TOXICITY AND PROGENY REDUCTION POTENCY OF TWO POWDERED SPICES, TURMERIC AND CINNAMON ON ADULTS OF *RHYZOPERTHA DOMINICA* (F.) AND *SITOPHILUS GRANARIUS* (L.)

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ABSTRACT: Two powdered spices, turmeric (*Curcuma longa* L.) and cinnamon (*Cinnamomum zeylanicum* Ness.) were evaluated for their ability to protect stored wheat grains against infestation by two important stored-product pests. The spices were added separately to 20 g wheat grains as direct admixtures at five different rates 0.5, 0.85, 1.5, 3 and 5% (w/w) to assess for mortality and reduction of F_1 progeny. Twenty adult insects were released in each container. All tested insects were removed after 14 days and the experiments were monitored for the following 36 days in order to count the number of emerged adults. Each of the experiments was performed in four replicates. The results revealed that powders had significant insecticidal effects on the adults of both insects. The toxicities of these powders increased with an increase in dosage as well as an increase in the period of exposure to the plant materials. Powders at 5% (w/w) exhibited a significant toxicity on the adults of both pests, but did not cause complete mortality. Turmeric is more effective than cinnamon against both insects and *S. granarius* adults were more sensitive than *R. dominica*. Moreover, they caused complete reduction in F_1 progeny of both insects at the highest dosages.

KEY WORDS: Cinnamon, turmeric, powder, *Rhyzopertha dominica*, *Sitophilus granarius*.

The efficient control of stored grain pests has long been the aim of entomologists throughout the world. Synthetic chemical pesticides have been used for many years to control stored grain pests (Salem et al., 2007). However, the potential hazards for mammals from synthetic insecticides, increased concern by consumers over insecticide residues in processed cereal products, the occurrence of insecticide-resistant insect strains, the ecological consequences, increasing cost of application and the precautions necessary to work with traditional chemical insecticides call for new approaches to control stored-product insect pests (Aslam et al., 2002; Fields, 2006; Mahdiand & Rahman, 2008; Salem et al., 2007; Udo, 2005). Therefore, there is a need to look for alternative organic sources that are readily available, cheap, affordable, relatively less poisonous and less detrimental to the environment (Udo, 2005).

The use of plant materials as traditional protectants of stored products is an old practice used all over the world (Aslam et al., 2002). Nowadays, management of stored product pests using materials of natural origin has been the subject which received much research to overcome their problems, because of their little environmental hazards and low mammalian toxicity (Nadra, 2006). Previous research indicated that some plant powders, oils and extracts have strong effects on stored grain insects such as toxicity and the inhibition of reproduction (Emeasor et al., 2005; Nadra, 2006). Peasant farmers and researchers often claim successful use of material of plant origin in insect pest control including spices and powders of plant parts (Akinneye et al., 2006). The simplest way to apply plants to a stock of seeds is harvesting the plant and adding them to the seeds (Rajapakse, 2006).

Spices are dried seed, fruit, root, bark or vegetative substance used in nutritionally insignificant quantities as a food additive for flavoring. Many of these substances have other uses, e.g. as food preservation, medicine, cosmetics, perfumery or vegetables (Mahdiand & Rahman, 2008).

The spices are safe for higher animals and the environment, and could be easily produced by farmers and small-scale industries (Viglianco et al., 2008).

Some studies regarding to efficacy of the spice powders on stored product insects have been reported. Aslam et al. (2002) tested six spice powders such as cinnamon against pulse beetle (*Callosobruchus chinensis* L.) on stored chickpea. Salvadores et al. (2007) evaluated the insecticidal effects of plant powders from nine seasoning spices such as *Cinnamomum zeylanicum* (Ness) to control maize weevil, *Sitophilus zeamais* (Mots.). Mahdiand & Rahman (2008) conducted an experiment to investigate the insecticidal potency of some spices such as black pepper (*Piper nigrum* L.), Ceylon cinnamon (*Cinnamomum zeylanicum* Ness.), turmeric (*Curcuma longa* L.) and red pepper (*Capsicum frutescens* L.), against the pulse beetle, *Callosobruchus maculatus* (F.) on stored black gram (*Phaseolus bengalensis* L.).

The objective of present study to evaluate the efficacies of two local spices, turmeric (*C. longa*) rhizome powder and cinnamon (*C. zeylanicum*) bark powder in the control of two stored-grain insects, lesser grain borer (*Rhyzopertha dominica* F.) and granary weevil (*Sitophilus granarius* L.) in stored wheat grains.

MATERIALS AND METHODS

The trials were conducted at the laboratory of the Department of Entomology, University of Urmia, Iran, during 2008-2009.

Preparation of spices and wheat grains

Turmeric (*C. longa*) (Zingiberaceae) rhizome and cinnamon (*C. zeylanicum*) (Lauraceae) bark powders were used in this study. They were selected based on the assumption of absence of mammalian toxicity owing to its use as a popular spice in several diets. The dry spices and wheat kernels were purchased from a local market in Urmia, Iran. The dry spices were brought to the laboratory where they were passed through a 40-mesh sieve to obtain a fine dust before application to the grains. The powders were carefully placed inside airtight containers and kept until when needed. Wheat grains were disinfested by keeping them in a freezer at a temperature of –18 °C for 24 hours, and then conditioned to room temperature before being used for experimental purposes.

Rearing of test insects

Local strains of two important stored-product pests namely granary weevil (*S. granarius*) and lesser grain borer (*R. dominica*) were reared on un-infested whole kernels of wheat. Insects were collected from wheat flour factories, Urmia, Iran. Two hundred adults were released in 1 L jars containing 400 kg of wheat grains. Opening of the jars was covered with muslin cloth and tied with a rubber band and kept in an incubator maintained at a temperature of 28 ± 1°C and 70 ± 5% relative humidity (RH). After two weeks of oviposition, the parent insects were separated and egg laid grains were maintained and re-cultured to produce newly emerged adults of same generation. For this purpose, the insects emerged after four weeks were removed. One to fourteen day old *S. granarius* adults and one to four day old *R. dominica* adults were used in the experiments.

Mortality and progeny production assays

Turmeric rhizome and cinnamon bark powder were tested against adults of *S. granarius* and *R. dominica* on wheat grains. Wheat kernels (20 g) were put in each container and mixed with each of spice powders properly in plastic containers (9 cm high x 7 cm diameter) at five dosages 0.5, 0.85, 1.5, 3 and 5% (w/w), while the control treatment had no spices added. The experiments were replicated four times. The experimental design for mortality tests was completely randomized design. The test materials were tumbled thoroughly and vigorously in the containers by manual agitation until the materials were evenly distributed among the grains and ensure a homogeneous admixture. The contents of the plastic containers were awaited for about 30 minutes before introducing adults into each jar. Wheat grain in each plastic container was infested with twenty adult beetles (1 to 14 day old for *S. granarius* and 1 to 4 day old for *R. dominica*). Perforated muslin cloth was used to cover the opening of each container to ensure good aeration. The containers were placed in an incubator maintained at a temperature of 28 ± 1 °C and 70 ± 5% RH. The content of each of the boxes was poured in a dish and dead or live adults were counted. Mortality counts in each treatment were recorded after 24 hours and up to 14 days after treatment (Data were recorded on days till to 100% mortality). The insects were allowed to mate and oviposit for 14 days. All adults in both treated and untreated containers were removed after 14 days and the experiments were monitored for further 36 days. At the end of the period, the number of emerged adults was counted. Percentage of reduction in progeny production was determined using following Aldryhim's (1990) formula:

$$[\frac{C-T}{C} \times 100]$$

Where;

C: Number of emerged adults in control.

T: Number of emerged adults in treatment.

Data analysis

Corrected mortalities were estimated by using Abbott's formula (Abbott, 1925) {[(Sc – St) / Sc] × 100, where Sc = % survival in control while St = % survival in treated}. Arcsine transformation was applied to mortality data were transformed before ANOVA. Adult emergence data were transformed by the square root or arcsine methods. The resulting data were subjected to two-way ANOVA ($P < 0.05$) by using MSTATC statistical package. The data obtained from progeny production tests were analyzed statistically using randomized complete block design, one-way ANOVA ($P < 0.05$). Means for the treatments were subjected to Duncan's new multiple range test (DNMR) for significance of their differences.

RESULTS

The results revealed that cinnamon bark powder and turmeric rhizome powder had a significant insecticidal effect on *R. dominica* and *S. granarius* adults. They were found to be very effective in causing adult mortalities and reducing the adult emergence of both insect species. It is obvious from the data that highly significant differences ($P < 0.05$) were found among all the treatments.

Mean mortalities of *R. dominica* and *S. granarius* adults exposed to five concentrations of two plant powders are presented in Tables 1 and 2. The toxicity of these powders increased with an increase in both dosage as well as an increase in the period of exposure to the plant powders. The results indicated that both of powdered spices significantly ($P < 0.05$) reduced the number of both tested insects. In general, toxic activity for two powders was observed and turmeric powder was more toxic to both insects than cinnamon powder.

Both plant powders did not result in complete mortality on two insect species but the promising results were obtained at the highest dosage (5%, w/w) after 14 days. For both plant powders, the highest doses (5%, w/w) resulted in maximum mortality of test insects. The best protection was observed on *S. granarius* with turmeric powder, and poor effects were recorded with cinnamon powder on *R. dominica*, so that *S. granarius* adults were more susceptible than *R. dominica*. However, adults of both insect species were equally susceptible to the toxicity of turmeric powder. In general, turmeric powder performed better toxicity activity than cinnamon powder at various treatments.

Tables 3 and 4 show the mean reduction of F_1 adult emergence of *R. dominica* and *S. granarius* exposed to the turmeric and cinnamon powders at five concentrations after 50 days. Adult emergence was significantly suppressed by two plant powders (100% efficiency). From this study, it was observed that adult emergence reduced with increasing application dosage of the turmeric and cinnamon powders. All dosages of both powdered spices caused a significant reduction of adult emergence of *S. granarius* and at the highest dosages complete inhibition of adult emergence was observed. The cinnamon powder had the highest suppression effect on *S. granarius* at 3 and 5% (w/w). Cinnamon powder completely prevented the emergence of adult beetles of *R. dominica* at the highest doses (5%, w/w). Significant reductions were also found on *R. dominica* with turmeric powder. In contradictory to mortality tests, cinnamon powder performed better activity in progeny production tests than turmeric powder.

DISCUSSION

Results reported in this study show that both plant powders have insecticidal effects on *S. granarius* and *R. dominica* at all levels of treatment but varied with the exposure period and powder concentration.

Unfortunately, there is not any reference (in accessible literatures) regarding effects of turmeric (*C. longa*) rhizome powder and cinnamon (*Cinnamomum zeylanicum* Ness.) bark powder on *R. dominica* and *S. granarius* to be compared with the results obtained in the present study. Even thought, these finding are relatively similar to those of Aslam et al. (2002) have stated, they reported that admixture of 2.5% (w/w) cinnamon (*C. zeylanicum*) powder and stored cowpea caused 100% mortality of pulse beetle (*Callosobruchus chinensis* L.) after 8.25 days. On the other hand, these results are similar to those reported by Salvadores et al. (2007) showed that admixture of 4% (w/w) of cinnamon (*C. zeylanicum*) powder and wheat resulted in 80% mortality of maize weevil (*Sitophilus zeamais* Motschulsky) adults and adult insect emergence (F1) was obtained 7.9%. Mahdi & Rahman (2008) also found that admixture of 3% of turmeric and cinnamon powder (w/w) with black gram seeds, caused 100% mortality and reduced F1 progeny of *Callosobruchus maculatus* (F.) and they reported that cinnamon was effective than turmeric. These results certify our results that turmeric and cinnamon powders are effective in killing adults of test insects and suppressing the F_1 adult emergence. Furthermore, there is an inverse relationship between count of adult emergence and tested dosages.

In conclusion, these plant powders had a significant toxic effect on two insect species, which can be used as grain protectant. This technology is cheap, safe, environmentally friendly and easy to adopt by small-scale farmers.

LITERATURE CITED

Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. Journal of Economic Entomology, 18: 265-267.

Akinneye, J. O., Adedire, C. O. & Arannilewa, S. T. 2006. Potential of *Cleisthopholis patens* Elliot as a maize protectant against the stored product moth, *Plodia interpunctella* (Hubner) (Lepidoptera; Pyralidae). African Journal of Biotechnology, 5 (25): 2510-2515.

Aldryhim, Y. N. 1990. Efficacy of the amorphous silica dust, Dryacide against *Tribolium confusum* DuV. and *Sitophilus granarius* (L.) (Coleoptera. Tenebrionidae and Curculionidae). Journal of Stored Products Research, 26: 207-210.

Aslam, M., Ali Khan, Kh. & Bajwa, M. Z. H. 2002. Potency of some spices against *Callosobruchus chinensis* L. Online Journal of Biological Sciences, 2 (7): 449-452.

Emeasor, K. C., Ogbuji, R. O. & Emosairue, S. O. 2005. Insecticidal activity of some seed powders against *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) on stored cowpea. Journal of Plant Diseases and Protection, 112 (1): 80–87.

Fields, P. G. 2006. Effect of *Pisum sativum* fractions on the mortality and progeny production of nine stored-grain beetles. Journal of Stored Products Research, 42: 86-96.

Mahdian, S. H. A. & Rahman, M. K. 2008. Insecticidal effect of some spices on *Callosobruchus maculatus* (Fabricius) in black gram seeds. Rajshahi University Zoological Society, 27: 47-50. Available from: http://journals.sfu.ca/bd/index.php/UJZRU.

Nadra, H. A. M. 2006. Use of *Sesbania sesban* (L.) Merr Seed Extracts for the Protection of Wheat Grain against the Granary Weevil, *Sitophilus granarius* (L.) (Coleoptera: Curculionidae). Scientific Journal of King Faisal University (Basic and Applied Sciences), 7 (2): 121-135.

Rajapakse, R. H. S. 2006. The potential of plants and plant products in stored insect pest management. The Journal of Agricultural Sciences, 2 (1): 11-21.

Salem, S. A., Abou-Ela, R. G., Matter, M. M. & El-Kholy, M. Y. 2007. Entomocidal Effect of *Brassica napus* Extracts on Two Store Pests, *Sitophilus oryzae* (L.) and *Rhizopertha dominica* (Fab.) (Coleoptera). Journal of Applied Sciences Research, 3 (4): 317-322.

Salvadores, Y. U., Silva, G. A., Tapia, M. V. & Hepp, R. G. 2007. Spices powders for the control of maize weevil, *Sitophilus zeamais* Motschulsky, in stored wheat. Agricultura Tecnica. 67 (2): 147-154.

Udo, I. O. 2005. Evaluation of the potential of some local spices as stored grain protectants against the maize weevil *Sitophilus zeamais* Mots (Coleoptera: Curculionidae). Journal of Applied Sciences and Environmental Management, 9 (1): 165-168. Available from: www.bioline.org.br/ja.

Viglianco, A. I., Novo, R. J., Cragnolini, C. I., Nassetta, M. & Cavallo, A. 2008. Antifeedant and repellent effects of extracts of hree plants from Córdoba (Argentina) against *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae). Sociedade Entomologica do Brasil 3: 4. Available from: www.bioassay.org.br/articles/3.4.

Table 1. Mean mortality of adults of *Rhyzopertha dominica* exposed to wheat grains treated with cinnamon (A) and turmeric (B) powders at different concentrations for different exposure times.

(A)

Dosage (w/w)	Exposure time (day)				
	1	3	5	7	14
0.5	14.31 ± 1.38 k	16.77 ± 2.39 ijk	18.15 ± 2.02 ijk	21.57 ± 1.96 ghij	22.65 ± 1.66 fghij
0.85	14.31 ± 1.38 k	19.53 ± 1.09 hijk	22.51 ± 2.35 fghij	26.21 ± 3.03 efgh	29.90 ± 1.92 cde
1.5	15.69 ± 1.59 jk	21.57 ± 1.96 ghij	23.37 ± 2.93 efghi	29.10 ± 1.60 cdef	33.93 ± 1.93 cd
3	20.62 ± 1.26 ghijk	23.60 ± 1.94 efghi	27.35 ± 1.72 defg	33.93 ± 1.93 cd	41.40 ± 1.83 b
5	20.62 ± 1.26 ghijk	26.21 ± 3.03 efgh	35.34 ± 3.55 bc	41.40 ± 2.47 b	55.43 ± 2.91 a

(B)

Dosage (w/w)	Exposure time (day)				
	1	3	5	7	14
0.5	4.61 ± 4.61 l	12.45 ± 4.35 kl	23.60 ± 1.94 ghij	25.40 ± 2.45 ghij	29.16 ± 0.86 fgh
0.85	11.07 ± 3.91 kl	16.77 ± 2.39 jk	24.46 ± 2.49 ghij	28.96 ± 2.58 fgh	35.46 ± 1.95 def
1.5	13.54 ± 4.95 k	22.65 ± 1.66 hij	27.44 ± 0.86 fghi	32.33 ± 2.05 efg	42.14 ± 1.18 d
3	19.53 ± 1.09 ijk	26.49 ± 1.47 ghi	38.47 ± 1.88 de	42.12 ± 2.06 d	50.81 ± 1.20 c
5	29.96 ± 1.36 fgh	40.68 ± 1.88 de	51.55 ± 1.40 c	61.89 ± 2.24 b	78.79 ± 6.71 a

* Means in the same box followed by the same letters are not significantly different by Duncan's multiple range test at the 5% level ($P < 0.05$). Means were subjected to arcsin – transformation. Values are means of four replicates ± S.E.

Table 2. Mean mortality (mean±S.E) of adults of *Sitophilus granarius* exposed to wheat grains treated with cinnamon (A) and turmeric (B) powders at different concentrations for different exposure times.

(A)

Dosage (w/w)	Exposure time (day)				
	1	3	5	7	14
0.5	3.23 ± 3.23 m	12.93 ± 0.00 kl	14.31 ± 1.38 k	15.81 ± 1.67 jk	18.57 ± 0.12 ijk
0.85	6.46 ± 3.73 lm	12.93 ± 0.00 kl	20.48 ± 2.03 hijk	24.87 ± 1.21 fghi	24.87 ± 1.21 fghi
1.5	15.40 ± 2.47 jk	17.86 ± 2.85 ijk	27.35 ± 1.72 efgh	31.80 ± 1.51 def	34.11 ± 1.18 de
3	17.86 ± 2.85 ijk	23.37 ± 2.93 ghij	35.50 ± 1.44 d	36.54 ± 1.26 d	44.72 ± 2.42 c
5	17.86 ± 2.85 ijk	30.26 ± 4.21 defg	56.43 ± 4.05 b	62.79 ± 3.17 ab	64.63 ± 3.09 a

(B)

Dosage (w/w)	Exposure time (day)				
	1	3	5	7	14
0.5	16.77 ± 2.39 j	26.00 ± 2.13 hij	28.99 ± 1.68 ghi	30.00 ± 0.75 fghi	30.00 ± 0.75 fghi
0.85	22.65 ± 1.66 ij	31.28 ± 1.90 fghi	33.17 ± 2.53 fghi	34.92 ± 2.34 efgh	39.80 ± 1.32 defg
1.5	25.26 ± 3.13 hij	41.41± 3.89 def	47.52 ± 2.34 bcd	48.23± 2.19 bcd	49.68 ± 1.56 bcd
3	28.92 ± 2.86 ghi	45.27 ± 4.45 cde	54.01 ± 4.29 bc	56.36 ± 3.41 bc	58.66 ± 2.66 b
5	31.32 ± 3.43 fghi	50.71 ± 4.47 bcd	69.36 ± 7.49 a	76.76 ± 7.67 a	79.74 ± 6.02 a

* Means in the same box followed by the same letters are not significantly different by Duncan's multiple range test at the 5% level ($P < 0.05$). Means were subjected to arcsin – transformation. Values are means of four replicates ± S.E.

Table 3. Mean reduction of F_1 adults emergence of *Rhyzopertha dominica* exposed to wheat grains treated cinnamon (A) and turmeric (B) powders at different concentrations for 50 days.

(A)

Dosage (w/w)				
0.5	0.85	1.5	3	5
26.63 ± 0.07 e	46.61 ± 0.28 d	74.14 ± 0.72 c	83.85 ± 2.14 b	90.00 ± 0.00 a

(B)

Dosage (w/w)				
0.5	0.85	1.5	3	5
37.66 ± 0.32 e	52.99 ± 0.43 d	61.68 ± 0.44 c	73.00 ± 0.56 b	88.36 ± 1.64 a

* Means in the same row followed by the same letters are not significantly different by Duncan's multiple range test at the 5% level ($P < 0.05$). Means were subjected to arcsin – transformation. Values are means of four replicates ± S.E.

Table 4. Mean reduction of F_1 adult emergence of *Sitophilus granarius* exposed to wheat grains treated with cinnamon (A) and turmeric (B) powders at different concentrations for 50 days.

(A)

Dosage (w/w)				
0.5	0.85	1.5	3	5
9.03 ± 0.05 d	9.50 ± 0.02 c	9.68± 0.02 b	10.00 ± 0.00 a	10.00 ± 0.00 a

(B)

Dosage (w/w)				
0.5	0.85	1.5	3	5
45.78 ± 0.30 e	60.12 ± 0.20 d	74.14 ± 0.68 c	83.19 ± 2.38 b	90.00 ± 0.00 a

* Means in same row for each plant powder followed by the same letters are not significantly different by Duncan's multiple range test at the 5% level ($P < 0.05$). Means were subjected to square root – transformation and arcsin - transformation for data of cinnamon and turmeric powder treatments respectively. Values are means of four replicates ± S.E.