INSECTICIDAL ACTIVITIES OF TWO POWDERED SPICES, BLACK PEPPER AND RED PEPPER ON ADULTS OF *RHYZOPERTHA DOMINICA* (F.) AND *SITOPHILUS GRANARIUS* (L.)

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ABSTRACT: The experiment was conducted to investigate the insecticidal potency of black pepper (*Piper nigrum* L.) seed powder and red pepper (*Capsicum annuum* L.) fruit powder, against two important stored-product pests. These powders were mixed with 20 g wheat grains as direct admixtures at five different rates viz, 0, 0.15, 0.2, 0.27, 0.37 and 0.5% (w/w) for black pepper and 0, 0.5, 0.85, 1.5, 3 and 5% (w/w) for red pepper to assess for mortality and reduction of F_1 progeny. The treated grains were infested with 20 adults. All insects were removed after 14 days and the experiments were monitored for the extra 36 days in order to count the number of emerged adults. The results revealed that black pepper at 0.5% concentration caused 100% mortality of *S. granarius* in the first five days, also *R. dominica* showed complete mortality at 5% level after 14 days, but red pepper did not cause complete mortality on two insects after 14 days. Both plant materials caused complete reduction in F_1 progeny of *S. granarius* at highest tested dosages. Also they significantly reduced F_1 progeny emergence of *R. dominica.* This plant powders exhibited promising potential in protecting wheat grains against two species of insects.

KEY WORDS: Black pepper, powder, red pepper, *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; Udo, 2005; Fields, 2006; Salem et al., 2007; Mahdian & Rahman, 2008). 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).

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). 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).

The simplest way to apply plants to a stock of seeds is harvesting the plant and adding it to the seeds. The modes of action of powders vary, but with low to moderate dosages, the effect is always repellent or toxic, never mechanical

(Rajapakse, 2006). For the last few years the influence of different plant dried materials (added as powder to the products the pests feed on) on the cereal and flour pests has been widely researched (Blazejewska & Wyrostkiewicz, 1998).

The use of spices is also less costly, easily available, safer and don't do any hazard using in the stores (Aslam et al., 2002; Mahdian & Rahman, 2008).

A number of spices had been tried and found effective. Some include powders from red peppers (*Capsicum* spp.) and black peppers (*Piper* spp.) that were evaluated.

Javier & Morallo-Rejesus (1986), Morallo-Rejesus et al. (1990) and Javaid & Poswal (1995) evaluated the insecticidal effects of black pepper (*Piper nigrum* L.) powder on *S. zeamais, Callosobruchus chinensis* and *C. maculatus,* respectively. Ivbijaro & Agbaje (1986) and Zibokere (1994) tested insecticidal activities of dry red pepper (*Capsicum annuum* L.*)* powder on *C. maculates* (Fao, 1999).

Aslam et al. (2002) tested six spice powders against *C. chinensis.* Clove and black pepper were good protectants of stored chickpea against the beetle. Nadra (2004) showed that *Capsicum frutescens* caused high and significant mortality (85%) of *Trogoderma granarium* adults at all 1, 2, 4 and 6% concentrations within 7 days. Oparaeke & Bunmi (2006) showed *Piper guineense* powder exhibited acute toxicity on *C. subinnotatus* (Pic.) (Over 90% mortality in all the three concentrations: 2.5, 5.0 and 7.5 % per 150 g seed) assayed in 48 h. It also significantly reduced oviposition by 85.44 to 90 percent while adult emergence and seed damage were reduced by 100 percent each. Echezona (2006) stated that dried and ground fruits of four pepper cultivars (*Capsicum* spp.) significantly increased adult mortality of *C. maculatus* (F.) earlier than the no protectant control. Owoade (2008) conducted an experiment to expose *Dermestes maculatus* larvae (24 - 48 hour old) to three concentrations (15, 20 and 25g/kg) of *P. guinees.* Mortalities monitored for the first five days showed that *P. guineese* gave mortality up to 100% at the end of 24 hours and by the end of 72 hours, 100% mortality was recorded in all three concentrations. Mahdian & Rahman (2008) investigated the insecticidal potency of some spices such as black pepper (*P. nigrum*), Ceylon cinnamon (*Cinnamomum zeylanicum*), turmeric (*Curcuma longa*) and red pepper (*C. frutescens*), against the pulse beetle, *C. maculatus* (F.) on stored black gram (*Phaseolus bengalensis* L.). All the spices were effective as protectants of black gram seeds and black pepper was the most effective.

In the present investigation, the insecticidal activity of black pepper (*Piper nigrum* L.) seed powder and red pepper (*Capsicum annuum* L.) fruit powder were evaluated in order to determine their effects on the mortality and progeny production (adult emergence) of two stored-grain insects, the lesser grain borer (*Rhyzopertha dominica* F.) and the granary weevil (*Sitophilus granarius* L.) in laboratory experiments wheat grains.

MATERIALS AND METHODS

The experiments were carried out in the laboratory of the Department of Entomology, University of Urmia, Iran, during 2008-2009.

Preparation of plant products & stored grains

Black pepper (*Piper nigrum* L.) (Piperaceae) seed and red pepper (*Capsicum annuum* L.) (Solanaceae) fruit powders were used in this investigation. They were selected based on assumption of absence of mammalian toxicity owing to its use as a popular spice in several diets. The powders and a local variety of wheat grains were obtained from a local market in Urmia, Iran. The powders were sieved with a

40-mesh sieve to obtain a fine dust before application to the grains. The spices were stored in airtight plastic containers at room temperature before use. Wheat grains were disinfested by keeping them in a freezer at -18°C for a day and subsequently in room temperature before being used for experimental purposes.

Rearing of experimental insects

Local strains of two important stored-product insects namely granary weevil (*Sitophilus granarius* L.) and lesser grain borer (*Rhyzopertha dominica* F.) were reared on uninfected whole kernels of wheat. Insects were obtained from wheat flour factories, Urmia, Iran. Insects were released at the rate of 200 adults in containing 400 kg of wheat grains. The jars were 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-14 day old adults for *S. granarius* and 1-4 day old adults for *R. dominica* were used in the experiments.

Mortality and progeny assessment assays

Powders were added separately to 20 g of wheat in plastic containers (9cm high, 7cm diameter) at five dosages 0.15, 0.2, 0.27, 0.37 and 0.5% (w/w) for black pepper and 0.5, 0.85, 1.5, 3 and 5% (w/w) for red pepper, while the control treatment had no plant seed powder. All treatments were replicated four times. The test materials were admixed thoroughly and gently 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 allowed to settle down for about 30 minutes before introducing adults into each jar. Twenty adult beetles (1-14 days old for *S. granarius* and 1-4 days old for *R. dominica*) were introduced into the each container. The plastic containers were securely covered with white perforated muslin cloth held in place with rubber bands to ensure adequate ventilation. 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 insects were counted. Mortality counts in each treatment were recorded after 1, 3, 5, 7 and 14 days (Data were recorded on days 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 the extra 36 days. At the end of the period, the number of emerged adults was counted. Percentage of reduction in progeny production was determined using 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.

Statistical analysis

Data were corrected for mortalities in the control by using Abbott's formula (Abbott, 1925) {[(Sc – St) / Sc] ×100, where Sc = % survival in control while St = % survival in treated} and transformed with an arcsin (percentages) method. Adult emergence data were transformed with arcsin or the square root method. The resulting data were subjected to analysis of variance. Analyses of Variance (ANOVA) were employed on the data using a 2-way ANOVA of the MSTAT-C statistical package. The experimental design for mortality tests was completely

randomized design. The data obtained from progeny assays were analyzed statistically using randomized complete block design, one-way ANOVA ($P< 0.05$). Means of the four replicates of treatments were tested by Duncan's new multiple range test (DNMR) for significance of their differences.

RESULTS

The results revealed that black pepper seed powder and red pepper fruit powder had significant insecticidal effects on the adults of *R. dominica* and *S. granarius* as compared to the control. They were found to be very effective in causing mortality and reducing adult emergence of both insects. A highly significant differences ($P<0.05$) were found among all the treatments.

Mean mortality of the adults of *R. dominica* and *S. granarius* exposed to five concentration levels of two plant powders is presented in Tables 1 and 2. A direct mortality rate was observed. It means that the toxicities of these powders increased with increase in dosage as well as 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, toxicity for two powders was observed and black pepper was more toxic than red pepper powder to both insects.

Black pepper seed powder significantly ($P<0.05$) causing complete mortality at highest concentration level tested (0.5%). The best protection with application of black pepper was observed on *S. granarius* because it caused complete mortality in the first five days but *R. dominica* showed complete mortality after 14 days so that *S. granarius* adults were more susceptible than *R. dominica* adults.

The red pepper fruit powder did not cause complete mortality on two insects, but good results were obtained at highest dosage (5%) after 14 days. Both adult insects were equally susceptible to the toxicity of it.

Tables 3 and 4 show the mean adult emergence count of *R. dominica* and *S. granarius* after being exposed to the black pepper and red pepper powder at five concentrations after 50 days. Adult emergence was significantly suppressed by two plant powders (100% efficiency). All dosages of both powdered spices caused significant reduction of adult emergence of *S. granarius* and at the highest dosages completely inhibited that. Also significant reductions were found on *R. dominica*. Treatment with red pepper was less effective than black pepper against *R. dominica*.

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 references (in accessible literatures) regarding effects of the black pepper (*Piper nigrum* L.) seed powder and red pepper (*Capsicum annuum* L.) fruit powder on *R. dominica* and *S. granarius* to be compared with the results obtained in the present study.

Even thought, these finding are similar with the observation of Udo (2005) who reported that powder of *P.guineense* on maize weevil (*Sitophilus zeamais* Mots) at 1% and 5% concentrations, caused significant mortality and also progeny production was significantly influenced by it ($P<0.05$).

Also this result is similar with what Asawalam et al. (2007) found who showed that at 2% concentration the powders of *P. guineense* and *C. frutescens* had the

highest percentage mortality against *S. zeamais* (Mots) 79.8 and 75.1 respectively, and significantly reduced adult emergence when compared with control.

Also, Donald et al. (2008) stated that 5 and 10% powder of *P. guineense* was significantly toxic to *S. zeamais* and suppressed F_1 progeny emergence compared to 1% powder and the control. It also corresponds to the studies of other researchers who study about powders of black and red peppers effects on *Callosobruchus* spp. that are cited in the introduction.

These results certify our results that black pepper and red pepper powder are effective in causing mortality and suppressing F_1 adult emergence and there is an inverse relationship between count of adult emergence and tested dosages.

On the bases of the findings it could be concluded that plant powders pose potential in protecting wheat against two species of tested insects. Regarding the side effects of synthetic pesticides, the study demonstrates that these plant powders can play an important role in protection of wheat from insect invasion during storage. This technology is cheap, safe, environmentally friendly and easy to adopt by small-scale farmer.

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.

Asawalam, E. F., Emosairue, S. O., Ekeleme F. & Wokocha, R. C. 2007. Insecticidal effects of powdered parts of pight nigerian plant species against maize weevil *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae). EJEAFChe, 6(11): 2526-2533.

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.

Blazejewska, A. & Wyrostkiewicz, K. 1998. The Influence of *Foeniculum vulgare* Fruit Powder. EJPAU, 1(1): 05. Available in: http://www.ejpau.media.pl/volume1/issue1/agronomy/art-05.html

Donald, A. U., Gabriel, A. A. & Emmanuel, I. O. 2008. Toxicity and oviposition deterrence of *Piper guineense* (Piperaceae) and *Monodora myristica* (Annonaceae) against *Sitophilus zeamais* (Motsch.) on stored maize. Journal of Entomology. Available in: http://scialert.net/qredirect.php?doi=je.2008.295.299&linkid=pdf

Echezona, B. C. 2006. Selection of pepper cultivars (*Capsicum* spp.) for the control of bruchids *Callosobruchus maculatus* (F.) on stored cowpea (*Vigna unguiculata* (L.) Walp.) seeds. African Journal of Biotechnology, 5(8): 624-628. Available in: http://www.academicjournals.org/AJB

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.

Fao. 1999. The Use of Spices and Medicinals as Bioactive Protectants for Grains. Fao Agricultural Services Bulletin No. 137. Available in: http://www.fao.org/docrep/x2230E/x2230e00.HTM

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

Nadra, H. A. M. 2004. Testing some various botanical powders for protection of wheat grain against *Trogoderma granarium* Everts. Journal of Biological Sciences, 4(5): 592-597.

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.

Oparaeke, A. M. & Bunmi, J. O. 2006. Bioactivity of two powdered spices (*Piper guineense* Honn & Schum and *Xylopia Aethiopica* (Dunal) A. Richard) as home made insecticides against *Callosobruchus subinnotatus* (Pic.) on stored Barbara groundnut. Agricultura Tropica et Subtropica, 39(2): 132-134.

Owoade, R.A. 2008. Mortality, growth and development of *Dermestes maculatus* larvae exposed to dry *Clarias* sp. treated with four local spices. African Scientist, 9(1): 31-34.

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.

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 in: www.bioline.org.br/ja

Table 1. Mean mortality of adults of *R. dominica* exposed to wheat grains treated with black pepper (A) and red pepper (B) powders at different concentrations and after different exposure times.

(A)

Dosage [w/w]	Exposure time [day]				
	1	3	5	7	14
0.15	3.23±3.23 n	18.44±0.00 kl	27.21±2.63 ij	35.80±5.01 gh	39.09±3.66 fg
0.2	3.23±3.23 n	20.62±1.26 jk	32.33±2.05 ghi	45.02±2.04 ef	53.02±0.74 d
0.27	3.23±3.23 n	24.60±1.80 ijk	36.26±1.23 gh	51.58±1.88 de	58.52±2.09 cd
0.37	11.07±3.91 m	27.35±1.72 ij	37.77±0.86 fgh	56.21±2.71 d	69.42±1.26 b
0.5	12.16±4.67 lm	30.82±0.80 hi	39.98±0.73 fg	63.55±1.47 bc	90.00±0.00 a

(B)

Dosage [w/w]	Exposure time [day]				
	1	3	5	7	14
0.5	12.93±0.00 l	15.69±1.59 kl	19.24±2.34 hijkl	22.65±1.66 ghijk	26.49±1.47 efghi
0.85	12.93±0.00 l	17.07±1.38 jkl	21.28±2.92 ghijkl	27.44±0.86 efgh	33.93±1.93 de
1.5	18.15±1.59 ijkl	20.62±1.26 ghijkl	29.01±2.43 efg	32.39±1.51 def	39.20±2.10 cd
3	19.24±2.34 hijkl	25.41±2.61 fghij	33.63±4.82 def	39.89±3.25 cd	46.47±1.86 bc
5	21.71±1.09 ghijk	34.36±4.64 de	42.79±4.33 c	52.53±4.33 b	60.23±2.46 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 ($P<0.05$).
* Values are means of four replicates ± S.E.
* Means subjected to arcsin-transformation.

Table 2. Mean mortality of adults of *S. granarius* exposed to wheat grains treated with black pepper (A) and red pepper (B) powders at different concentrations and after different exposure times.

(A)

Dosage [w/w]	Exposure time [day]		
	1	3	5
0.15	29.26±2.37 h	42.06±1.18 fg	52.11±0.90 de
0.2	31.00±2.28 h	42.79±0.75fg	59.41±4.34 cd
0.27	35.00±2.28 gh	49.06±2.43 ef	62.68±2.73 c
0.37	35.74±2.48 gh	49.78±2.12 ef	71.52±6.70 b
0.5	38.03±2.79 gh	55.83±1.50 cde	90.00±0.00 a

(B)

Dosage [w/w]	Exposure time [day]				
	1	3	5	7	14
0.5	17.07±1.38 j	17.07±1.38 j	18.52±2.08 j	18.52±2.08 j	20.74±3.02 ij
0.85	20.62±1.26 ij	24.46±2.49 ghi	27.02±1.36 fgh	27.02±1.36 fgh	28.12±1.78 fg
1.5	21.57±1.96 hij	27.07±3.18 fgh	29.69±1.45 efg	29.69±1.45 efg	31.65±1.64 def
3	24.69±1.09 ghi	29.10±1.60 efg	34.72±0.52 de	36.26±1.25 d	42.73±2.60 c
5	26.49±1.47 fgh	31.53±2.09 def	37.06±1.05 d	48.81±2.32 b	59.22±1.40 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 ($P<0.05$).
* Values are means of four replicates ± S.E.
* Means subjected to arcsin-transformation.

Table 3. Mean reduction of F_1 adult emergence of *R. dominica* exposed to wheat grains treated with black pepper (A) and red pepper (B) powders at different concentrations after 50 days.

(A)

Dosage [w/w]				
0.15	0.2	0.27	0.37	0.5
57.25±0.22 d	65.69±0.12 c	76.48±0.83 b	76.68±0.72 b	80.81±0.27 a

(B)

Dosage [w/w]				
0.5	0.85	1.5	3	5
33.40±0.88 d	39.45±0.23 c	47.27±0.26 b	59.02±0.34 a	60.32±0.37 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 ($P<0.05$).
* Values are means of four replicates ± S.E.
* Means subjected to arcsin-transformation.

Table 4. Mean reduction of F_1 adult emergence of *S. granarius* exposed to wheat grains treated with black pepper (A) and red pepper (B) powders at different concentrations after 50 days.

(A)

Dosage [w/w]				
0.15	0.2	0.27	0.37	0.5
9.60±0.01 e	9.69±0.01 d	9.79±0.02 c	9.85±0.03 b	10.00±0.00 a

(B)

Dosage [w/w]				
0.5	0.85	1.5	3	5
9.93±0.03 b	9.94±0.03 b	9.97±0.02 ab	10.00±0.00 a	10.00±0.00 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 ($P<0.05$).
* Values are means of four replicates ± S.E.
* Means subjected to square root -transformation.