*J. Crop Prot. 2014, 3 (Supplementary): 589-595*

Research Article

# The effects of topical application of two essential oils against *Sitophilus granarius* (Coleoptera: Curculionidae) and *Tribolium confusum* (Coleoptera: Tenebrionidae)

**Masumeh Ziaee**

Department of Plant Protection, Faculty of Agriculture, Shahid Chamran University of Ahvaz, Ahvaz, Iran.

**Abstract:** Bioassays were conducted to assess the contact toxicity of two plant essential oils against adults of *Sitophilus granarius* (L.) and *Tribolium confusum* Jacquelin du Val. Essential oils were extracted from seeds of *Carum copticum* L. and *Cuminum cyminum* L. Contact toxicity was assessed by topical application and adult mortality was counted 1, 2, 6 and 24 h after exposure. Bioassays were carried out at 27 ± 1 °C and 65 ± 5% RH in continuous darkness. Results indicated the two essential oils tested were topically toxic to both species. The mortality increased with increase in the oils dose and time exposed to each dose. Adults of *S. granarius* were more sensitive to *C. copticum* oil ($LD_{50}$ = 0.009 µg/mg body wt) than *C. cyminum* essential oil ($LD_{50}$ = 0.016 µg/mg body wt). In general, *T. confusum* showed similar sensitivity to both essential oils. However, adults of *T. confusum* were more resistant than *S. granarius*. *C. copticum* and *C. cyminum* oils have potential for use in stored-product pest management.

**Keywords:** Essential oil, stored products, topical application

## Introduction

Protection of agricultural products from pest infestations is in the concern of government, farmers, and those involved in this matter. From earlier times, synthetic pesticides have been used for pest control. However, hazardous effects of synthetic pesticides tend to the use of safer pesticides (Conway and Pretty, 2013). Pesticides based on plant essential oils are considered relatively safe and their efficacy has been demonstrated against different insect species. Essential oils have volatile compounds with insecticidal, antifungal and antimicrobial activity (George *et al.*, 2014). Therefore, plant essential oils or their constituents are one of the most promising alternatives to pesticides. They are of natural origin, eco-friendly and have low mammalian toxicity (Ebadollahi, 2011).

Ajwain, *Carum copticum* L. (Apiaceae) and cumin, *Cuminum cyminum* L. (Apiaceae) are two medicinal plants that their essential oils proved to have insecticidal activity against a number of stored product pests (Sahaf *et al.*, 2007). The insecticidal efficacy of *C. copticum* essential oil has been investigated against *Callosobruchus maculatus* (F.), *Sitophilus oryzae* (L.), *Tribolium castaneum* (Herbst) and *Plodia interpunctella* (Hubner) (Sahaf and Moharramipour, 2008; Sahaf *et al.*, 2007; Shojaaddini *et al.*, 2008). Cumin is used as a food additive with white or pink flowers and small green seeds. It is an aromatic, annual plant that grows in Iran, Egypt, Saudi-Arabia, and some other part of the world (Boskabady *et al.*, 2006). The fumigant toxicity of *C. cyminum*

Handling Editor: Saeid Moharramipour

* **Corresponding author**, e-mail: masumeh_ziaee@yahoo.com
Received: 05 April 2014, Accepted: 14 June 2014
Published online: 15 June 2014

essential oil has been evaluated on *C. maculatus, C. chinensis*, *Acanthoscelides obtectus* Say, *T. castaneum*, *S. oryzae* and *S. granarius* (Arabi *et al.*, 2007; Chaubey, 2007, 2008, 2011; Karakoc *et al.*, 2006).

The confused flour beetle, *Tribolium confusum* Jacquelin du Val. (Coleoptera: Tenebrionidae) is categorized as a secondary pest feeding on cereal grains that are damaged, or going out of condition, flour and related products. The granary weevil, *Sitophilus granarius* (L.) (Coleoptera: Curculionidae), is known as a primary pest; these two are able to feed on whole and undamaged cereal grains. These pests are probably two of the most destructive stored-product insect pests throughout the world affecting the quantity as well as quality of the grains (Athanassiou *et al.*, 2005).

The aim of the present study was to investigate contact toxicity of *C. copticum* and *C. cyminum* essential oils against adults of *T. confusum* and *S. granarius.*

## Materials and Methods

### Insects

Adults of *T. confusum* and *S. granarius* were used in the experiments. *T. confusum* was reared on wheat flour plus 5% brewer yeast and *S. granarius* on wheat at 27 ± 1 °C and 65 ± 5% RH in continuous darkness. All adults used in the experiments were 7-14 days old and of mixed sex.

### Plant materials

Seeds of *C. copticum* and *C. cyminum* were purchased from a research farm in Ferdowsi University-Mashhad-Iran on June 2012. Seeds were packed in bags and kept in the refrigerator at 4 °C until they were needed.

### Essential oil extraction

Oil extraction was performed using a Clevenger type apparatus (Made by Karimpour, Tehran University). Conditions of extraction were: 40 g of seeds; 600 mL distilled water and 4 h distillation. Anhydrous sodium sulphate (Merck Co.) was used to remove water after extraction. Essential oil was stored in self standing screw cap microtubes covered with foil at 4˚C until beginning of the experiment. Density of *C. copticum* essential oil was measured 0.9472 mg/ml and for *C. cuminum* oil density was 0.9574 mg/ml.

### Bioassays

In order to assess the contact toxicity of essential oils by topical application, preliminary dose setting experiment was carried out to determine a range of doses that would cause a range of 20–80% mortality. For each treatment doses were selected in the symmetric dose design (Robertson *et al.*, 1984) and measured in micrograms per mg body weight (µg/mg body wt) (based on oils density). The doses are presented in Tables 1-4. Six replicates of 10 adults were prepared and untreated beetles served as a control. Adults weighing 1.54 ± 0.01 mg for *S. granarius* and 2.5 ± 0.01 mg in case of *T. confusum* were selected for the bioassays. Doses were topically applied to the ventral surface of the thoracic segments of the insects with a Hamilton microsyringe (Hamilton Company). Treated and untreated insects were introduced into petri dishes in incubator set at 27 ± 1 °C and 65 ± 5% RH in continuous darkness. The mortality was counted 1, 2, 6 and 24 h after exposure to the essential oils.

### Statistical analysis

There were no mortality in control groups; so, there was no need to correct the mortality data. Mortality percentages were transformed to square root of arcsine to normalize the data. The data were subjected to one-way analysis of variances to determine significant differences between exposure time and dose levels. To estimate $LD_{50}$ values, data were subjected to Probit analysis (Finney, 1971). Statistical analysis were performed using SPSS software version 16.0 (SPSS, 2007).

## Results

The toxicity of essential oils increased with increasing dose level and time exposed to each dose. The two essential oils tested were topically effective to *S. granarius*. The dose of 0.06 µg/mg body wt of *C. copticum* oil was significantly more effective to control *S. granarius*, and caused 95% mortality after 2 h of exposure (Table 1). While for *C. cyminum* essential oil, this dose was effective after 6 h and lead to more than 92% mortality (Table 2). *T. confusum* treated with 0.152 µg/mg body wt of *C. copticum* oil caused 91.66% mortality after 1 h exposure which exceeded to 100% after 24 h (Table 3). The same results were observed for *C. cyminum* oil. The dose of 0.152 µg/mg body wt caused 93.3% mortality after 1 h and reached to 100% after 24 h of exposure (Table 4); indicating the essential oils were more toxic at longer durations.

Based on $LD_{50}$ values adults of *S. granarius* were more sensitive to *C. copticum* oil (Table 5); while the toxicity of both essential oils were the same on *T. confusum* (Table 6). Also according to results *T. confusum* adults are more resistant than *S. granarius.*

**Table 1** Mortality (%) ± SE of *Sitophilus granarius* exposed topically to different concentrations of *Carum copticum* essential oil.

| Concentration (µg/mg body wt) | Exposure time (h) | | | |
|---|---|---|---|---|
| | 1 | 2 | 6 | 24 |
| 0.006 | 0.0 ± 0.00h | 21.7 ± 1.66g | 26.3 ± 2.71fg | 36.4 ± 3.35ef |
| 0.019 | 3.3 ± 2.10h | 58.3 ± 3.07d | 63.2 ± 3.59cd | 70.9 ± 3.63bcd |
| 0.031 | 41.7 ± 3.07e | 65.0 ± 4.28cd | 70.2 ± 3.23bcd | 80.0 ± 3.35b |
| 0.060 | 73.3 ± 2.10bc | 95.0 ± 2.23a | 96.5 ± 2.21a | 98.2 ± 1.81a |
| 0.124 | 96.7 ± 2.10a | 100 ± 0.00a | 100 ± 0.00a | 100 ± 0.00a |

Means followed by the same letter are not significantly different; Tukey Multiple Range Test at *P* = 0.05.

**Table 2** Mortality (%) ± SE of *Sitophilus granarius* exposed topically to different concentrations of C*uminum cyminum* essential oil.

| Concentration (µg/mg body wt) | Exposure time (h) | | | |
|---|---|---|---|---|
| | 1 | 2 | 6 | 24 |
| 0.006 | 0.0 ± 0.00h | 21.7 ± 3.07fg | 28.1 ± 5.02f | 32.7 ± 4.37ef |
| 0.019 | 0.0 ± 0.00h | 35.0 ± 3.41ef | 36.8 ± 2.71def | 45.5 ± 4.87cde |
| 0.031 | 46.7 ± 2.10cde | 51.7 ± 3.07cd | 52.6 ± 2.35c | 58.2 ± 3.35c |
| 0.060 | 76.7 ± 3.33b | 85.0 ± 4.28ab | 93.0 ± 3.50a | 94.5 ± 3.72a |
| 0.124 | 95.0 ± 2.23a | 98.3 ± 1.66a | 100 ± 0.00a | 100 ± 0.00a |

Means followed by the same letter are not significantly different; Tukey Multiple Range Test at *P* = 0.05.

**Table 3** Mortality (%) ± SE of *Tribolium confusum* exposed topically to different concentrations of *Carum copticum* essential oil.

| Concentration (µg/mg body wt) | Exposure time (h) | | | |
|---|---|---|---|---|
| | 1 | 2 | 6 | 24 |
| 0.019 | 0.0 ± 0.00k | 23.3 ± 2.10ij | 31.6 ± 4.70hij | 36.6 ± 4.20ghi |
| 0.038 | 5.0 ± 3.41k | 31.6 ± 1.60hij | 35.0 ± 4.28hi | 40.0 ± 3.65fgh |
| 0.076 | 20.0 ± 2.58j | 53.3 ± 2.10ef | 63.3 ± 2.10de | 73.3 ± 3.30cd |
| 0.114 | 50.0 ± 2.58efg | 61.6 ± 3.00de | 70.0 ± 2.58cd | 81.7 ± 1.66bc |
| 0.152 | 91.7 ± 3.07ab | 95.0 ± 2.23ab | 98.3 ± 1.66a | 100 ± 0.00a |

Means followed by the same letter are not significantly different; Tukey Multiple Range Test at *P* = 0.05.

**Table 4** Mortality (%) ± SE of *Tribolium confusum* exposed topically to different concentrations of C*uminum cyminum* essential oil.

| Concentration (µg/mg body wt) | Exposure time (h) | | | |
|---|---|---|---|---|
| | 1 | 2 | 6 | 24 |
| 0.019 | 0.0 ± 0.0l | 20.0 ± 2.58jk | 30.0 ± 2.58hij | 36.7 ± 2.10gh |
| 0.038 | 10.0 ± 3.65kl | 23.3 ± 2.10ij | 33.3 ± 2.10hi | 40.0 ± 2.58fgh |
| 0.076 | 21.6 ± 3.07j | 30.0 ± 3.65hij | 45.0 ± 2.23efg | 48.3 ± 3.07ef |
| 0.114 | 55.0 ± 2.23e | 75.0 ± 2.23d | 83.3 ± 2.10cd | 88.3 ± 3.07bc |
| 0.152 | 93.3 ± 2.10abc | 96.6 ± 2.10ab | 100 ± 0.00a | 100 ± 0.00a |

Means followed by the same letter are not significantly different; Tukey Multiple Range Test at $P = 0.05$.

**Table 5** $LD_{50}$ values of *Sitophilus granarius,* 24 h after topically exposing to *Carum copticum* and *Cuminum cyminum.*

| Plants | $LD_{50}$ (µg/mg body wt) | 95%Confidence limit | | Slope | $\chi^2$ (df = 2) | *P* value |
|---|---|---|---|---|---|---|
| | | Lower | Upper | | | |
| *C. copticum* | 0.009 | 0.006 | 0.011 | 1.94 | 2.44 | 0.29 |
| *C. cyminum* | 0.016 | 0.007 | 0.037 | 0.81 | 0.27 | 0.60 |

**Table 6** $LD_{50}$ values of *Tribolium confusum,* 24 h after topically exposing to *Carum copticum* and C*uminum cyminum.*

| Plants | $LD_{50}$ (µg/mg body wt) | 95%Confidence limits | | Slope | $\chi^2$ (df = 2) | *P* value |
|---|---|---|---|---|---|---|
| | | Lower | Upper | | | |
| *C. copticum* | 0.037 | 0.027 | 0.046 | 1.63 | 2.370 | 0.305 |
| *C. cyminum* | 0.039 | 0.029 | 0.049 | 1.66 | 4.185 | 0.123 |

## Discussion

Fumigant toxicity of *C. copticum* and *C. cyminum* essential oils have been extensively studied (Chaubey, 2007; Sahaf and Moharramipour, 2008; Sahaf *et al.*, 2007; Shojaaddini *et al.*, 2008). The effectiveness of these plant powders have also been proved on *S. granarius* and *T. confusum* adults (Ziaee and Moharramipour, 2013). However, contact toxicity of the oils has not been evaluated. Results indicated that the longer exposure time to the oils, the lower dose is required to control the beetles. Essential oils can be toxic via the respiratory system (fumigant effect), cuticle (contact effect) and digestive system (ingestion effect) (Prates *et al.*, 1998). In direct contact, essential oils may penetrate via insect's cuticle and contact the nerve endings in the invertebrate pest's trachea, and cause neurotoxic activity and more rapid death (Bessette *et al.*, 2013). According to our results, 100% mortality was observed on both tested beetles when exposed for 24 h to *C. copticum* and *C. cyminum* essential oils and it could be concluded that topical application method could control insects effectively. Haouas *et al.* (2012) stated that topical application of *Chrysanthemum grandiflorum* (L.) Batt. essential oil caused a significant insect mortality (27%) on *T. confusum* after 7 days of exposure. Zapata and Smagghe (2010) evaluated contact toxicity of two essential oils by topical application. They claimed that $LD_{50}$ values by topical application of *Laurelia sempervirens* essential oil extracted from leaf was 44 µg/mg insect; and for *Drimys winteri* leaf oil was 85 µg/mg insect against *T. castaneum* after 24 h of exposure. On the basis of $LD_{50}$ values, in this study, *C. copticum* and *C. cyminum* essential oils were found to be more toxic than *L. sempervirens* and *D. winteri* oils. In addition, *S. granarius* adults indicated more sensitivity (overlap in 95% confidence limits) than *T. confusum*. Liu and Ho (1999) declared that adults of *S. zeamais* were more sensitive ($LD_{50}$ = 0.043 µg/mg insect) than *T. castaneum* ($LD_{50}$ = 0.118 µg/mg insect) to *Evodia rutaecarpa* Hook f. et Thomas essential oil applied topically. Chu *et al.* (2011) evaluated contact toxicity of some constituents of *Illicium difengpi* stem bark essential oil by topical application against *T. castaneum* and *Sitophilus zeamais* Motsch. They reported that safrole have more contact toxicity against both insect species with $LD_{50}$ = 4.67 µg/adult for *T. castaneum* and 8.54 µg/adult for *S. zeamais*. According to their findings linalool efficacy was less than safrole with $LD_{50}$ = 8.12 µg/adult for *T. castaneum* and 24.88 µg/adult for *S. zeamais*. Therefore, essential oils toxicity could be according to their chemical constituents.

Moreover, the method applied for the bioassays is also effective in causing mortality in stored-products insect pests. Aggarwal *et al.* (2001) evaluated toxicity of 1,8-cineole against *C. maculatus*, *S. oryzae* and *Rhyzopertha dominica* (F.). They stated that higher doses were required to achieve 100 % kill when using fumigant toxicity with filter paper discs than in topical application. This may be because impregnated filter paper provides less direct contact. Deletre *et al.* (2013) emphasized that essential oils easily penetrate insect cuticle, which increases their bioavailability which may be the reason for high toxicity of essential oils in direct contact.

## Conclusion

It could be concluded that *T. confusum* adults were significantly more resistant than *S. granarius*. The insecticidal efficacy of both essential oils was more or less the same. Direct contact of essential oils cause more penetration of the oils via insect's cuticle causing fast knockdown and more mortality. Therefore, the essential oils of *C. copticum* and *C. cyminum* may be applied as an alternative to synthetic insecticides for stored-products insect pest management.

## Acknowledgements

Special thanks to Miss Yasaman Shafighi for providing insect colonies used in this study.

## References

Aggarwal, K. K., Tripathi, A. K., Prajapati, V. and Kumar, S. 2001. Toxicity of 1, 8-cineole towards three species of stored product coleopterans. International Journal of Tropical Insect Science, 21: 155-160.

Arabi, F., Moharramipour, S. and Sefidkon, F. 2007. Insecticidal effects of essential oils from *Cuminum cyminum* L. (Apiaceae) and *Perovskia abrotanoides* Karel (Lamiaceae) on some stored-product insects. Unpublished Master's Thesis, Tarbiat Modares University. Tehran-Iran.

Athanassiou, C. G., Vayias, B. J., Dimizas, C. B., Kavallieratos, N. G., Papagregoriou, A.S. and Buchelos, C. T. 2005. Insecticidal efficacy of diatomaceous earth against *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae) and *Tribolium confusum* du Val (Coleoptera: Tenebrionidae) on stored wheat: influence of dose rate, temperature and exposure interval. Journal of Stored Products Research, 41: 47-55.

Bessette, S., Lindsay, A. and Enan, E. 2013. Pesticidal compositions containing rosemary oil and wintergreen oil. US Patent. US 20130142893 A1.

Boskabady, M. H., Kianai, S., Azizi, H. and Khatami, T. 2006. Antitussive effect of *Cuminum cyminum* Linn. in guinea pigs. Natural Product Radiance, 5: 266-269.

Chaubey, M. K. 2007. Toxicity of essential oils from *Cuminum cyminum* (Umbelliferae), *Piper nigrum* (Piperaceae) and *Foeniculum vulgare* (Umbelliferae) against stored-product beetle *Tribolium castaneum* Herbst (Coleopetera: Tenebrionidae). Electronic Journal of Environmental Agricultural and Food Chemistry, 6: 1719-1727.

Chaubey, M. K. 2008. Fumigant toxicity of essential oils from some common spices against pulse beetle, *Callosobruchus* *chinensis* (Coleoptera: Bruchidae). Journal of Oleo Science, 57: 171-179.

Chaubey, M. K. 2011. Fumigant toxicity of essential oils against rice weevil *Sitophilus oryzae* L. (Coleoptera: Curculionidae). Journal of Biological Sciences, 11: 411-416.

Chu, S. S., Wang, C. F., Du, S. S., Liu, S. L. and Liu, Z. L. 2011. Toxicity of the essential oil of *Illicium difengpi* stem bark and its constituent compounds towards two grain storage insects. Journal of Insect Science, 11: 1-10.

Deletre, E., Martin, T., Campagne, P., Bourguet, D., Cadin, A., Menut, C., Bonafos, R. and Chandre, F. 2013. Repellent, irritant and toxic effects of 20 plant extracts on adults of the malaria vector *Anopheles gambiae* Mosquito. PLoS ONE, 8: e82103.

Ebadollahi, A. 2011. Chemical constituents and toxicity of *Agastache foeniculum* (Pursh) kuntze essential oil against two stored−product insect pests. Chilean Journal of Agricultural Research, 71: 212-217.

Finney, D. J. 1971. Probit Analysis, third ed. Cambridge University Press, London.

George, D. R., Finn, R. D., Graham, K. M. and Sparagano, O. A. 2014. Present and future potential of plant-derived products to control arthropods of veterinary and medical significance. Parasites and Vectors, 7: 28-355.

Haouas, D., Cioni, P., Ben Halima-Kamel, M., Flamini, G. and Ben Hamouda, M. 2012. Chemical composition and bioactivities of three *Chrysanthemum* essential oils against *Tribolium confusum* (du Val) (Coleoptera: Tenebrionidae). Journal of Pest Science, 85: 367-379.

Conway, G. R. and Pretty, J. N. 2013. Unwelcome Harvest: Agriculture and Pollution. Routledge, London. 676 pp.

Karakoc, Ö. C., Gökce, A. and Telci, I. 2006. Fumigant activity of some plant essential oils against *Sitophilus oryzae* L., *Sitophilus granarius* L. (Col.: Curculionidae) and *Acanthoscelides obtectus* Say. (Col.: Bruchidae). Turkiye Entomoloji Dergisi, 30: 123-135.

Liu, Z. L. and Ho, S. H. 1999. Bioactivity of the essential oil extracted from *Evodia rutaecarpa* Hookf. et Thomas against the grain storage insects, *Sitophilus zeamais* Motsch.and *Tribolium castaneum* (Herbst). Journal of Stored Products Research, 35: 317-328.

Prates, H. T., Santos, J. P., Waquil, J. M., Fabris, J. D., Oliveira, A. B. and Foster, J. E. 1998. Insecticidal activity of monoterpenes against *Rhyzopertha dominica* (F.) and *Tribolium castaneum* (Herbst). Journal of Stored Products Research, 34: 243-249.

Robertson, J. L., Smith, K. C., Savin, N. E. and Lavigne, R. J. 1984. Effects of dose selection and sample size on the precision of lethal dose estimates in dose mortality regression. Journal of Economic Entomology, 77: 833-837.

Sahaf, B. Z. and Moharramipour, S. 2008. Fumigant toxicity of *Carum copticum* and *Vitex pseudo-negundo* essential oils against eggs, larvae and adults of *Callosobruchus maculatus*. Journal of Pest Science, 81: 213-220.

Sahaf, B. Z., Moharramipour, S. and Meshkatalsadat, M. H. 2007. Chemical constituents and fumigant toxicity of essential oil from *Carum copticum* against two stored product beetles. Insect Science, 14: 213-218.

Shojaaddini, M., Moharramipour, S. and Sahaf, B. Z. 2008. Fumigant toxicity of essential oil from *Carum copticum* against Indian meal moth, *Plodia interpunctella*. Journal of Plant Protection Research, 48: 411-419.

SPSS, 2007. SPSS 16 for Windows User’s Guide Release. Spss Inc, Chicago

Zapata, N. and Smagghe, G. 2010. Repellency and toxicity of essential oils from the leaves and bark of *Laurelia sempervirens* and *Drimys winteri* against *Tribolium castaneum*. Industrial Crops and Products, 32: 405-410.

Ziaee, M. and Moharramipour, S. 2013. Effectiveness of medicinal plant powders on *Sitophilus granarius* and *Tribolium confusum*. Journal of Crop Protection, 2: 43-50.

# اثر حشره‌کشی دو اسانس گیاهی علیه *Sitophilus granarius* (Coleoptera: Curculionidae) و *Tribolium confusum* (Coleoptera: Tenebrionidae) به روش موضعی

**معصومه ضیائی**

گروه گیاهپزشکی، دانشکده کشاورزی، دانشگاه شهید چمران اهواز، اهواز، ایران.
* پست الکترونیکی نویسنده مسئول مکاتبه: m.ziaee@scu.ac.ir
دریافت: ۱۶ فروردین ۱۳۹۳؛ پذیرش: ۲۴ خرداد ۱۳۹۳

**چکیده:** زیست‌سنجی‌ها به‌منظور ارزیابی اثر تماسی دو اسانس گیاهی علیه حشرات بالغ شپشه گندم *Sitophilus granarius* (L.) و شپشه آرد *Tribolium confusum* Jacquelin du Val. به روش موضعی صورت گرفت. اسانس از بذر دانه‌های زنیان *Carum copticum* L. و زیره سبز *Cuminum cyminum* L. استخراج شد. مرگ و میر حشرات کامل ۱، ۲، ۶ و ۲۴ ساعت پس از تیمار شدن بررسی شد. زیست سنجی‌ها در دمای ۱ ± ۲۷ درجه سلسیوس، رطوبت نسبی ۵ ± ۵۵ درصد و در تاریکی انجام شد. نتایج نشان داد هر دو اسانس مورد آزمایش به‌صورت موضعی روی دو گونه حشره سمی بودند. مرگ‌ومیر حشرات کامل با افزایش دز اسانس و زمان قرارگیری در مجاورت هر دز افزایش یافت. حشرات کامل شپشه گندم نسبت به اسانس زنیان ($LD_{50}$= ۰/۰۰۹ µg/mg body wt) حساس‌تر از اسانس زیره سبز ($LD_{50}$= ۰/۰۱۶ µg/mg body wt) بودند. به‌طور کلی، شپشه آرد حساسیت مشابهی به هر دو اسانس نشان داد. حشرات بالغ شپشه آرد مقاوم‌تر از شپشه گندم بودند. اسانس‌های زنیان و زیره سبز دارای پتانسیل استفاده در برنامه‌های مدیریت آفات محصولات انباری هستند.

**واژگان کلیدی:** اسانس گیاهان، محصولات انباری، کاربرد موضعی