Effect of four powdered spices as repellents against adults of *Rhyzopertha dominica* (F.), *Sitophilus granarius* (L.) and *Tribolium castaneum* (Herbst) in laboratory conditions

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Abstract

Studies were conducted to test the repellency of four powdered spices, black pepper (*Piper nigrum.*), chili pepper (*Capsicum annuum*), cinnamon (*Cinnamomum aromaticum*) and turmeric (*Curcuma longa*), against three stored-product insects, the lesser grain borer, *Rhyzopertha dominica*, the granary weevil, *Sitophilus granarius* and the red flour beetle, *Tribolium castaneum*. The cup bioassay technique was used, to determine the response of insects to potential repellents by measuring their movement from treated grain. The device is made of galvanized screening with 2 mm perforations shaped into a cylinder of 6 cm diameter and 15 cm high, with a mesh bottom, and is placed in the centre portion of plastic container of 15 cm diameter and 15 cm high. The powdered spices were poured into 200 g of wheat mass by a long-stemmed funnel at concentrations of 0, 0.25, 0.75, 1.5 and 2.5% on (w/w) basis. Twenty adults of three species are released into the centre of the grain mass in the container through a long-stemmed funnel. The experiments were conducted at room conditions. The number of trapped insects was determined at 3 different intervals after the introduction of the insects. Results showed that all tested plant powders had repellent activity against the three stored-product insects. Adults of *S. granarius* repelled faster, followed by *T. castaneum* and *R. dominica*. At the highest concentrations and intervals, wheat grains treated with cinnamon powder were the most repellent to adults of *S. granarius* (up to 92.5% after 1 h), followed by chili pepper treatment for *T. castaneum* (up to 72.5% after 6 h) and black pepper treatment for *R. dominica* (up to 58.75% after 24 h).

Keywords: Repellency, Spices, Rhyzopertha dominica, Sitophilus granarius, Tribolium castaneum

1. Introduction

Insects are one of the basic problems of stored grains throughout the world, due to the quantitative and qualitative losses they cause (Fields, 2006). 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, the increased of the 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; Mahdi and Rahman, 2008). Therefore, there is a need to look for alternative organic sources that are readily available, affordable, less toxic to mammals 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). The protection of stored products generally involves mixing grains with plant-based protectants (Tapondjou et al., 2002).

In fact, management of stored product pests using materials of natural origin is nowadays the subject which received much attention, 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 high toxicity and the inhibition of reproduction (Emeasor et al., 2005; Nadra, 2006). In addition to high toxicity to insects, many natural products are also repellent or attractive (Mohan and Fields, 2002). 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 mode of action of powders vary, but with low to moderate dosages, the effect is repellent or toxic, never mechanical (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. food preservation, as medicine, in religious rituals, as cosmetics, in perfumery or as vegetables (Mahdi and Rahman, 2008). The use of spices is less costly, easily available for the developing world, safer and do not cause hazards in the commodity (Aslam et al., 2002; Mahdi and Rahman, 2008). Many repellents have been tested using laboratory bioassays; however, these tests do not mimic field conditions or require large amounts of grain to be treated. In the present study, we used a simple, rapid and reliable technique to determine if specific plant products are repellent to stored-product insects and exploits the oriented movement of insects away from or towards the product (Mohan and Fields, 2002).

2. Materials and methods

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

2.1. Preparation of spices and stored products

Black pepper (*Piper nigrum* L.) (Piperaceae) seed, chili pepper (*Capsicum annuum* L.) (Solanaceae) fruit, cinnamon (*Cinnamomum aromaticum* Ness.) (Lauraceae) bark and turmeric (*Curcuma longa* L.) (Zingiberaceae) rhizome powders were used in this investigation. They were selected based on the assumption of absence of mammalian toxicity owing to their use as popular spices in several diets. The spices and wheat kernels were purchased from a local market in Urmia, Iran. The spices were bought dry and 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 the beginning of the experiments. 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.

2.2. Rearing of experimental insects

Local strains of three important stored-product pests were obtained from wheat flour factories, Urmia, Iran. The granary weevil (*Sitophilus granarius* (L.)) (Curculionidae) and the lesser grain borer (*Rhizopertha dominica* (F.)) (Bostrychidae) were reared on uninfected whole kernels of wheat, and the red flour beetle (*Tribolium castaneum* (Herbst)) (Tenebrionidae) was cultured on wheat flour mixed with yeast (10:1 w/w). Insects were released at the rate of 200 adults in 1 L jars containing 400 kg of wheat grains or flour. 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% r.h. After two weeks of oviposition, the parent insects were separated and egg laid materials 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 were used in the experiments.

2.3. Repellency tests

The cup bioassay technique (Mohan and Fields, 2000) determines the response of insects to potential repellents by measuring their movement from treated grain (Pretheep Kumar et al., 2004). The device is made of galvanized screening with 2 mm perforations, which allows only insects and not grain to pass through, shaped into a cylinder of 6 cm diameter and 15 cm high, with a mesh bottom, and is placed in the centre portion of plastic container of 15 cm diameter and 15 cm high. This plastic cup collects the insects that left through the sides and bottom. The powdered spices were poured into 200 g of wheat mass by a long-stemmed funnel at concentrations of 0.25, 0.75, 1.5 and 2.5% on the weight of plant material/weight of grain (w/w) basis. Controls without treatment were maintained to record natural movement. Twenty adults of three species are released into the centre of the grain mass in the container through a long-stemmed funnel. The container was covered by a muslin cloth to prevent the escape of flying insects. All experiments were conducted at a room conditions. The repellency was measured in terms of speed of response shown by the insects in their movement away from the treated source or grain. The number of trapped insects was determined at 3 different intervals after the introduction of the insects, 1, 6 and 24 h for *R. dominica*, 15, 30 and 60 min for *S. granarius* and 1, 3 and 6 h for *T. castaneum*, respectively. There were four replicates per treatment.

2.4. Statistical analysis

Data were transformed with an arcsine (percentages) method before ANOVA because the percentage data ranged from 0 to 100%. All counts were submitted to a two-way ANOVA ($P<0.05$), by using the MSTATC statistical package. The experimental design was completely randomized design. Means of the four replicates of treatments were compared using Tukey's multiple comparison tests for significance of their differences.

3. Results

Results showed that all tested powdered spices possess repellent activity against the three stored-product insects. The repellency of these powders increased with the increase in dosage as well as the increase in the period of exposure to the plant powders. Adults of *S. granarius* were repelled most quickly followed by *T. castaneum* and *R. dominica*, after 1, 6 and 24 h, respectively. At the highest concentrations and time periods, wheat grains treated with cinnamon powder were the most repellent to adults of *S. granarius* (up to 92.5% after 1 h), followed by chili pepper treatment for *T. castaneum* (up to 72.5% after 6 h) and black pepper treatment for *R. dominica* (up to 58.7% after 24 h). The order of repellency effects of four powdered spices at the highest dosages and period of time on *R. dominica* were black pepper>cinnamon>chili pepper>turmeric, on *S. granarius* were cinnamon>black pepper>chili pepper>turmeric and on *T. castaneum* were chili pepper>black pepper>cinnamon>turmeric.

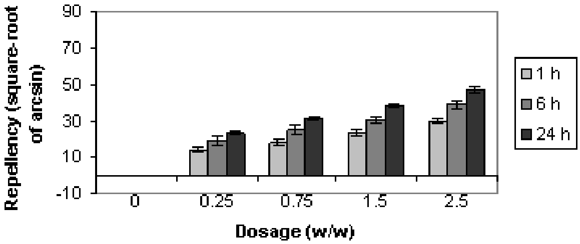

Figure 1 Mean repellency of cinnamon powder to *Rhyzopertha dominica* adults.

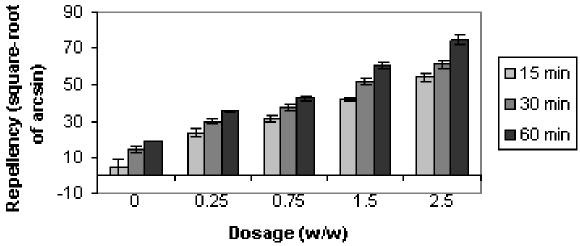

Figure 2 Mean repellency of cinnamon powder to *Sitophilus granarius* adults.

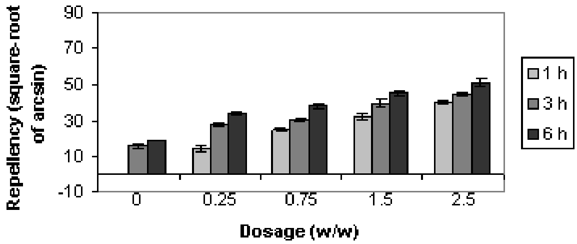

Figure 3 Mean repellency of cinnamon powder to *Tribolium castaneum* adults.

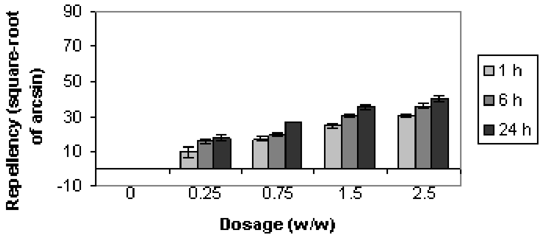

Figure 4 Mean repellency of turmeric powder to *Rhyzopertha dominica* adults.

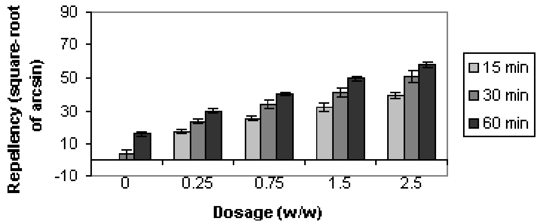

Figure 5 Mean repellency of turmeric powder to *Sitophilus granarius* adults.

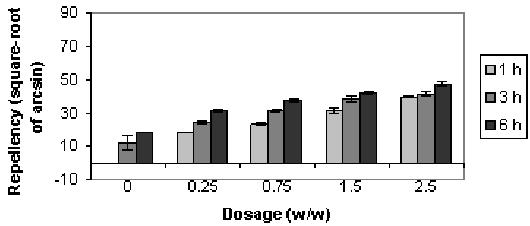

Figure 6 Mean repellency of turmeric powder to *Tribolium castaneum* adults.

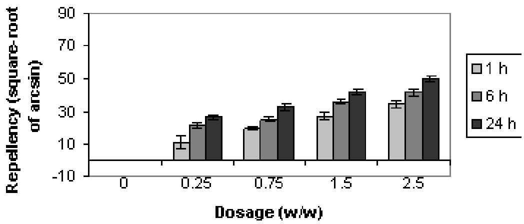

Figure 7 Mean repellency of black pepper powder to *Rhyzopertha dominica* adults.

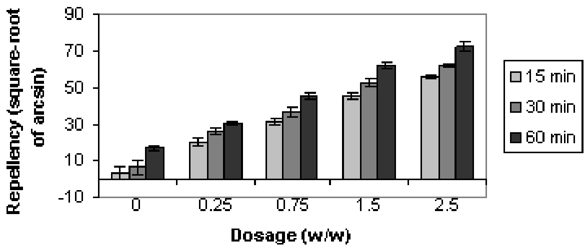

Figure 8 Mean repellency of black pepper powder to *Sitophilus granarius* adults.

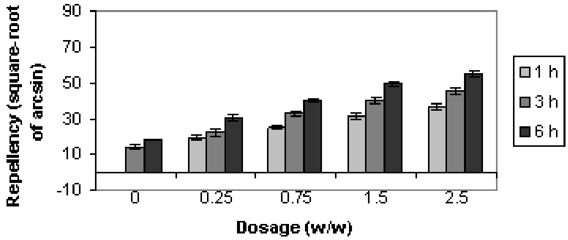

Figure 9 Mean repellency of black pepper powder to *Tribolium castaneum* adults.

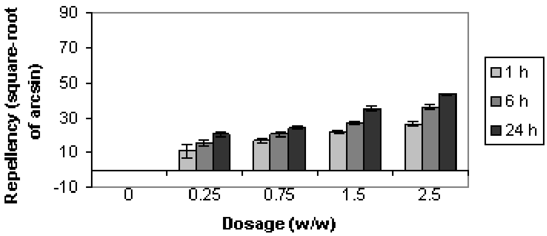

Figure 10 Mean repellency of red pepper powder to *Rhyzopertha dominica* adults.

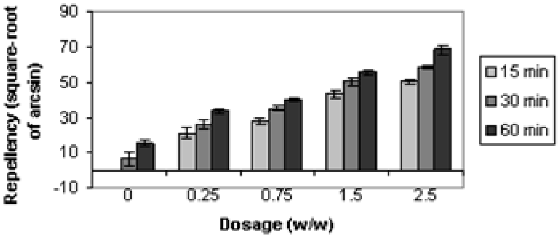

Figure 11 Mean repellency of red pepper powder to *Sitophilus granarius* adults.

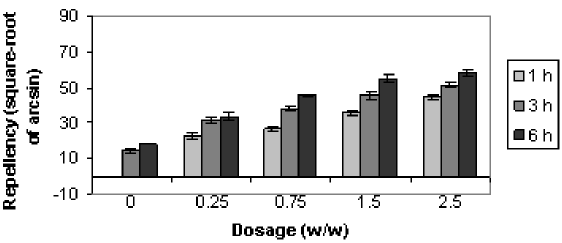

Figure 12 Mean repellency of red pepper powder to *Tribolium castaneum* adults.

4. Discussion

The cup bioassay technique used to test the repellency of plant products against the stored product insects closely mimics the grain storage conditions. The main advantage of the cup bioassay technique is that it is in the grain medium and actual storage conditions are taken into consideration. The cup bioassay technique can be used for the preliminary screening of plant products for their repellency against stored-product insects. This will help to save time in identifying the insecticidal property of plant products (Pretheep Kumar et al., 2004).

A good level of repellency was achieved with powders of these four spices, especially on the *S. granarius* adults, which indicates that would be highly effective in preventing the infestation by *S. granarius*. Cinnamon powder was found to be the highest repellent agent in comparison to all other powders on *S. granarius*. In addition, the repellency effects of cinnamon powder on adults of *R. dominica* and *T. castaneum* indicate that it caused noticeable repellent effects. The repellency of black pepper and chili pepper also showed the effective result to the insects at 2.5%. Turmeric powder produced the least effect to the three species examined.

Unfortunately, there is still inadequate information regarding the effects of these powders on *R. dominica, S. granarius* and *T. castaneum*. Nevertheless, the findings are similar with the observation of Udo (2005) who reported that powder of *P. guineense* had the highest repellent effect of 80% on maize weevil adults, *Sitophilus zeamais* (Mots.) (Curculionidae), among five different spices. It also corresponds to the studies of Salvadores et al. (2007) who showed that the powders of *P. nigrum*, *C. annuum* and *Cinnamomum zeylanicum* Blume had a repellent effect on *S. zeamais*.

Based on the present findings, it could be concluded that plant powders pose potential in protecting wheat against three 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 farmers.

References

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, 2510-2515.

Aslam, M., Ali Khan, Kh., Bajwa, M.Z.H., 2002. Potency of some spices against *Callosobruchus chinensis* L. Online Journal of Biological Sciences 2, 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, 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.

Mahdi, Sh.H.A., Rahman, Md.K., 2008. Insecticidal effect of some spices on *Callosobruchus maculatus* (Fabricius) in black gram seeds. Rajshahi University Zoological Society 27, 47-50.

Mohan, S., Fields, P.G., 2002. A simple technique to assess compounds that are repellent or attractive to stored-product insects. Journal of Stored Products Research 38, 23-31.

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, 121-135.

Pretheep Kumar, P., Mohan, S., Balasubramanian, G., 2004. Effect of whole pea flour and a protein-rich fraction as repellents against stored-product insects. Journal of Stored Products Research 40, 547-552.

Rajapakse, R.H.S., 2006. The potential of plants and plant products in stored insect pest management. The Journal of Agricultural Sciences 2, 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, 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, 147-154.

Tapondjou, L.A., Adler, C., Bouda, H., Fontem, D.A., 2002. Efficacy of powder and essential oil from *Chenopodium ambrosioides* leaves as post-harvest grain protectants against six-stored product beetles. Journal of Stored Products Research 38, 395-402.

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, 165-168.