Annals of Agric. Sci., Moshtohor **ISSN 1110-0419**
Vol. 54(1) (2016), 119–128 **http://annagricmoshj.com**

Efficacy of some plant oils against two stored product insects

Mohamed M. Azab[A*]; A. A. Darwish[A]; R. A. Mohamed[B]; Heba H. Mohamed[B]

[A]Plant Protection Department, Faculty of Agric., Benha Univ.,Qalubia, Egypt.
[B]Plant Protection Research Institute, Agric. Res. Center, Ministry of Agric.,Giza, Egypt.

*** Corresponding author:** mohamed.azab@fagr.bu.edu.eg

Abstract

To investigate the insecticidal activity of marjoram, caraway and worm wood oils against the adults of *Sitophilus oryzae* (L.) (Curculionidae, Coleoptera) and the active and diapausing larvae of khapera beetle *Trogoderema granarium* (Everts) laboratory bioassay tests were conducted, at four to five concentrations of each plant oil, of 21days under 30 and 20 ±1°C. The results indicated that the mortality of tested insects increased with increasing the plant oil concentration, exposure period and temperature, where the complete mortality of *S. oryzae* adults was obtained at 1.5 and 1% (v/w) of the three tested oils, after 21 days exposure periods at 30°C. Data also revealed that at 20°C, the worm wood oil was the most toxic for the studied insects, and it gave LC_{50s} of 2.41, 2.90 and 0.21% for active and diapausing larvae of *T. granarium* (after 14 days exposure period) and for the adults of *S. oryzae* (after 3 days exposure period), respectively. Caraway oil was the most toxic at 30ºC against the active and diapausing larvae of *T. granarium*. The adults of *S. oryzae* were more sensitive to investigated plant oils than active and diapausing larvae of *T granarium*. It can be concluded that marjoram, caraway and worm wood oils have a toxic activity against the two stored-product insects, *S. oryzae* and *T. granarium*.

Key words: majoram, caraway, worm wood, insecticidal activity, *Sitophilus oryzae*, *Trogoderema granarium*

Introduction

Insect pests cause damage to stored grains and processed products by reducing their dry weight and nutritional value **(Dubey*et al*., 2008)**. Additionally, insect infestation-induced changes in the storage environment may cause warm moist "hotspots" that provide suitable conditions for growth fungi that cause further losses **(Jacobson, 1982)**.

Although, methyl bromide and phosphine are effective and available, there is a global concern about their negative effects, such as ozone depletion, environmental pollution, toxicity to non-target organisms, pest resistance, and pesticide residues (**Hansen and Jensen, 2002; Benhalima *et al*., 2004; Bughio and Wilkins, 2004**). Thus, there is an urgent need to develop safe alternatives for stored-grain pest control.

One of possible alternatives to synthetic pesticides is the screening of plants in search for alternatives pest control agents such as extracts of plant leaves, seeds, flowers, plant oils etc., in order to overcome and reduce the danger of pollution occurring from the wide use of pesticides in controlling the pests. It is hoped that such agents would be more degradable in nature and with less adverse effects on mammals than the conventional synthetic insecticides **(EL-Lakwah *et al.*, 1997)**. Studies on plant extracts, dusts and plant oils as pest control agents against stored product pests gave promising results (**Yadav, 1984; Jaibal *et al.*, 1984; Su, 1985 and 1989; Javier *et al*., 1986; Sighamony *et al*., 1986; Darwish, 1992; EL-Lakwah *et al*., 1992, 1993, 1994, 1996, 1997 and 2002; Halawa, 1998; Boff *et al*., 2006)**.

Oils isolated from plants can play an important role in stored grain protection and reduce the risks associated with the use of synthetic insecticides **(Hernandez *et al.*, 2015)**. Different concentrations from eight plant oils, lemon grass, pinussylvestris, parsley, fennel, geranium, peppermint, pittegra in and sweet basil were used for protection of cowpea and chickpea seeds from infestation by *Callosobruchus maculatus* (**Hassan *et al*., 2013)**.
The aim of this work was to evaluate the effectiveness of plant oils of marjoram, caraway and worm wood against the adults of *S. oryzae* and active and diapausing larvae of *T. granarium*.

Materials and Methods

Insects

Two stored product insect species, namely the rice weevil, *Sitophilus oryzae* (L.) (Curculionidae, Coleoptera) and khapera beetle *Trogoderema granarium* (Everts) were obtained from the existing culture in the stored product pests Laboratory at the Plant Protection Department, Faculty of Agriculture, Benha University.

Rearing technique

The insects were reared in glass jars (approx. 500 ml) containing about 200 g of sterilized and conditioned wheat grains. The glass jars were

covered with muslin. Insect cultures were kept under controlled conditions of 30±1°C and 65±5% R.H. at the rearing room of the laboratory. Wheat grains were treated by freezing at -18°C for 2 weeks before application to eliminate any possible infestation by any insect species. The moisture content of the grains was around 14%. Around 300 adults o *S. oryzae* (1-2 weeks old) were introduced into the jars for laying eggs and then kept at 30±1°C and 65±5% R.H. Three days later, all insects were separated from the food, and the jars were kept again at the controlled conditions in the rearing room. This procedure was repeated several times in order to obtain large number of the adults needed to carry out the experiments during this study. In case of *T. granarium* about 200 adults 2-5 days old were added to the wheat grains inside the jars for laying eggs under controlled conditions. *T. granarium* active (3^{rd} and 4^{th} larval instar) and diapausing larvae were taken for the tests, the diapausing (quiescent) larvae were collected from roll of paper, which had been placed on the top of the culture media.

Batches of 30 active and diapausing larvae of *T. granarium* and 30adults of *S. oryzae* were used in all experiments.

Tested temperatures

All experiments were conducted under two temperatures 30 and 20 ±1°C and 65 ±5%.

Plant oils used

*Majorana hortensis, Carumcarvi and Matricari achamomilla*oils were bought form Guvadant Swaziland Company.

***Majoran ahortensis* (Marjoram)**

The major components in the oils are ar-curcumene (25%), β-caryophyllene (13%) and caryophyllene epoxide (7%).

***Carum carvi* (Caraway)**

The major components of caraway oil are carfoon and liemonin.

***Matricar a chamomilla* (Worm wood)**

The major component of worm wood oil is camazolen.

Bioassay test

Twenty milliliters each oil were diluted with 50 ml acetone to obtain 40% (v/v) stock concentration which diluted to obtain 40, 35, 30, 25, 20, 15, 10, 5, 2.5 and 1.25% (v/v) concentrations. From each concentration, 1 ml was taken and added to 10g wheat grains to obtain 4, 3.5, 3, 2.5, 2, 1.5, 1, 0.5, 0.25 and 0.125% (v/w) concentrations (4, 3.5, 3, 2.5and 2% in case of diapausing larvae of *T. granarium*, 3.5, 3, 2.5 and 2% in case of active larvae of *T. granarium*and 1.5, 1, 0.5, 0.25 and 0.125% in case of adults of *S. oryzae*). Thirty insects were added to each treatment and incubated at 30 and20±1°C. Three replicates were used for each treatment. For control only acetone was used for food treatment. Insect mortality was calculated after 1, 2, 3, 5, 7, 14and 21 days from initial treatment to calculate the lethal concentration and the lethal time of the oils.

Data analysis

Data were analysed using probit analysis models **(Finney, 1971)** using a computer program of **Noack and Reichmuth (1978)**.

Results and Discussion

Effect of the tested plant oils against the adult mortality of *Sitophilu soryzae* and the larvae of Khapera beetle *Trogoderma granarium* at 30 and 20 ±1°C and 65±5% R.H.

1.1. *S. oryzae* adults

1.1.1. Marjoram oil

The data of the effect of marjoram oil on the adult mortality of *S. oryzae* at 30 and 20±1°C were presented in **Fig (1-5).** The results revealed that the mortality increased by increasing the plant oil concentration, period of exposure and temperature. At marjoram oil concentration of 1.5% (v/w) the adult mortality of *S. oryzae*, after 1 day exposure period was 60.1 and 50.1 at 30 and 20°C, respectively. While, the mortality increased after 21 days post treatment to 100 and 80.1% at 30 and 20°C, respectively. At concentration 1% (v/w) the mortality was 53.3 and 45.5% after 1 day exposure period and increased after 21 days post treatment to 100 and 75.5% at 30 and 20°C, respectively. At concentration 0.5% (v/w) the mortality was 41.1 and 40.1% after 1 day exposure and increased after 21 days exposure period to 85.5 and 65.1% post treatment at 30 and 20°C, respectively. At concentration 0.25% (v/w) the mortality was 36.6 and 33.3% after 1 day exposure time and increased after 21 days post treatment to 82.2 and 61.1% at 30 and 20°C, respectively. At concentration 0.125% (v/w) the mortality was 28.8 and 20.1% after 1 day exposure and increased after 21days of the treatment to 67.7 and 58.5% at 30 and 20°C, respectively.

1.1.2. Caraway oil

The results of the effect of caraway oil on the adult mortality of *S. oryzae* at 30 and 20±1°C were presented in **Fig (1-5).** The data showed that the mortality increased by increasing the plant oil concentration, period of exposure and temperature. At caraway oil concentration of 1.5% (v/w) the adult mortality of *S. oryzae*, after 1 day exposure period was 63.3 and 55.5 at 30 and 20°C, respectively. While, the mortality increased after 21 days post treatment to 100 and 85.5 % at 30 and 20°C, respectively. At concentration 1% (v/w) the mortality was 60.1and 50.1% after 1 day exposure period and increased after 21 days post treatment to 100 and 85.5% at 30 and 20°C, respectively. At concentration 0.5% (v/w) the mortality was 45.5 and 42.2% after 1 day exposure and increased after 21 days exposure

period to 90.1 and 75.5% post treatment at 30 and 20°C, respectively. At concentration 0.25% (v/w) the mortality was 50.1 and 40.1% after 1 day exposure time and increased after 21 days post treatment to 85.5 and 70.1% at 30 and 20°C, respectively. At concentration 0.125% (v/w) the mortality was 41.1 and 33.3% after 1 day exposure and increased after 21days of the treatment to 75.5 and 68.1 % at 30 and 20°C, respectively.

1.1.3. Worm wood oil

The data of the effect of worm wood oil on the adult mortality of *S. oryzae* at 30 and 20±1°C were presented in **Fig (1-5).** The results indicated that the mortality increased by increasing the plant oil concentration, period of exposure and temperature. At worm wood oil concentration of 1.5% (v/w) the adult mortality of *S. oryzae*, after 1 day exposure period was 65.5 and 60.1 at 30 and 20°C, respectively. While, the mortality increased after 21 days post treatment to 100 and 90.1% at 30 and 20°C, respectively. At concentration 1% (v/w) the mortality was 63.3 and 55.5% after 1 day exposure period and increased after 21 days post treatment to 100 and 85.5% at 30 and 20°C, respectively. At concentration 0.5% (v/w) the mortality was 64.6 and 43.3% after 1 day exposure and increased after 21 days exposure period to 91.1 and 77.1 % post treatment at 30 and 20°C, respectively. At concentration 0.25% (v/w) the mortality was 52.2 and 45.5% after 1 day exposure time and increased after 21 days post treatment to 90.1 and 75.5 % at 30 and 20°C, respectively. At concentration 0.125% (v/w) the mortality was 42.2 and 35.5% after 1 day exposure and increased after 21days of the treatment to 80.1 and 72.2% at 30 and 20°C, respectively.

1.2. *T. granarium* active larvae

1.2.1. Marjoram oil

The results of the effect of marjoram oil on the larvae mortality of active larvae of *T. granarium* at 30 and 20±1°C were presented in **Fig (6-9).** The data showed that the mortality increased by increasing the plant oil concentration, period of exposure and temperature. At marjoram oil concentration of 3.5% (v/w) the active larvae mortality of *T. granarium*, after 1 day exposure period was 15.7 and 7.7 at 30 and 20°C, respectively. Whereas, the mortality increased after 21 days post treatment to 92.2 and 70.1% at 30 and 20°C, respectively. At concentration 3% (v/w) the mortality was 13.3 and 5.7 % after 1 day exposure period and increased after 21 days post treatment to 91.1 and 65.5% at 30 and 20°C, respectively. At concentration 2.5% (v/w) the mortality was 6.5 and 2.3% after 1 day exposure and increased after 21 days exposure period to 85.5 and 54.3% post treatment at 30 and 20°C, respectively. At concentration 2 % (v/w) the mortality was 4.3 and 1.2 % after 1 day exposure time and increased after 21 days post treatment to 80.1 and 20 % at 30 and 20°C, respectively. At concentration 1.5% (v/w) the mortality was 4.1 and 1.1% after 1 day exposure and increased after 21days of the treatment to 70.1 and 18.2% at 30 and 20°C, respectively.

1.2.2. Caraway oil

The data of the effect of caraway oil on the larvae mortality of active larvae of *T. granarium* at 30 and 20±1°C were presented in **Fig (6-9).** The results indicated that the mortality increased by increasing the plant oil concentration, period of exposure and temperature. At caraway oil concentration of 3.5% (v/w) the active larvae mortality of *T. granarium*, after 1 day exposure period was 17.1 and 7.8 at 30 and 20°C, respectively. While, the mortality increased after 21 days post treatment to 95.5 and 77.7% at 30 and 20°C, respectively. At concentration 3% (v/w) the mortality was 13.5 and 6.6 % after 1 day exposure period and increased after 21 days post treatment to 93.3 and 66.6 % at 30 and 20°C, respectively. At concentration 2.5% (v/w) the mortality was 10.1 and 5.5% after 1 day exposure and increased after 21 days exposure period to 86.5 and 60.1% post treatment at 30 and 20°C, respectively. At concentration 2 % (v/w) the mortality was 6.1 and 4.1 % after 1 day exposure time and increased after 21 days post treatment to 82.2 and 33.3% at 30 and 20°C, respectively. At concentration 1.5% (v/w) the mortality was 5.5 and 3.5% after 1 day exposure and increased after 21days of the treatment to 75.5 and 30.1% at 30 and 20°C, respectively.

1.2.3. Worm wood oil

The results of the effect of worm wood oil on the larvae mortality of active larvae of *T. granarium* at 30 and 20±1°C were presented in **Fig (6-9).** The data showed that the mortality increased by increasing the plant oil concentration, period of exposure and temperature. At worm wood oil concentration of 3.5% (v/w) the active larvae mortality of *T. granarium*, after 1 day exposure period was 18.2 and 8.1 at 30 and 20°C, respectively. While, the mortality increased after 21 days post treatment to 96.6 and 78.8% at 30 and 20°C, respectively. At concentration 3% (v/w) the mortality was 14.5 and 7.2% after 1 day exposure period and increased after 21 days post treatment to 94.1 and 68.2% at 30 and 20°C, respectively. At concentration 2.5% (v/w) the mortality was 11.1 and 6.3% after 1 day exposure and increased after 21 days exposure period to 90.1 and 62.2% post treatment at 30 and 20°C, respectively. At concentration 2 % (v/w) the mortality was 7.1 and 5.5 % after 1 day exposure time and increased after 21 days post treatment to 85.5 and 45.5% at 30 and 20°C, respectively. At concentration 1.5% (v/w) the mortality was 6.5 and 5.1% after 1 day exposure and increased after 21days of the treatment to 80.1 and 40.1 % at 30 and 20°C, respectively.

1.3. *T. granarium* diapausing larvae

1.3.1. Marjoram oil

The data of the effect of marjoram oil on the larvae mortality of diapausing larvae of *T. granarium* at 30 and 20±1°C were presented in **Fig (10-14).** The results revealed that the mortality increased by increasing the plant oil concentration, period of exposure and temperature. At marjoram oil concentration of 4% (v/w) the diapausing larvae mortality of *T. granarium*, after 1 day exposure period was 11.1 and 6.1 at 30 and 20°C, respectively. While, the mortality increased after 21 days post treatment to 72.2 and 69.6% at 30 and 20°C, respectively. At concentration 3.5% (v/w) the mortality was 10.1 and 5.7% after 1 day exposure period and increased after 21 days post treatment to 70.1 and 66.6% at 30 and 20°C, respectively. At concentration 3% (v/w) the mortality was 6.6 and 4.1% after 1 day exposure and increased after 21 days exposure period to 65.5 and 55.5% post treatment at 30 and 20°C, respectively. At concentration 2.5 % (v/w) the mortality was 5.1 and 3.2 % after 1 day exposure time and increased after 21 days post treatment to 50.1 and 45.5% at 30 and 20°C, respectively. At concentration 2 % (v/w) the mortality was 4.2 and 2.1% after 1 day exposure and increased after 21 days of the treatment to 45.5 and 18.1% at 30 and 20°C, respectively.

1.3.2. Caraway oil

The results of the effect of caraway oil on the larvae mortality of diapausing larvae of *T. granarium* at 30 and 20±1°C were presented in **Fig (10-14).** Data showed that the mortality increased by increasing the plant oil concentration, period of exposure and temperature. At caraway oil concentration of 4% (v/w) the diapausing larvae mortality of *T. granarium*, after 1 day exposure period was 11.5 and 6.5 at 30 and 20°C, respectively. While, the mortality increased after 21 days post treatment to 86.6 and 70.1% at 30 and 20°C, respectively. At concentration 3.5% (v/w) the mortality was 11.1 and 6.1% after 1 day exposure period and increased after 21 days post treatment to 77.7 and 61.1% at 30 and 20°C, respectively. At concentration 3 % (v/w) the mortality was 10.5 and 5.5% after 1 day exposure and increased after 21 days exposure period to 72.2 and 45.5% post treatment at 30 and 20°C, respectively. At concentration 2.5 % (v/w) the mortality was 7.5 and 4.5% after 1 day exposure time and increased after 21 days post treatment to 62.2 and 40.1% at 30 and 20°C, respectively. At concentration 2% (v/w) the mortality was 6.1 and4.1% after 1 day exposure and increased after 21days of the treatment to 55.1and 33.3% at 30 and 20°C, respectively.

1.3.3. Worm wood oil

The data of the effect of worm wood oil on the larvae mortality of diapausing larvae of *T. granarium* at 30 and 20±1°C were presented in **Fig (10-14).** The results showed that the mortality increased by increasing the plant oil concentration, period of exposure and temperature. At worm wood oil concentration of 4% (v/w) the diapausing larvae mortality of *T. granarium*, after 1 day exposure period was 14.1 and 7.1 at 30 and 20°C, respectively. While after 21 days post treatment, the mortality increased to 90.1and 75.5% at 30 and 20°C, respectively. At concentration 3.5% (v/w) the mortality was 11.5 and 6.5% after 1 day exposure period and increased after 21 days post treatment to 85.5 and 65.5% at 30 and 20°C, respectively. At concentration 3% (v/w) the mortality was 11.1 and 6.1% after 1 day exposure and increased after 21 days exposure period to 80.1 and 60.1% post treatment at 30 and 20°C, respectively. At concentration 2.5% (v/w) the mortality was 10.5 and 5.5% after 1 day exposure time and increased after 21 days post treatment to 75.5 and 50.1% at 30 and 20°C, respectively. At concentration 2% (v/w) the mortality was 8.2 and 5.1% after 1 day exposure and increased after 21days of the treatment to 70.1 and 35.5% at 30 and 20°C, respectively.

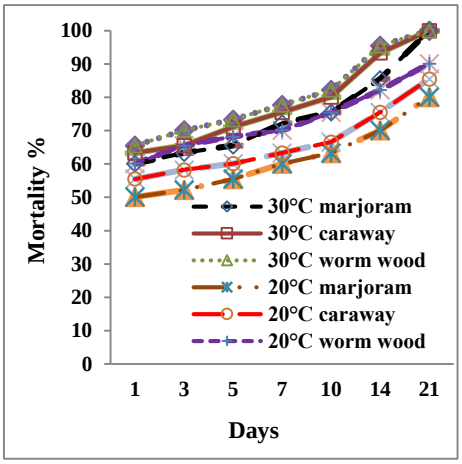

Fig. (1) Efficacy of tested plant oils (1.5%) against *S. oryzae* adults at 30 and 20°C

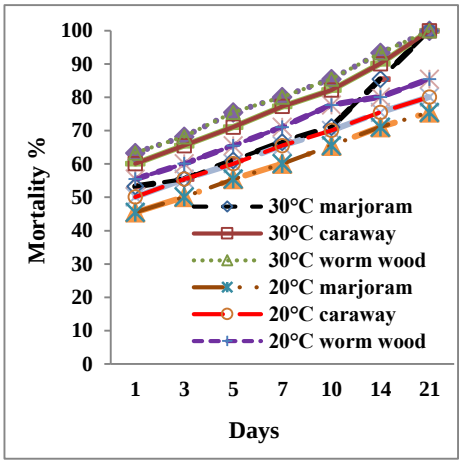

Fig. (2) Efficacy of tested plant oils (1%) against *S. oryzae* adults at 30 and 20°C

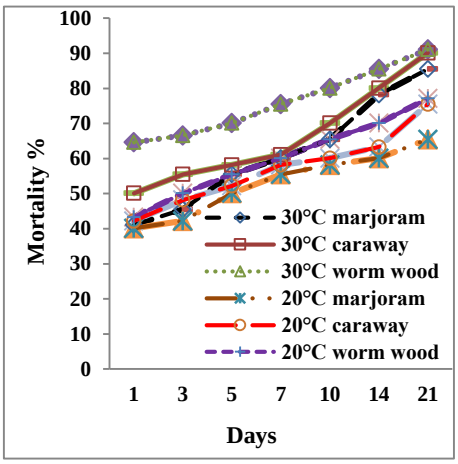

Fig. (3) Efficacy of tested plant oils (0.5%) against *S. oryzae* adults at 30 and 20°C

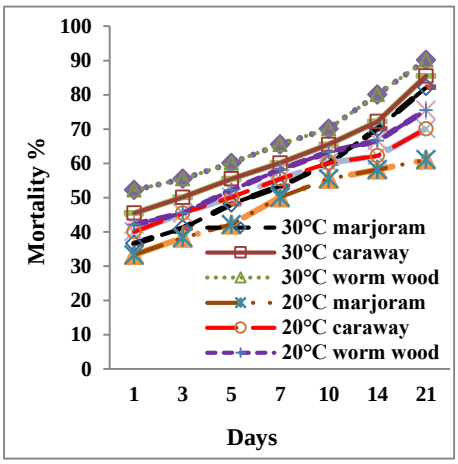

Fig. (4) Efficacy of tested plant oils (0.25%) against *S. oryzae* adults at 30 and 20°C

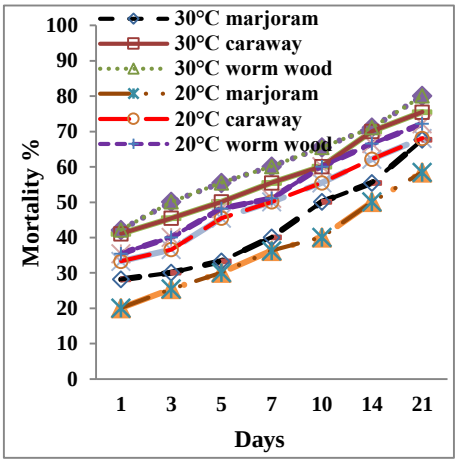

Fig. (5) Efficacy of tested plant oils (0.125%) against *S. oryzae* adults at 30 and 20°C

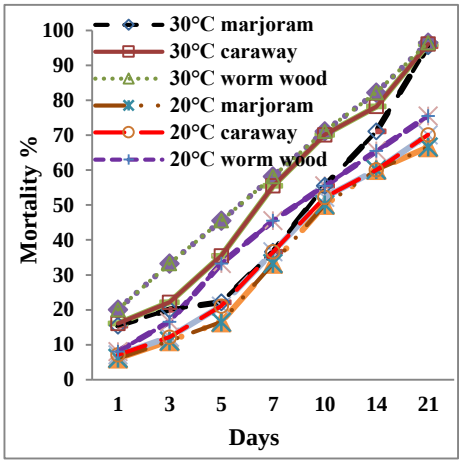

Fig. (6) Efficacy of tested plant oils (3.5%) against active larvae of *T. granarium* at 30 and 20°C

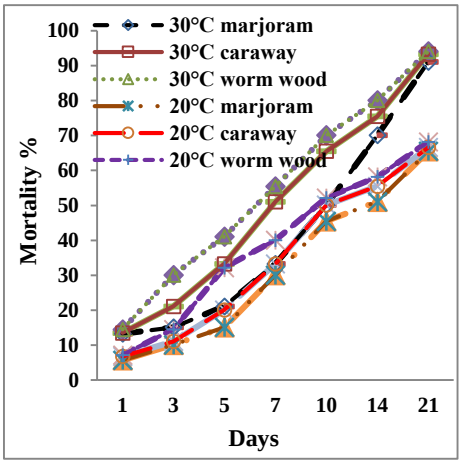

Fig. (7) Efficacy of tested plant oils (3%) against active larvae of *T. granarium* at 30 and 20°C

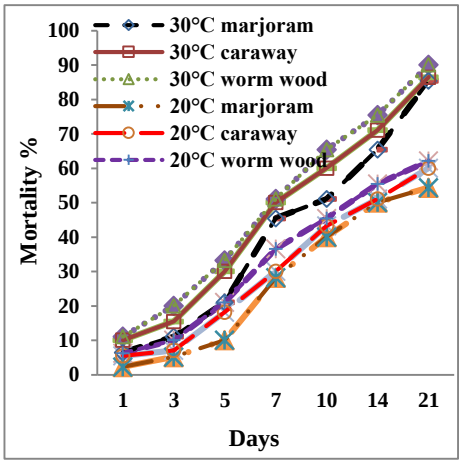

Fig. (8) Efficacy of tested plant oils (2.5%) against active larvae of *T. granarium* at 30 and 20°C

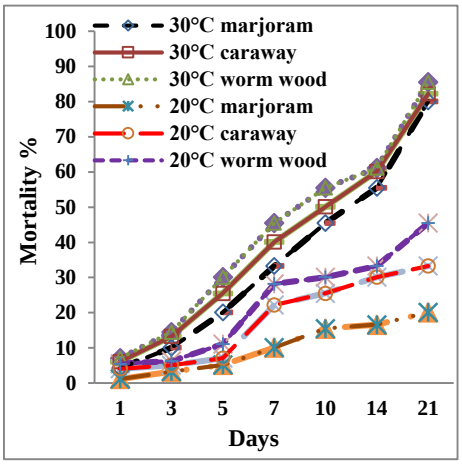

Fig. (9) Efficacy of tested plant oils (2%) against active larvae of *T. granarium* at 30 and 20°C

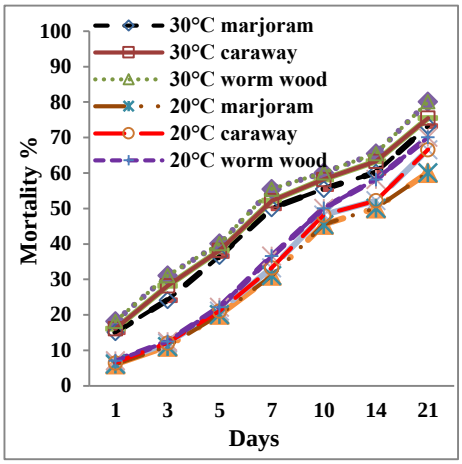

Fig. (10) Efficacy of tested plant oils (4%) against diapausing larvae of *T. granarium* at 30 and 20°C

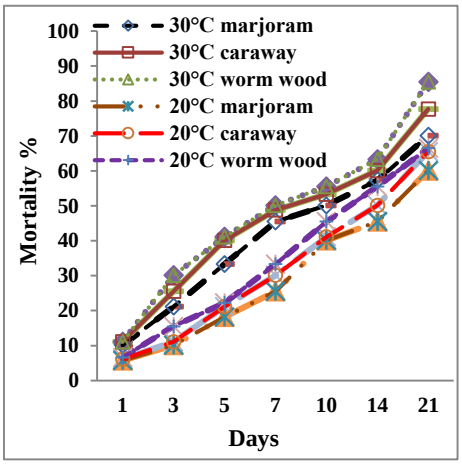

Fig. (11) Efficacy of tested plant oils (3.5%) against diapausing larvae of *T. granarium* at 30 and 20°C

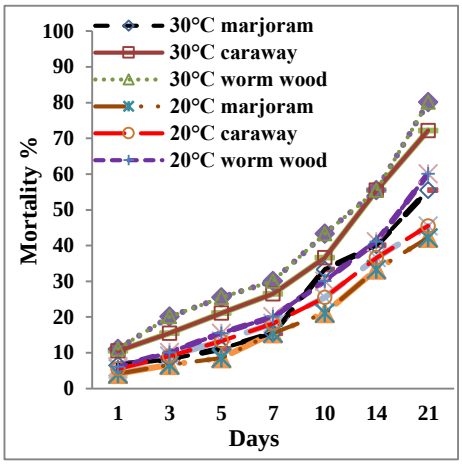

Fig. (12) Efficacy of tested plant oils (3%) against diapausing larvae of *T. granarium* at 30 and 20°C

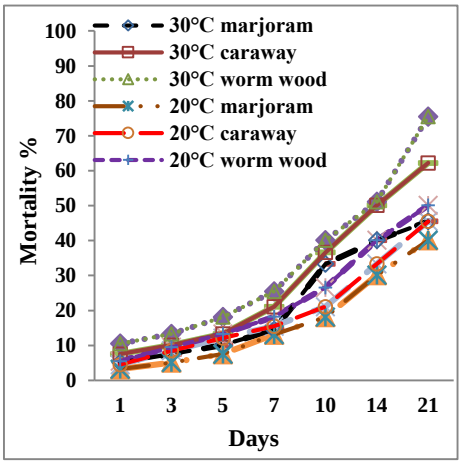

Fig. (13) Efficacy of tested plant oils (2.5%) against diapausing larvae of *T. granarium* at 30 and 20°C

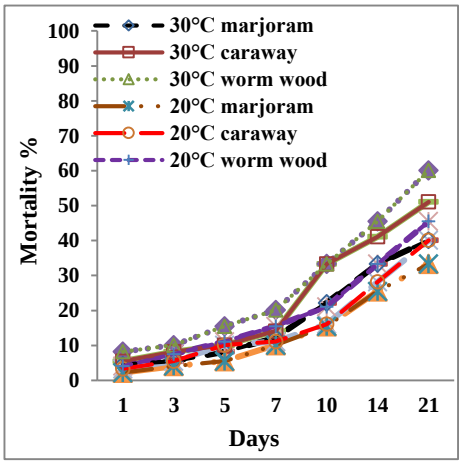

Fig. (14) Efficacy of tested plant oils (2%) against diapausing larvae of *T. granarium* at 30 and 20°C

2. Toxicity parameters of the studied plant oils against the adults of *Sitophilu s oryzae* and the larvae of Khapera beetle *Trogoderma granarium* at two tested temperatures and 65±5% R.H.

2.1. Marjoram oil

Table (1) showed that the lethal concentrations (LC_{50s}) of marjoram oil were 0.26, 1.92 and 2.27% at 30°C for *S. oryzae* adults (after 3 days exposure period) and active and diapausing larvae of *T. granarium* (after 14 days exposure period), respectively. While at 20°C, these values were 0.33, 3.2 and 3.02% for *S. oryzae* adults and active and diapausing larvae of *T. granarium*, respectively.

2.2. Caraway oil

Table (2) revealed that the lethal concentrations (LC_{50s}) of marjoram oil were 0.25, 1.8 and 2.1 % at 30°C for *S. oryzae* adults (after 3 days exposure period) and active and diapausing larvae of *T. granarium* (after 14 days exposure period), whereas at 20°C, they were 0.26, 2.8 and 2.9% for *S. oryzae* adults and active and diapausing larvae of *T. granarium*, respectively.

Table 1. Lethal concentration values and parameters of mortality regression line of marjoram oil on *T. granarium* larvae and *S. oryzae* adults at two tested temperatures and 65±5% R.H.

Temperature (ºC)	Insect Species	Stage	Lethal concentrations (v/w %)of marjoram[5] oil and Their 95% Confidence Limits		Slope ±SD[1]	R[4]
			LC_{50}	LC_{90}		
20	*T.granarium*	AL[2]	3.22 (2.96-3.70)	7.08 (5.40-12.96)	3.7±0.73	0.99
		DL[3]	3.02 (2.60-3.40)	9.35 (6.90-20.90)	2.6±0.54	0.97
	S.oryzae	Adult	0.33 (0.19-0.48)	1.20 (0.90-1.70)	1.9±0.18	0.91
30	*T.granarium*	AL[2]	1.92 (1.64-2.10)	3.87 (3.50-4.50)	4.5±0.75	0.95
		DL[3]	2.27 (1.20-4.50)	4.50 (2.10-6.30)	4.2±0.61	0.98
	S.oryzae	Adult	0.26 (0.22-0.31)	1.50 (1.10-3.80)	1.9±0.17	0.90

1: Standard deviation 2: Active larva 3: Diapausing larva4: Correlation coefficient of regression line5: Mortality was recorded after 14 days of treatment for active and diapausing larvae of *T. granarium* and 3 days for *S. oryzae* adults

Table 2. Lethal concentrations values and parameters of mortality regression line of caraway oil on *T. granarium* larvae and *S. oryzae* adults at two tested temperatures and 65±5% R.H.

Temperature (ºC)	Insect Species	Stage	Lethal concentrations(v/w%)of caraway[5]oil and Their 95% Confidence Limits		Slope ±SD[1]	R[4]
			LC_{50}	LC_{90}		
20	*T.granarium*	AL[2]	2.85 (2.55-3.31)	8.50 (5.70-28.60)	2.0±0.70	0.99
		DL[3]	2.92 (2.70-3.19)	7.50 (5.80-12.20)	3.2±0.55	0.99
	S.oryzae	Adult	0.26 (0.20-0.30)	1.40 (1.06-2.06)	1.7±.0.17	0.90
30	*T.granarium*	AL[2]	1.80 (1.50-2.40)	3.48 (3.15-4.17)	1.9±0.18	0.95
		DL[3]	2.10 (1.80-2.20)	5.12 (4.25-7.80)	2.8±0.70	0.96
	S.oryzae	Adult	0.25 (0.22-0.31)	1.2 (0.90-1.70)	1.9±0.18	0.91

1: Standard deviation 2: Active larva 3: Diapausing larva
4: Correlation coefficient of regression line 5: Mortality was recorded after 14 days of treatment for active and diapausing larvae of *T. granarium* and 3 days for *S. oryzae* adults

2.3. Worm wood oil

Table (3) exhibited that the lethal concentrations (LC_{50s}) of marjoram oil were 0.21, 1.5 and 2.1 % at 30°C for *S. oryzae* adults (after 3 days exposure period) and active and diapausing larvae of *T. granarium* (after 14 days exposure period), respectively. At 20°C, LC_{50s} were 0.23, 2.4 and 2.9 % for *S. oryzae* adults and active and diapausing larvae of *T. granarium*, respectively.

The present results are in accordance with the results of several authors, who concluded that mortality of tested insects increased with increase in concentration at maximum exposure period **(El-lakwah *et al.*, 2002; Boff*et al.*, 2006;Azab, 2015).**The data indicated clearly that *S. oryzae* adults were the most sensitive to the three tested oils, whereas the diapausing larvae of *T. granarium* were the least sensitive to the plant oils under study. These findings agree with the results with other investigations **(Padin, 2000; Wawrzyniak and Blazejewska 2002; Sahaf*et al*., 2008)**

Table 3. Lethal concentrations values and parameters of mortality regression line of **worm wood** oil on *T.granarium* larvae and *S. oryzae* adults at two tested temperatures and 65±5% R.H.

Temperature (ºC)	Insect Species	Stage	Lethal concentrations(v/w %)of wormwood[5] oil and Their 95% Confidence Limits		Slope ±SD[1]	R[4]
			LC_{50}	LC_{90}		
20	*T.granarium*	AL[2]	2.41 (1.85-2.60)	9.40 (5.04-22.15)	2.6± 0.70	0.97
		DL[3]	2.90 (2.7-3.07)	5.30 (4.70-6.40)	4.9±0.57	0.96
	S. oryzae	Adult	0.21 (0.16-.25)	1.13 (0.89-1.50)	1.8±0.18	0.97
30	*T. granarium*	AL[2]	2.18 (1.9-2.40)	5.12 (4.30-6.83)	2.6±0.70	0.97
		DL[3]	2.31 (1.8-2.6)	7.19 (0.04-221)	3.5±0.65	0.97
	S. oryzae	Adult	0.23 (0.09-0.30)	1.10 (0.90-5.00)	1.9±0.17	0.87

1: Standard deviation 2: Active larva 3: Diapausing larva
4: Correlation coefficient of regression line 5: Mortality was recorded after 14 days of treatment for active and diapausing larvae of *T. granarium* and 3 days for *S. oryza e* adults

On the other hand, at 30ºC the three investigated oils had relatively equal toxicity to *S. oryzae* adults, while at 20ºCthe worm wood oil was the most toxic for all tested insects, however in case of active and diapausing larvae of *T. granarium*, caraway oil was the most toxic at 30ºC.Where, the toxicity of plant oils for stored-product insects was influenced by their chemical composition **(Lee *et al.*, 2001)**. Moreover, the diverse effects of the two tested temperatures were observed on oil toxicity and the insect species. On the contrary,**Fang and subramanyam (2003)** evaluated the activity of spinosad against *R. dominica*is not affected by wheat temperature. Also, some authors reported that plant oils possess similar type of activity against pests **(Maggi *et al.*,2005;Zamani *et al.*,2010)**. Plant oils are generally broad spectrum due to the presence of several active ingredients that may operate through various modes of action **(Chiasson*et al.*, 2004)**.

Conclusion

Therefore the findings of present study suggested that plant oils of marjoram, caraway and worm wood may be potentially used as eco- friendly pest controlagents against insect pests of stored products.

References

Azab, M. M. (2015): Combined activity of spinosyns A, D, J and L on two stored product insects. Egypt. Acad. J. Biolog. Sci., 7(1): 71-80.

Benhalima, H., Chaudhry, M.Q. Mills, K.A. and Price, N.R. (2004): Phosphine resistance in stored-product insects collected from various grain storage facilities in Morocco. J. Stored. Prod. Res. 40:241-249.

Boff, M.I.C.;Sartoarid, V.andBogo, A. (2006): Effect of extracts of *Piper nigrum*L. on the bean weevil, *Acanthosceli desobtectus*(Say). RevistaBrasileria de Armazenamento, 31: 17-22.

Bughio, F.M. and W ilkins, R.M. (2004): Influence of malathion resistance status on survival and

growth of *Tribolium castaneum* (Coleoptera: Tenebrionidae), when fed on flour from insect resistant and susceptible grain rice cultivars. J. Stored. Prod. Res.40:65-75.

Chiasson, H.;Vincent, C. and Bostanian N.J. (2004): Insecticidal properties of a Chenopodium-based botanical. J. Econ .Entomol., 97 (4): 1378–1383.

Darwish, A.A. (1992): Laboratory studies on toxicity and effect of some plant extracts as stored product protectants.Egypt. J. Appl. Sci., 7(12):138-147.

Dubey N.; Srivastava, B.and Kumar, A. (2008): Current status of plant products as botanical pesticides in storage pest management. J. Biopest; 1(2):182–186.

El-Lakwah, F.A.; Omnia M.Khaled and Darwish, A.A (1992): Toxic effect of pulverized black pepper (*Pippernigrum*L.) on some stored product insects. Annals Agric. Sc., Moshtohor, 30 (4): 2049-2057.

El –Lakwah,F.A; Omnia M.Khaled and Darwish,A.A.(1993): Toxic effect of fenugreek(*Trigonella foenumgroecnum* L.) and fennel (*Foentcumvulgare* L.) extract alone and in mixture with two organophosphorus insecticides against *Rhizopertha dominica* (F). Annals Agric. Sc., Moshtohor,31(1):605-615.

El-Lakwah, F.A.;Mohamed, R.A. and Omnia M.Khaled (1994): Toxic effect of chinaberry tree (*Meliaazedrach*)on *Rhizopertha dominica*(F). Annals Agric.Sc.,Moshtohor,32(4):2195-2204.

El-lakwah, F.A.; Omnia M. KhaledandHalawa, Z.A.(1996): Effect of modified atmosphere of more than 99% nitrogen or enriched with carbon dioxide on mortality of some stored product insects, seed germination, chlorophyll and carotene contents of certain crop seed lings. Annals of Agric. Sc.Moshtohor, 34(4): 1869 - 1877.

El-Lakwah, F.A.; Darwish, A.Aand Mohamed, R.A. (1997): Efficacy of a modified atmosphere of around 1% oxygen plus 99% nitrogen on some stored product insects. Annals Agric. Sc., Moshtohor, 35 (1): 549-557.

El-Lakwah, F.A.; El-Kashlan, I.H.; Abd El-Aziz, A.E.and Halawa, Z.A. (2002): Reliable potencies of some grain protectant and their combinations with carbon dioxide against the Rice weevil, *Sitophilusoryzae*(L.) Annals Agric. Sc., Moshtohor, 40(2):1295-1308.

Fang, L. and Subramanyam, B. (2003): Activity of spinosad against adults of *Rhyzoperth adominica*(F.) (Coleoptera: Bostrychidae) is not affected by wheat temperature and moisture. J. Kansas Entomol. Soc., 76: 529-532.

Finney, D.J. (1971): Probit analysis. 3rd.Eddn, Cambridge University press: Cambridge, U.K. 318 pp.

Halawa, Z.A. (1998); Evaluation of acetone and petroleum ether extracts of *Lantana camara* leaves and Delonixregia seeds aganists the cowpea beetle –*Callosobruchus maculates* (F)Annals Agric.Sc. Moshtohor,36(4):2651-2669.

Hansen, L.S.and Jensen, K.M.V. (2002): Effect of temperature on parasitism and host-feeding of *Trichogramma turkestanica* (Hymenoptera: Trichogrammatidae) on *Ephestiakuehniella* (Lepidoptera: Pyralidae). J Econ.Entomol.,95:50-56.

Hassan, R.S.;Mikhaiel, A.A.andSileem,Th.M. (2013): Integration of Gamma Irradiation and Some Botanical oils to Protect Cowpea and Chickpea Seeds from Infestation with the Bruchid Beetle, *Callosobruchus maculatus*J Stored Prod Res, 50:357-364.

Hernandez, R. L.; Pajaro, N. C.; Caballero, K. G.; Elena Stashenko and Olivero, J. V. (2015): Essential oils from plants of the genus Cymbopogon as natural insecticides to control stored product pests. J. Stored. Prod. Res., 62:81-83.

Jacobson, M. (1982): Plants, insects, and man-their interrelationships. Econ. Bot., 36(3):346– 354.

Jaipal,S.; Singh, Z. and Malik, O.P. (1984): Insecticidal activity of various neem leaf extracts on *Rhizopertha dominica* as stored grain. Neem. New SI., 1:35-36.

Javier, P.A.; Morallo – Rejesus and Rejesus, B.(1986): Insecticidal activity of black pepper (*Piper nigerum* L.) extracts. Philippine- Entomologist 6(5): 517-525.

Lee, S.E.; Lee,B.H.; Choi, W.S.;Park,B.S.; Kim,J.G. and Campbell,B.C. (2001): Fumigant toxicity of volatile natural products from Korean spices and medicinal plants towards the rice weevil, *Sitophilusoryzae*(L). Pest Manag. Sci., 57:548-553.

Maggi, M.E. ;Mangeand, A.;Carpinella, M.C., Ferrayoli, G.C.;Valladars, G.R.and Palacios, S.M. (2005): Laboratory evaluation of *Artemisia annua*L. Extract and artemisinin activity against *Epilachnapae mula*and *Spodoptera eridania*,J. Chem. Ecol., 31:1527-1536.

Noack, S. and Reichmuth, C.H. (1978): Einrechnerisches Verfahrenzur Bestimmung von beliebigenDosiswerteneinesWirkstoffesausempirischen Dosis-Wirkungs-Daten. Mitt.Biol. BundesanstaltfuerL and u. Forts-Wirtschaft, Berlin-Dahlem, Heft, 185: 1-49.

Padin, S.; Ringuelet, J. A.; Bello, D.; Cerimele, E. L.; Re, M. S.and Henning, C. P.(2000): Toxicology and repellent activity of essential oils on *Sitophilus oryzae* L. and *Tribolium castaneum* Herbst,J. Herbs Spices Med. Plants, 7(4):67-73.

Sahaf, B. Z.; Moharramipour, S. and Meshkatalsadat, M.H. (2008): Fumigant toxicity of essential oil from *Vitex pseudo-negundo* against *Tribolium castaneum* (Herbst) and *Sitophilusoryzae* (L.), J. Asia Pac. Entomol., 11: 175–179.

Sighamony, S., Anees, I., Chandrakala, T.andOsmani, Z. (1986): Efficacy of certain indigenous plant products as grain protectants against *Sitophilus oryzae* (L.) and *Rhizopertha dominica* (F.). J. Stored. Prod. Res. 22: 21 - 23.

Su, H.C.F.(1985): Laboratory evaluation of dill seed extract in reducing infestation of rice weevil in stored wheat. J. Ent.Sci., 24: 317-320.

Su, H.C.F. (1989): Laboratory study on effects of *Anethum graveolens* seeds on four species of stored product insects. J. Econ. Entomol. 78 (2): 451-453.

Wawrzyniak, M. and Blazejewska, A. (2002): Estimation of influence of essential oil of *Foeniculumca pillaceum*Gilib and *Coriandrum sativum* L. on the fecundity of *Sitophilusoryzae* L. [Polish]. Progress in Plant Protection. 42(2):644-646.

Yadav, T.D. (1984): Efficacy of neemAzadirachta indigo A.Juss- Kernel powder as seedtreatment against pulse beetles. Neem News 1, 1: 13-15.

Zamani S., Sendi J.J.and Ghadamyari M. (2010): Effect of *Artemisia annua*L. (Asterales: Asteraceae) essential oil onmortality, Development, Reproduction and Energyreserves of *PlodiaInter punctella* (Hubner). (Lepidoptera:Pyrallidae). J. BiofertilBiopestic, 2:105.

فاعلية بعض الزيوت النباتية ضد اثنين من حشرات المواد المخزونة

محمد محمد عزب[1] ، أحمد عبد الغفار درويش[1] ، رفعت عبد الشافى محمد[2] ، هبه حمدان محمد[2]

1 قسم وقاية النبات – كلية الزراعة – جامعة بنها

2 معهد بحوث وقاية النباتات – مركز البحوث الزراعية – الدقى– الجيزة

أجرى هذا البحث لدراسة التأثير الإبادى للزيوت النباتية للبردقوش والكراوية والشيح على الحشرة الكاملة لسوسة الأرز واليرقات النشطة والساكنة لخنفساء الصعيد بإستخدام أربع إلى خمس تركيزات للزيوت النباتية و تمت الإختبارات لمدة 21 يوم تحت درجتى حرارة هى 20 و30 ±1 درجة مئوية.وقد أشارت النتائج إلى زيادة نسبة الموت للحشرات بزيادة تركيز الزيت المستخدم أو بزيادة مدة التعرض للزيت أو بزيادة درجة الحرارة حيث أمكن الحصول على نسبة موت 100% للحشرات الكاملة لسوسة الأرز بإستخدام تركيزى 1.5 أو 1% من أى من الزيوت المستخدمة بعد 21 يوم من التعرض للزيت على درجة حرارة 30 درجة مئوية. كما أظهرت النتائج كذلك أن زيت الشيح هو الأكثر سمية لجميع الحشرات تحت الدراسة على درجة الحرارة 20 درجة مئوية حيث كان التركيز القاتل النصفى من الحشرات هى 2.41و2.90 و0.21 فى حالةاليرقات النشطة والساكنة لخنفساء الصعيد (بعد 14يوم من المعاملة) والحشرة الكاملة لسوسة الأرز (بعد3 أيام من المعاملة) على التوالى. بينما كان زيت الكراوية هو الأكثر سمية على درجة الحرارة 30درجة مئوية ضداليرقات النشطة والساكنة لخنفساء الصعيد. كما وجد أن الحشرات الكاملة لسوسة الأرز هى الأكثر حساسية لكل الزيوت المختبرة مقارنةباليرقات النشطة والساكنة لخنفساء الصعيد. ويستنتج من ذلك أن كلاً من زيت البردقوش والكراوية والشيح لها تأثير سام ضد كل من حشرتى سوسة الأرزو خنفساء الصعيد.