LABORATORY EVALUATION OF THE TOXICITY AND REPELLENCY OF CORIANDER SEED TO FOUR SPECIES OF STORED-PRODUCT INSECTS[1]

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ABSTRACT

Seed and oil of *Coriandrum sativum* L. (coriander) were evaluated for their contact toxicity to adults of *Callosobruchus maculatus* (F.), *Sitophilus oryzae* (L.), *Lasioderma serricorne* (F.), and *Tribolium confusum* Jacquelin du Val; and for their repellency to *S. oryzae* and *T. confusum*. The acetone extract of the seed was topically nontoxic to *C. maculatus*, slightly toxic to *L. serricorne* and *T. confusum*, and moderately toxic to *S. oryzae* at 40 μg/insect and higher at 48 hr after application. The oil was topically nontoxic to *C. maculatus*, *L. serricorne*, and *T. confusum*, and was moderately toxic to *S. oryzae* at 30 μg/insect and higher.

Both the acetone extract and oil were repellent to *S. oryzae* when they were used to surface treat the wheat at dosages of 0.2, 0.1, and 0.05%, with the oil slightly more repellent than the extract at the 0.2% concentration. Both the extract and oil repelled *T. confusum* when the insects were exposed to the surface of the treated paper at concentrations of 600, 400, 200, and 100 $\mu g/cm^2$, with the extract more effective than the oil.

Key Words: *Coriandrum sativum*, coriander, toxicity, repellency, *Callosobruchus maculatus*, *Sitophilus oryzae*, *Lasioderma serricorne*, *Tribolium confusum*.

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INTRODUCTION

Coriandrum sativum L. (coriander) is a member of the Apiaceae (= Umbelliferae) family. The name *Coriandrum* is derived from the Greek word for a bug, referring to the fetid, bug-like odor given off by the bruised fresh plant. The fruit or seed lose their odor when dried and are used as a condiment in curries and in some alcoholic beverages, and medicinally it is used to remedy flatulence. The seed is very rich in fat, with only about 5% of essential oil. The seed oil is obtained by distillation, while the solvent extraction gives the oleoresin which contains the oil. After extraction of the oil or oleoresin, the remaining coriander seed can be used as a cattle feed.

Only a limited number of studies concerning the biological activities of coriander seeds were reported; the ovicidal activity of the oil to screwworm, *Cochliomyia hominivorax* (Coquerel) (= *americana* C. & P.) (Bushland 1939); the larvicidal activity to the southern house mosquito, *Culex quinquefasciatus* Say (Hartzell

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1944); the bactericidal activities to several microorganisms (Kellner and Kober 1954; Capek 1955; Khanin et al. 1968; Morris et al. 1979); the repellency to German cockroach, *Blattella germanica* L. (Inazuka 1982); and the insecticidal property to American cockroach, *Periplaneta americana* (L.) (Heal et al. 1950). In this study, the contact toxicity and repellency of coriander seed extract and oil to four species of stored-product insects are reported.

MATERIALS AND METHODS

Materials

Dry coriander seed (distributed by McCormick & Co.) was purchased from the local supermarket, and the coriander oil was purchased from LaPine Scientific Co., Chicago, IL.

The seed was ground in a CRC high speed micromill into fine powder of less than 250 μm. The powder (75 g) in acetone (Reagent grade, 400 ml) at 40 - 50°C was stirred for 30 min and filtered. The extraction process was repeated with the residue for three more times, and the combined filtrate was concentrated under reduced pressure to a small volume and then lyophilized to provide the extract.

Insects

Four species of stored-product insects, reared at 27 ± 1°C and 60 ± 5% RH at the Stored-Product Insects Research and Development Laboratory, Savannah, GA, were used. They were adults of cowpea weevil, *Callosobruchus maculatus* (F.) (< 5 h old); rice weevil, *Sitophilus oryzae* (L.) (< 24 h old); cigarette beetle, *Lasioderma serricorne* (F.) (< 72 h old); and confused flour beetle, *Tribolium confusum* Jacquelin du Val (7 - 14 d old).

Toxicity Study by Topical Treatment of Insects

A stock solution of 100 mg/ml was obtained by dissolving 100 mg of the extract or oil in acetone (Reagent grade) for a total volume of 1 ml. Lower concentrations of 80, 60, 40, and 20 mg/ml were obtained by dilution of the stock solution with solvent.

Insects were anesthetized briefly with CO_2 and then picked up individually with a vacuum needle. Using a microapplicator, 0.5 μl of the solution was applied to the dorsum of the thorax of each insect. Twenty insects of each species (unsexed except for 10 ♂ and 10 ♀ cowpea weevils) were treated with each dose. After treatment, insects were placed in 100-mm diameter petri dishes, 10 insects/dish (10 kernels of undamaged soft winter wheat were placed in each dish together with rice weevils), and kept in a room maintained at 27 ± 1°C and 60 ± 5% RH under alternating 12-h light and dark cycles. The insects were examined daily for one week. Those that did not move or respond to the gentle touch of a small probe were considered dead.

Repellency Study by Food Preference Method

Required amounts of the coriander acetone extract or oil were dissolved in 1 to 2 ml of acetone (Reagent grade) and applied to wheat at 0.2, 0.1, and 0.05% by weight. These treated samples were evaluated using the modified Loschiavo food preference apparatus as described by Laudani and Swank (1954). The apparatus consisted of a circular platform 50 cm in diameter, with a 5-cm metal rim. The platform had 12 holes, 8.75 cm in diameter, equally spaced along the outer edge to accommodate paper cups which were filled to the rim (about 80 g each) with treated or untreated grain samples. The center of the wheel cover had an opening, 1.25 cm in diameter, fitted with a plastic tube through which 120 adult rice weevils were introduced for a 24 h exposure period. For each experiment, three cups were filled with untreated wheat, and three each were filled with wheat treated with the extract or with the oil at 0.2, 0.1, and 0.05% by weight. The cups were arranged in different repeated sequence for each experiment (in A-B-C-D- for expt. 1, A-C-B-D for expt. 2, and A-B-D-C- for expt. 3). At the end of each exposure period, the insects in each cup were collected and counted to determine their distribution. For each material, the test was repeated three times.

Data were analyzed by using analysis of variance, and Duncan's multiple range test (Duncan 1955).

Another test was carried out with the food preference method when only one dose of treatment of wheat, either 0.2 or 0.1% by weight of wheat, was tested with the untreated. Six cups were filled with treated wheat and six cups with untreated wheat. The cups were arranged in an alternated sequence. At the end of the exposure period, the insects in the cups were collected and counted to determine their distribution. The data were analyzed as previously described.

Repellency Study by Treated Paper Method

Both the acetone extract and the oil were evaluated for its repellency against the confused flour beetle using the method described by Laudani et al. (1955) and McDonald et al. (1970). Strips of aluminum foil laminated to 40-lb kraft paper were treated on the paper side with acetone solutions of the extract or oil at concentrations of 600, 400, 200, and 100 $\mu g/cm^2$ and then air dried. Each treated strip (10 $\times$ 20 cm) was attached lengthwise, edge to edge, to an untreated strip by cellulose tape on the reverse side. Two glass rings, 2.5 cm high and 6.4 cm ID, were placed over the two matched papers so that the joined edge bisected the ring. Ten adult confused flour beetles were exposed in each test area inside the glass ring, and their numbers on the treated and untreated halves were recorded at 9 a.m. and 4 p.m. each day for 5 consecutive days. The average of counts of each 5-day period was converted to percent repellency. The mean repellency from exposure at periods of 1 wk, 2 wk, 1 mo, 2 mo, and 4 mo after application was assigned a repellency class by using the following scale (class, percent repellency): 0, $<$ 0.1; I, 0.1 - 20; II, 20.1 - 40; III, 40.1 - 60; IV, 60.1 - 80; V, 80.1 - 100.

Data of overall average repellency were analyzed as previously described.

RESULTS AND DISCUSSION

The acetone extraction of 75 g of pulverized coriander seed yielded 12.4 g (16.5%) or oleoresin as a heavy brownish oil. The extract showed no contact toxicity to adults of cowpea weevils, but was slightly toxic to cigarette beetles and confused flour beetles, and moderately toxic to rice weevils at dosages of 40 μg/insect and higher (Table 1). The coriander oil showed practically no toxicity to cowpea weevils, cigarette beetles, and confused flour beetles, and was moderately toxic to rice weevils at 30 μg/insect and higher.

Both the extract and the oil showed strong repellency to rice weevils when evaluated by the food preference repellency wheel method. At dosages of 0.2, 0.1,

Table 1. Toxicity of coriander seed acetone extract and coriander oil applied topically to four species of adult stored-product insects (cowpea weevil — CW, rice weevil — RW, cigarette beetle — CB, and confused flour beetle — CFB).

Dose (μg/insect)	Avg. % mortality ± SE*† at 48 hr after application CW	RW	CB	CFB
		Coriander seed acetone extract		
50	5.00 ± 2.04	40.00 ± 7.91	18.75 ± 3.15	8.75 ± 2.39
40	0	43.75 ± 6.25	12.50 ± 4.33	7.50 ± 3.23
30	1.25 ± 1.25	5.00 ± 2.04	3.75 ± 2.39	3.75 ± 1.25
20	0	2.50 ± 2.50	2.50 ± 2.50	2.50 ± 2.50
10	0	0	2.50 ± 2.50	1.25 ± 1.25
Acetone only	0	0	0	0
Untreated	0	0	0	0
		Coriander oil		
50	1.25 ± 1.25	46.25 ± 5.54	1.25 ± 1.25	3.75 ± 2.39
40	0	46.25 ± 8.99	1.25 ± 1.25	3.75 ± 1.25
30	0	30.00 ± 5.40	0	2.50 ± 2.50
20	0	6.25 ± 3.15	1.25 ± 1.25	0
10	0	3.75 ± 2.39	0	0
Acetone only	0	0	0	0
Untreated	0	0	0	0

* Average of four replicates, 20 insects/replicate.
† Standard error of the mean.

and 0.05% on wheat, the repellency of the three doses was not statistically different to each other at $P = 0.05$ level analyzed by the Duncan's multiple range test (Table 2),

Table 2. Distribution of *S. oryzae* adults present in wheat with coriander seed acetone extract or coriander oil, and untreated wheat after a 24-h exposure in a repellency wheel.

Dose (% wt. of grain)	Distribution of insects (%)* in expt. no. 1	2	3	Overall avg. (%)†‡
		Coriander seed acetone extract		
0.2	9.17	15.00	18.33	14.17 ab
0.1	8.33	12.50	18.33	13.05 ab
0.05	21.67	24.17	14.17	20.00 b
Untreated	60.83	48.33	49.17	52.78 c
		Coriander oil		
0.2	1.69	4.10	2.52	2.77 a
0.1	5.08	19.67	12.61	12.45 ab
0.05	5.93	13.93	29.41	16.42 ab
Untreated	87.30	62.30	55.46	68.35 c

* Distribution of 120 insects with three samples of each treatment in each experiment.
† Average of three experiments.
‡ Values followed by the same letter within a column are not significantly different at the 0.05 level according to Duncan's multiple range test.

but they were significantly different to the untreated. The 0.2% coriander oil treated wheat had the lowest number (2.77%) of insects present.

When dosage of 0.2 or 0.1% of the extract or oil treated wheat was compared to the untreated wheat separately, the extract-treated samples demonstrated only a weak repellency against rice weevils (Table 3), and the effect was not significantly different from that of the untreated at the $P = 0.05$ level. The oil, however, gave significantly different repellency to the insects as compared to the untreated wheat.

Table 3. Distribution of *S. oryzae* adults present in wheat with coriander seed acetone extract or coriander oil, and untreated wheat after a 24-h exposure in a repellency wheel.

Dose (% wt. of grain)	Distribution of insects (%) ± SE*† in expt. no. 1	2	3	Overall avg. (%)‡
	Coriander seed acetone extract			
0.2	50.00 ± 2.13	52.50 ± 0.91	26.67 ± 3.08	43.06 ± 1.27 b
Untreated	50.00 ± 1.65	47.50 ± 2.37	73.33 ± 2.12	56.94 ± 1.22 b
0.1	53.33 ± 2.03	36.67 ± 1.27	50.83 ± 1.69	46.94 ± 0.96 b
Untreated	46.67 ± 0.95	63.33 ± 1.44	49.17 ± 1.21	53.06 ± 0.72 b
	Coriander oil			
0.2	0.83 ± 0.14	3.33 ± 0.41	8.33 ± 0.35	4.16 ± 0.22 a
Untreated	99.17 ± 0.95	96.67 ± 2.24	91.67 ± 2.35	95.84 ± 1.25 c
0.2	9.17 ± 0.50	23.33 ± 0.63	17.50 ± 0.60	16.67 ± 0.39 a
Untreated	90.83 ± 2.00	76.67 ± 1.27	82.50 ± 3.51	83.33 ± 1.34 c

* Distribution of 120 insects with six samples of each treatment in each experiment.
† Standard error of the mean.
‡ Average of three experiments. Values followed by the same letter within a column are not significantly different at the 0.05 level according to Duncan's multiple range test.

When the repellency to confused flour beetles was tested with the treated paper, the repellency of the oil decreased gradually during the first month (Table 4),

Table 4. Average repellency of coriander seed acetone extract and coriander oil to *Tribolium confusum* adults by the treated paper method.

Rate of application ($\mu g/cm^2$)	Avg. % repellency* at indicated period after treatment: 1 wk	2 wk	1 mo	2 mo	4 mo	Overall avg. (%)†‡	Repellency (class)
	Coriander seed acetone extract						
600	31.00	48.50	46.25	64.25	74.00	52.80 ± 5.28 a	III
400	31.75	53.50	28.50	60.75	73.50	49.60 ± 5.83 a	III
200	39.25	42.75	35.75	51.75	67.00	47.30 ± 4.11 a	III
100	42.25	42.25	17.25	38.00	57.75	39.50 ± 4.46 ab	II
	Coriander oil						
600	46.25	28.00	0.50	17.25	25.25	23.45 ± 5.36 bc	II
400	36.75	25.25	8.50	15.00	19.50	21.00 ± 3.77 c	II
200	32.75	25.00	13.00	22.00	9.75	20.50 ± 3.69 c	II
100	27.00	16.50	12.50	14.75	16.75	17.50 ± 2.94 c	I

* Average of data from four replicates, 10 insects per replicate.
† Average data of 1 wk, 2 wk, 1 mo, 2 mo, and 4 mo.
‡ Standard error of the mean. Values followed by the same letter within a column are not significantly different at the 0.05 level according to Duncan's multiple range test.

but then increased gradually over the next 3 months. Dosages of 600, 400, 200, and 100 $\mu g/cm^2$ of the extract showed greater repellency than the oil. The extract had irregular repellency at the beginning from 1 wk to 1 mo at all 4 dosages. After 4 mo, the repellency was greater for all dosages than after 1 wk. This could be due to the various unstable or volatile components present in the acetone extract of oleoresin.

The coriander seed, extract and oil, showed contact toxicity to rice weevils, and showed repellency to rice weevils and confused flour beetles. It warrants further consideration as a candidate for development as a protectant for commodities against these insects.

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