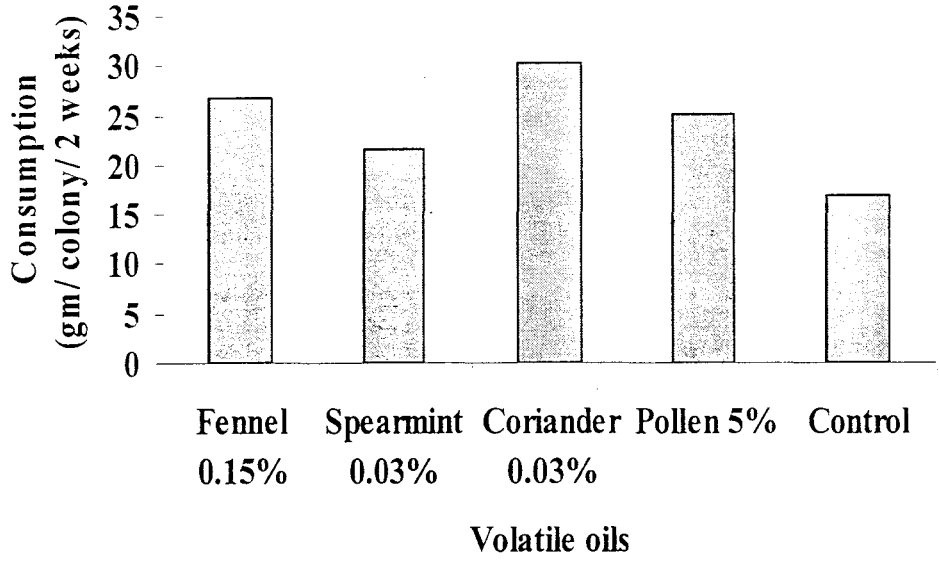

Figure 2. Means of consumption rates of pollen substitutes mixed with volatile oils of three plants and bee pollen as attractive agents to honeybee workers.

followed by fennel 0.15% and pollen grain 5.0% evenly. The lowest effect was recorded for spearmint oil 0.03% (Fig. 2). **Waller *et al* (1970)** found that the consumption of patties or substitutes increased, when sugar syrup was mixed with anise, fennel and artificial honey essences. **Omran and Omar (2003)** used five volatile oils (camphor, thyme, carnation, rosemary and spearmint) at concentration of 1%. They reported that honeybee consumption of diets containing volatile oils was more efficient than control.

The addition of pollen grains 5% to pollen substitute increased the paste consumption significantly to +47.82%. **Doull and Standifer (1970)** reported that the failure of bees to consume non-pollen supplement may be due to lack of specific feeding stimulants, which are assumed to release feeding behavior in honeybee colonies. **Doull (1973) and Hanna & Schmidt (2004)** reported that pollen grains contain phagostimulants that are highly vital in feeding behavior of honeybees and could play crucial role in successful artificial diets. **Schmidt and Hanna (2006)** stated that phagostimulants consist of matching set of diverse components that additively or synergistically act to exceed a threshold level of stimulation necessary for feeding. However, they reported that the addition of phagostimulants to artificial diets did not increase the life spans of honeybee workers. Results have showed also that the addition of coriander oil 0.03% to the artificial diet was more significant than the addition of pollen grains 5.0% (Figure 2). This finding confirms the economic importance of volatile oils of some plants. They play a crucial role in maintaining honeybee colonies productivity and lowering the adverse effects in times of pollen shortage.

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استخدام بعض الزيوت العطرية كجاذبات لزيادة استهلاك الغذاء في طوائف نحل العسل [١٥]

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المقدمـــــه

يهدف البحث إلى معرفة التأثير الجاذب لخمسة زيوت طيارة على طوائف نحل العسل. أضيفت الزيوت إلى المحلول السكري وبدائل حبوب اللقاح. أجري اختبار تقدير استهلاك المحلول السكري بواسطة شغالات نحل حديثة السن في أقفاص صغيرة بالمعمل، كما قدرت نسبة النحل الميت تحت تأثير المعاملات المختلفة . وتم تقدير استهلاك طوائف النحل الميت تحت تأثير المعاملات المختلفة، وتم تقدير استهلاك طوائف نحل العسل لبدائل حبوب اللقاح المختلفة داخل خلايا النحل بطريقة الاختيار من متعدد. بمعني أنه تم عرض البدائل الغذائية للنحل وترك للنحل حرية الاختيار منها.

وقد وجد أن هناك تأثير إيجابي معنوي باستخدام زيت الكزبرة بتركيز ٠,٠٣% تلاه تأثير زيت الشمر بتركيز ٠,١٥% وزيت النعناع بتركيز ٠,٠٣% ، بينما أظهر زيت حبة البركة تأثيراً طارداً لنحل العسل وذلك بالتركيزات تحت الاختبار. أما النسبة المئوية لموت للشغالات فقد كانت منخفضة جداً وبدون أية فروق معنوية بين المعاملات.

وقد أثبتت النتائج أن إضافة حبوب لقاح بنسبة ٥% إضافة إلى استخدام ثلاثة أنواع من الزيوت العطرية ، أدى إلى زيادة معنوية في استهلاك بدائل حبوب اللقاح. وكانت أعلى نسبة سجلت للاستهلاك باستخدام زيت الكزبرة.

وقد خلصت النتائج إلى أن استهلاك بدائل الأغذية المحتوية على الزيوت العطرية كان أكثر نجاحاً مع استخدام زيت الكزبرة والشمر والنعناع مقارنة بالكنترول.

تحكيم: أ.د جمال الدين محمود حجازى