

The insecticidal activity of some plant-seeds extracts against two coleopteran pest Granary Weevils *Sitophilus Granarius* (Linnaeus.) and the Lesser Grain Borer *Rhyzopertha Dominica* (Fabricius).

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Abstract

Acetone and petroleum ether seed extracts of fennel [*Foeniculum vulgare*, *Apiaceae*] and arugula seeds [*Eruca vesicaria*, *Brassicaceae*] were tested for their contact and stomach poison activity on adults the granary weevil *Sitophilus granarius* Linnaeus. (Coleoptera: *Curculionidae*) and lesser grain borer *Rhyzopertha dominica* Fabricius. (Coleoptera: *Bostrochidae*). The results revealed that, percentage of mortality increased with increasing the concentration of different extracts and exposure time. Extracts of arugula seeds of petroleum ether and acetone gave higher mortality percent compared with the extracts from fennel seeds. Petroleum ether and acetone extract of arugula seeds was founded to be the higher effect on the two species insect than the fennel seeds extracts. The LC₅₀ of arugula seed extracts of petroleum ether and acetone ranged from 0.722, 0.620, 0.622 and 0.475 ml/ kg after 5 days treatment against *R. dominica* and *S. granarius*, respectively. On the other hand, these values of fennel seeds extract ranged from 1.331, 0.798, 1.093 and 0.662 for *R. dominica* and *S. granarius*, Respectively. While the higher concentration 1.5 and 2 % (W/V) give complete mortality at two extracts against two insects. The petroleum ether of fennel seeds extract with *R. dominica* give 73.3 and 83.3 % after 14 days treatment. The inhibition rates in the reduction of the first generation (F1-progeny) of *R. dominica* and *S. granarius* adults in grains treated with various extracts were higher than mortality at all concentrations to all extract.

Keywords: *Sitophilus granarius*, *Rhyzopertha dominica*, plant -seeds extracts.

Introduction

The stored grain pests are a great economic importance due to their numerous species infesting diversity of stored products as well as their much more prevailing over the world countries. The losses in the stored grains is one of the main reasons in increasing the global food crisis, very large quantities losses in the stored grains happened all over in the world. The stored insect pests cause postharvest losses

about 9% in developed countries to 20% or more in developing countries. (Zapata and Smagghe 2010). So, an urgent need to research and development to minimize the losses in the stored grains.

In this study there are two major insects from the stored insect pests as the most important insects infesting wheat, the granary weevil *Sitophilus granarius* Linnaeus. and lesser grain and lesser grain borer *Rhyzopertha dominica* Fabricius. these insects causing the major losses in wheat stored grains by laying eggs inside, in, or out the wheat kernels and start growing by

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feeding upon the grain mass until their adults emerge out.

Several losses had been reported due to the infestation of these insects in weight of grains and the grain contaminating with the insects metabolic waste, causing significant public health risk from the contamination by allergens, such as uric acid (Swaminathan, 1977; Jood and Kapoor, 1993). Insect infestations also lead the grains to become low economic value and the off odors can render the product not valid for the human consumption.

In stored products pest management the control methods was using fumigation and low toxicity insecticide but these chemical control methods caused many problems like the resistant strains insects in addition to environmental contamination and health hazards (Rahman *et al.*, 2009).

The present study aimed to study the efficiency of the two plant-seed extracts, Fennel (*Foeniculum vulgare*) and Arugula (*Eruca vesicaria*) acetone and petroleum ether, against the tested Coleopteran insects.

Materials and Methods

Insect species:

Two species of stored product insects namely granary weevil *Sitophilus granarius* (Linnaeus.) (Coleoptera: Curculionidae) and the lesser grain borer *Rhyzopertha dominica* (Fabricius.) (Coleoptera: Bostrichidae) were used in this study. Experiments were performed at the stored product pests' laboratory of the plant protection department faculty of the Agriculture, Qena, South Valley University .

Insects cultures

Adults insects of *S. granarius* and *R. dominica* were reared in plastic jars, each jar containing 500 g of sterilized wheat grains which treated by freezing at -14°C for 2 weeks before application, to eliminate any possible

infestation by any insect species. 400 adults were introduced into the plastic jars for laying eggs and covered with muslin cloth and fixed with rubber bands. For a week, then kept it under controlled conditions at the rearing laboratory room.

Plant extracts

The plants were bought from herb-shop, the petroleum ether and acetone extracts of Fennel seeds (*Foeniculum vulgare*) (Family: *Apiaceae*) and Arugula seeds (*Eruca vesicaria*) (Family: *Brassicaceae*) were used at 0.5, 1, 1.5, 2% (W/V) concentrations.

Bioassay tests

300g of each plant were grounded in an electric mill into fine powder. According to polarity solvent (acetone) and non polarity solvent (petroleum ether), two solvents were chosen to use to extract the effective materials from the plants. The ground plant material was soaked in the solvents in a large flask for three days. The flask was shaken for one hour in a shaker and its content was blitzed. The solvent was evaporated at 50°C under pressure using a rotary evaporator as described by (Su: 1985).

The extract in the form of crude gum was weighted and dissolved by the same solvent to get 10% (w/v) stock solution in the solvent. Concentrations of 0.5, 1, 1.5 and 2% (w/v) were prepared for all plant extracts by diluting stock solution in the solvent.

Technique

The 200 ml volume jars which contained 20 gm of the treated media were left for 24 h for the insecticides to evaporate the solvent. Then 20 adults insects were introduced into each jar of treatment and control. Three replicates were used for each concentration and three for the solvent only with the grains as control replicates. Jars were covered with muslin cloth and fixed with rubber band and kept in the

laboratory condition. Mortalities were recorded at 1, 3, 5, 7 and 14 days after treatment.

The mortality corrected was calculated using Abbott's formula (1925). After 14 days adults in all insects were removed from all replicates for studying the F₁-progeny. Number of F₁-progeny was inspected after 45 days from treatment and reduction rate in F₁- progeny was calculated using the following equation:

$$\% \text{ reduction} = \frac{F1 \text{ emerged in control} - F1 \text{ emerged in treatment}}{F1 \text{ emerged in control}} \times 100$$

Results

Effect of the plant extracts on the tested insects:

The efficiency of arugula seed- extracts (E. vesicaria) on insect mortality and reduction in the progeny of R. dominica:

The results of the efficiency of arugula seed-extracts (*E. vesicaria*) on insect mortality and reduction in the progeny of *R. dominica* is presented in Table (1-2). The results indicated

very high mortality values recorded after 3 days from treatment with the petroleum ether and acetone of arugula seeds extract at 1.5% (w/v) against *R. dominica* adults were 76.7 and 100%, respectively. While, low mortality percentages at 0.5% (w/v) after 1 day were 5.0 and 10.0%, respectively.

The mortality was increased with increasing concentration and exposure time. After 14 days from treatment, mortalities were increased to reach 33.3, 86.7, 100 and 100% and 40.0, 100, 100 and 100% (w/v) for petroleum ether and acetone of arugula seeds extract against *R. dominica* at various concentrations, respectively. Inhibition in number of F₁-progeny was much higher than mortality values at the various concentrations. These values ranged from 74.5 at 0.5% (w/v) and 100% reduction in F₁- progeny at 1, 1.5, 2 % (w/v) for petroleum ether but in acetone extract 88-100% at the same concentration, respectively.

Table 1. Efficiency of petroleum ether arugula (*E. vesicaria*) seed extracts on *R. dominica* adults and reduction in F₁-progeny under laboratory conditions.

Petroleum ether extracts treatment	Conc. (W/V)%	(%)Adult mortality after indicated days					Average No. of emerged Adults after 45 days	% reduction in F ₁ -Progeny
		1	3	5	7	14		
Arugula	0.5	5.0±0.0	13.3±0.6	21.7±0.6	28.3±0.6	33.3±0.6	12.0	74.5
	1	26.7±0.6	50.0±1.0	70.0±1.0	78.3±0.6	86.7±1.2	0.0	100.0
	1.5	43.3±0.6	76.7 ±0.6	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
	2	55.0±1.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
Control		0.0	0.0	0.0	0.0	0.0	47.0	0.0

Table 2. Efficiency of acetone arugula (*E. vesicaria*) seed extracts on *R. dominica* adults and reduction in F₁-progeny under laboratory conditions.

Acetone extracts treatment	Conc. (W/V)%	(%)Adult mortality after indicated days					Average NO. of emerged Adults after 45 days	% reduction in F ₁ -Progeny
		1	3	5	7	14		
Arugula	0.5	10.0±1.0	25.0±1.0	30.0±1.0	35.0 ±1.0	40.0±1.0	4.3	88.0
	1	40.0 ±1.0	76.7 ±0.6	86.7 ±0.6	100.0±0.0	100.0±0.0	0.0	100.0
	1.5	65.0±1.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
	2	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
Control		0.0	0.0	0.0	0.0	0.0	32.3	0.0

The efficiency of arugula seed extracts (E. vesicaria) on insect mortality and reduction in the progeny of S. granarius:

The results of the efficiency of arugula seeds extracts (*E. vesicaria*) on insect mortality and reduction in the progeny of *S. granarius* data given in Table (3-4). The results showed that the impact of acetone of arugula seeds extract on *S. granarius* higher than the petroleum ether extract. The obtained mortalities after one day from treatments were 21.7, 51.7, 83.3 and 100% and 11.7, 41.7, 73.3 and 100% (w/v) at various concentrations for acetone and petroleum ether extract, respectively.

These, values reached were 83.3, 100, 100 and 100% and 45.0, 100, 100 and 100% (w/v) after 14 days for the same extracts with the same insects. Reduction in F₁-progeny was 100% at all concentrations for two extract against *S. granarius*. The results revealed that the arugula seeds acetone extract was more effective than its petroleum ether extract with two tested insect species.

The efficiency of fennel seed extracts (F. vulgare) on insect mortality and reduction in the progeny of R. dominica:

The results of the efficiency of fennel seeds extracts (*F. vulgare*) on insect mortality and

reduction in the progeny of *R. dominica* is shown in Table (5-6). The results obtained that adult mortality increased with increasing the concentrations and the exposure time. The mortality clearly that after 5 days there were high mortality percentage about 100% with 1.5 % (w/v) concentration to acetone extract, while its 56.7% (w/v) for petroleum ether extract. In respect to acetone extract the mortalities were 28.3, 73.3, 100 and 100% with 0.5, 1.0, 1.5 and 2% concentrations after 14 days, respectively.

About petroleum ether extract the mortality percentage were 21.7, 58.3, 73.3 and 83.3% (w/v) after the same period post treatment for the same concentrations, respectively. Reduction in F₁-progeny ranged from 75.2-100% and 44-100% with fennel acetone and petroleum ether extract at various concentrations, respectively. The obtained results indicate clearly that the bioactivity of fennel acetone extract has is the highest effect in the mortality percentage and reduction in F₁-progeny. In comparison with petroleum ether extract of the same plant which had low effect of them.

Table 3. Efficiency of petroleum ether arugula (*E. vesicaria*) seed extracts on *S. granarius* adults and reduction in F₁-progeny under laboratory conditions.

Petroleum ether extracts treatment	Conc. (W/V)%	(%)Adult mortality after indicated days					Average NO .of emerged Adults after 45 days	% reduction in F ₁ -Progeny
		1	3	5	7	14		
Arugula	0.5	11.7±0.6	23.3 ±0.6	31.7 ±0.6	38.3±0.6	45.0±1.0	0.0	100.0
	1	41.7 ±1.2	61.7±0.6	83.3±0.6	88.3±0.6	100.0±0.0	0.0	100.0
	1.5	73.3±0.6	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
	2	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
Control		0.0	0.0	0.0	0.0	0.0	44.7	0.0

Table 4. Efficiency of acetone arugula (*E. vesicaria*) seeds extracts on *S. granarius* adults and reduction in F₁-progeny.

Acetone extracts treatment	Conc. (W/V)%	(%)Adult mortality after indicated days					Average NO .of emerged Adults after 45 days	% reduction in F1-Progeny
		1	3	5	7	14		
Arugula	0.5	21.7±1.5	46.7±0.6	56.7±0.6	70.0 ±1.0	83.3±0.6	0.0	100.0
	1	51.7±1.2	90.0±1.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
	1.5	83.3±1.5	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
	2	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
Control		0.0	0.0	0.0	0.0	0.0	28.7	0.0

Table 5. Efficiency of petroleum ether fennel seed (*F. vulgare*) extracts on *R. dominca* adults and reduction in F₁-progeny under laboratory conditions.

Petroleum ether extracts treatment	Conc. (W/V)%	(%)Adult mortality after indicated days					Average NO. of emerged Adults after 45 days	% reduction in F1-Progeny
		1	3	5	7	14		
Fennel	0.5	0.0±0.0	5.0 ±0.0	11.7 ±0.6	16.7 ±0.6	21.7 ±0.6	26.3	44.0
	1	13.3±0.6	23.3±0.6	31.7±1.2	43.3 ±0.6	58.3±0.6	10.0	78.7
	1.5	28.3±1.2	43.3±1.2	56.7 ±0.6	66.7±0.6	73.3 ±0.6	0.0	100.0
	2	38.3±0.6	58.3 ±1.2	71.7 ±1.5	76.7 ±1.5	83.3±1.2	0.0	100.0
Control		0.0	0.0	0.0	0.0	0.0	47.0	0.0

Table 6. Efficiency of acetone fennel seed (*F. vulgare*) extracts on *R. dominca* adults and reduction in F₁-progeny under laboratory conditions.

Acetone extracts treatment	Conc. (W/V)%	(%)Adult mortality after indicated days					Average NO .of emerged Adults after 45 days	% reduction in F1-Progeny
		1	3	5	7	14		
Fennel	0.5	3.3±0.6	11.7 ±0.6	18.3 ±1.2	23.3 ±1.2	28.3 ±1.2	8.0	75.2
	1	21.7±0.6	40.0 ±0.0	63.3±0.6	68.3±0.6	73.3±0.6	0.3	99.0
	1.5	33.3 ±0.6	66.7 ±0.6	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
	2	46.7 ±0.6	93.3 ±0.6	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
Control		0.0	0.0	0.0	0.0	0.0	32.3	0.0

The efficiency of fennel seed extracts (*F. vulgare*) on insect mortality and reduction in the progeny of *S. granarius*:

The results of the efficiency of fennel seeds extracts (*F. vulgare*) on insect mortality and reduction in the progeny against *S. granarius* shown in Table(7-8). The results revealed that after 5 days there were high mortality percentage about 100% with 1.5% (w/v) concentration to acetone extract. While the percentage of mortality was 61.7% at the same concentration to petroleum ether extract with the same insect, respectively. The mortality clearly that after 1 days there were low mortality percentage about 0.0 and 5.0 % with

0.5 % (w/v) concentration to petroleum ether and acetone extract, respectively.

These values mortality percentage after 14 days were 50.0, 88.3, 100 and 100% and 35.0, 68.3, 100 and 100% for acetone and petroleum ether extract at 0.5, 1.0, 1.5 and 2% (w/v) concentrations against *S. granarius*, respectively. Reduction in F₁-progeny was much higher than mortality values at all concentration. It ranged from 89.5-100% and 87.2-100% with acetone and petroleum ether extract for *S. granarius*, respectively. Data revealed that *R. dominica* was more resistant than *S. granarius* to the various plant extracts.

Table 7. Efficiency of petroleum ether fennel seed (*F. vulgare*) extracts on *S. granarius* adults and reduction in F₁-progeny under laboratory conditions.

Petroleum ether extracts treatment	Conc. (W/V)%	(%)Adult mortality after indicated days					Average NO .of emerged Adults after 45 days	% reduction in F1-Progeny
		1	3	5	7	14		
Fennel	0.5	0.0±0.0	8.3±0.6	16.7±0.6	21.7±0.6	35.0±1.7	5.7	87.2
	1	18.3±0.6	30.0±1.0	38.3±1.5	51.7±1.2	68.3±0.6	1.0	97.8
	1.5	33.3±0.6	46.7 ±0.6	61.7±0.6	83.3±0.6	100.0±0.0	0.0	100.0
	2	50.0±1.0	73.3 ±1.5	88.3±0.6	100.0±0.0	100.0±0.0	0.0	100.0
Control		0.0	0.0	0.0	0.0	0.0	44.7	0.0

Table 8. Efficiency of acetone fennel seed (*F. vulgare*) extracts on *S. granarius* adults and reduction (%) in F₁-progeny.

Acetone extracts treatment	Conc. (W/V)%	(%)Adult mortality after indicated days					Average NO .of emerged Adults after 45 days	% reduction in F1-Progeny
		1	3	5	7	14		
Fennel	0.5	5.0±0.0	28.3±0.6	36.7±0.6	43.3 ±0.6	50.0±1.0	3.0	89.5
	1	23.3±0.6	53.3±1.2	66.7±0.6	76.7±0.6	88.3±0.6	0.0	100.0
	1.5	55.0±1.0	91.7 ±0.6	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
	2	93.3±0.6	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0	0.0	100.0
Control		0.0	0.0	0.0	0.0	0.0	28.7	0.0

Lethal concentration of arugula seed extracts against R. dominica adults.

Lethal concentration and confidence limits of arugula seed extracts against *R. dominica* adults after different exposure periods at laboratory conditions were presented in Table (9). Data showed that, based on the LC₅₀ values, the most toxic insecticide was arugula acetone (1.085, 0.680 and 0.620 % w/v), followed by arugula petroleum ether (1.720, 0.940 and 0.722 % w/v) after 1, 3 and 5 days, respectively.

The results indicated also that, the toxicity of arugula petroleum ether and acetone extracts against *R. dominica* adults were significantly increased with the increase of the exposure times.

Lethal concentration of fennel seed extracts against R. dominica adults.

Lethal concentration and confidence limits of fennel seed extracts against *R. dominica* adults after different exposure periods at laboratory conditions were presented in Table (10). Data showed that, based on the LC₅₀ values, the most toxic values were fennel acetone (0.798, 0.752 and 0.673 % w/v), followed by fennel petroleum ether (1.331, 1.103 and 0.900 % w/v) after 5, 7 and 14 days, respectively.

The results indicated also that, the toxicity of fennel petroleum ether and acetone extracts against *R. dominica* adults were significantly increased with the increase of the exposure times.

Lethal concentration of arugula seed extracts against S. granarius adults.

Lethal concentration and confidence limits of arugula seed extracts against *S. granarius* adults after different exposure periods at laboratory conditions were presented in Table (11). Data showed that, based on the LC₅₀ values, the most toxic insecticide was arugula acetone (0.849, 0.525 and 0.475 % w/v), followed by arugula petroleum ether (1.015, 0.763 and 0.622 % w/v) after 1, 3 and 5 days, respectively.

The results indicated also that, the toxicity of arugula petroleum ether and acetone extracts against *S. granarius* adults were significantly increased with the increase of the exposure times.

Lethal concentration of fennel seed extracts against S. granarius adults.

Lethal concentration and confidence limits of fennel seed extracts against *S. granarius* adults after different exposure periods at laboratory conditions were presented in Table (12). Data showed that, based on the LC₅₀ values, the most toxic values were fennel acetone (0.622, 0.576 and 0.510 % w/v), followed by fennel petroleum ether (1.093, 0.849 and 0.654 % w/v) after 5, 7 and 14 days, respectively.

The results indicated also that, the toxicity of fennel petroleum ether and acetone extracts against *S. granarius* adults were significantly increased with the increase of the exposure times.

Table 9. Lethal concentration and confidence limits of arugula seed extracts against *R. dominica* adults after different exposure periods

Plant extracts	Exposure period (days)	LC50	Slope
Arugula petroleum ether	Day 1	1.720 b(1.509-2.067)	3.320
	Day 3	0.940 b(0.844-1.033)	4.647
	Day5	0.722 b(0.648-0.793)	5.675
Arugula acetone	Day 1	1.085 a(0.975-1.197)	4.350
	Day 3	0.680 a(0.608-0.749)	5.663
	Day5	0.620 a(0.553-0.684)	5.874

Table 10. Lethal concentration and confidence limits of fennel seed extracts against *R. dominica* adults after different exposure periods.

Plant extracts	Exposure period (days)	LC50	Slope
Fennel petroleum ether	Day 5	1.331 b(1.165-1.546)	2.991
	Day 7	1.103 b(0.953-1.268)	2.871
	Day14	0.900 b(0.761-1.034)	2.894
Fennel acetone	Day 5	0.798 a(0.710-0.887)	4.926
	Day 7	0.752 a(0.659-0.842)	4.464
	Day14	0.673 a(0.597-0.745)	5.263

Table 11. Lethal concentration and confidence limits of arugula seed extracts against *S. granarius* adults after different exposure periods.

Plant extracts	Exposure period (days)	LC50	Slope
Arugula petroleum ether	Day 1	1.015 b(0.912-1.117)	4.569
	Day 3	0.763 b(0.674-0.849)	4.673
	Day 5	0.622 b(0.551-0.689)	5.531
Arugula acetone	Day 1	0.849 a(0.752-0.942)	4.184
	Day 3	0.525 a(0.446-0.593)	5.049
	Day 5	(0.475 a0.406-0.521)	7.732

Table 12. Lethal concentration and confidence limits of fennel seed extracts against *S. granarius* adults after different exposure periods.

Plant extracts	Exposure period (days)	LC50	Slope
Fennel petroleum ether	Day 5	1.093 b(0.961-1.235)	3.338
	Day 7	0.849 b(0.752-0.942)	4.184
	Day14	0.654 b(0.566-0.733)	4.356
Fennel acetone	Day 5	0.662 a(0.558-0.755)	3.789
	Day 7	0.576 a(0.487-0.655)	4.326
	Day14	0.510 a(0.424-0.581)	4.687

N.B :

CL: confidence limits, toxicity index = [(LC₅₀ of the most toxic tested compound/LC₅₀ of the tested compound) x100]. Sun (1950).

LC₅₀ values within the same row having different letters are significantly different (95% FL did not overlap). Finney (1971).

The toxicity index of various tested extracts against S. granarius and R. dominicaadults.

The toxicity index of various tested extracts against *S. granarius* and *R. dominica*adults at laboratory conditions were presented in Table (13). Data indicated that the toxicity index of the different extracts against *R. dominica* adults showed that arugula has the highest efficacy,

followed by, fennel was the least toxic compound against *R. dominica* adults.

On the other hand data indicated that the toxicity index of the different extracts against *S. granarius* adults showed that fennel was the least toxic, followed by, arugula has the most effective extract against *S. granarius* .

Table 13. Toxicity index of various tested extracts against the adults of *R. dominica* and *S. granarius*.

Treatments	Lethal concentrations at 5 days (w/v %)					
	<i>R. dominica</i> .			<i>S. granarius</i> .		
	LC 50	Slope	Toxicity index	LC 50	Slope	Toxicity index
Fennel acetone extract	0.798	4.926	77.69	0.662	3.789	71.75
Arugula petroleum ether extract	0.722	5.675	85.87	0.622	5.531	76.36
Fennel petroleum ether extract	1.331	2.991	46.58	1.093	3.338	43.45
Arugula acetone extract	0.620	5.874	100	0.475	7.732	100

CL: confidence limits, toxicity index = [(LC₅₀ of the most toxic tested compound/LC₅₀ of the tested compound) x100]. Sun (1950).

Discussion

In the current study, the mortality was increased with increasing concentration and exposure time. percentage of mortality increased with increasing the concentration of different extracts and exposure time. Extracts of arugula seeds of petroleum ether and acetone gave higher mortality percent compared with the extracts from fennel seeds. These results are in agreement with those of Abd-El-Aziz (2002) reported that the mortality of *C. maculatus* caused by extract of *S. aromaticum* increased with the increase in concentration and exposure period with percentage of 100, 90, 70 and 40 % for the tested concentrations at 5 days from the initial treatment.

In the harmony with the current results, El-Lakwah *et al.* (2011) were used acetone and petroleum ether extracts of poinciana seeds (*Delonix regia*), cloves flowering buds (*Syzygium aromaticum*), cinnamon (*Cinnamomum zeylancicum*), radish seeds (*Raphanus sativus*), and mustard seed (*Brassica alba*) against *Sitophilus oryzae*, *Rhizopertha dominica* and *Tribolium Castaneum*. Tested at 0.4% and 0.8% (w/w) concentrations under modified atmosphere of 20±5% CO₂. Results showed that *S. oryzae* was the most sensitive followed by *R. dominica* and *T. castaneum* adults.

In similar studies Adel *et al.* (2015) investigated the effect of acetone extract of geranium, basil and fennel seeds oils on *Sitophilus oryzae* and *Callosobruchus macullatus*. The results showed that in the absence of rice grains geranium oil was the most effective against *S. oryzae* and *C. maculatus*. Followed by both basil and fennel oils. In the presence of grains fennel oil exhibited *S.oryzae* adults followed by basil oil. Fennel oil induced the highest mortality rate to *C. maculatus* followed by geranium and basil oils.

Karakas (2016) evaluated effects of the solvent acetone, ethanol, methanol and water of seeds and leaves *Petroselinum crispum*, *Eruca vesicaria* and *Thymus vulgaris* against granary weevil, *Sitophilus granarius*. The results showed that *T. vulgaris* was the most effective followed by *E. vesicaria* and *P. crispum* was the least effectively. Ethanol was the highly effective in the reduction of reproductivity adult emergence of *S. granarius* followed by acetone and water extract.

Karakas (2018) studied the effect of dill leaves (*Anethum graveolens*), bay (*Laurus nobilis*), basil (*Ocimum basilicum*), fennel (*Foeniculum vulgare*), rosemary (*Rosmarinus officinalis*) and hibiscus (*Malve sylvestris*) were extracted using acetone, ethanol and water solvents against *Sitophilus granarius*. Extracts of water solvent showed higher repellent effect than of others expect ethanol extract of *R. officinalis*.

At 12.0% dose level all plant extracts showed the highest repellency rate and were in repellency *F. vulgare*. This support previous finding on the other research projects (Mohanny *et al.*, 2020; Ahmed *et al.*, 2020; Ali *et al.*, 2019; Aly *et al.*, 2019). Also, Pierattini *et al.* (2019) evaluated the effect of hexane of essential oil of *Pistacia lentiscus*, *Ocimum basilicum* and *Foeniculum vulgare* against *Sitophilus granarius*. The results observed that *F. vulgare* and *O. basilicum* was more effective than the *P. lentiscus*.

Conclusions

From the previous results of the various plant extracts against *Rhyzopertha dominica* and *Sitophilus granarius*, data clearly that arugula extract was the most effective followed by fennel extracts which was the least effective against *R. dominica* and *S. granarius*.

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Conflict of interest

The authors hereby declare that no competing and conflict of interests exist.

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