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Efficacy of some plants as a post-harvest protectant against some major stored pests

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The toxicity of vapours of the essential oil of Ferula gummosa, Elettaria cardamomum and Salvia officinalis on the adults and larvae of some stored product pests was investigated. The bioassays were carried out in 70 mL vials containing 10 individuals of each insect. The LC₅₀ values of fumigant bioassay after 24 h were calculated. Results indicated that the effect of the essential oil of F. gummosa was stronger than E. cardamomum, S. officinalis on stored pests. Also fumigant toxicity of S. officinalis on Sitophilus oryzae was similar to that of Sitophilus granarius adults. On the other hand, R. officinalis had a good effect on adults of Tribolium castaneum and larvae of Ephestia kuehniella. According to our results and good effect of these compounds, they will be a safe replace for chemical compounds in the future.

Keywords: Ferula gummosa; Elettaria cardamomum; Salvia officinalis; essential oil; fumigant toxicity

Introduction

Using the synthetic pesticides for control of stored product pests is expensive, dangerous and has toxic residue in foods. Absence of these and having less harm compounds to non-target organisms, has changed plants to good replacement of synthetic compounds (Shaaya et al. 1997; Prabakr and Jebanesan 2004). A wide variety of higher plants may provide new sources of natural pesticides (Granige and Ahmed 1988). Using essential oils, a suitable way for preservation grains from stored products, traditionally were used in some Asian and African countries (Shaaya et al. 1997).

A perennial plant, Ferula gummosa Boiss. (Apiaceae), is original to Central Asia and Iran. The gum of F. gummosa has a vast application in Iran (Zargari 1991). The gum of aerial parts of F. gummosa has been used for the treatment of some disease in Iranian traditional medicine (Aqili-Khorassani 1991; Zargari 1991). F. gummosa is a rich source of terpenoid compounds (Valencia et al. 1994). Rosmarinus officinalis L. (Lamiaceae) is a small evergreen which grows wild in most Mediterranean countries
(Hethhelyi et al. 1987). This plant has been used in the traditional medicine and cosmetics and has been used as flavouring agent in foods (Pintore et al. 2002). The small cardamom, *Elettaria cardamomum* (Maton) (Zingiberaceae) is an old spice plant for human consumption. The home of this crop is southern part of the Western Ghats, India (Wilkinson and Elevitch 2000). A popular herb, *Salvia officinalis*, is used as a culinary for seasoning and for medicine in treatment of several diseases. The botanical name of that is composed from two parts: *Salvia* (salvëre in Latin) means “to save” or “to heal” and *officinalis* means medicinal (Dweck 2000; Miura et al. 2002).

Two curculionid insects, *Sitophilus oryzae* (L.) and *Sitophilus granarius* (L.) (Coleoptera: Curculionidae) are serious pests in stores. They may also infest grain in the field. Holes in the side of the grain are made by adults and emerging adults. *S. oryzae* attracts to rice and *S. granarius* can infest wheat, barley, maize and various other cereals (Prickett and Muggleton 1991; Dress and John 1999). Two major pests of flour industrial are *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) and The Mediterranean flour moth, *Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae) (Jacob and Cox 1977; Millas and Pedersen 1990).

This study was a part of a project to investigate the insecticidal activity of the botanical compounds (extracts and essential oils) of some plants on some insect pests. Some of the results of this project were reported (Abbasipour et al. 2010a, 2011; Mahmoudvand et al. 2011a, 2011b) and some of them are in reviewing process. Current study was composed from three sections. The first was comparison of fumigant toxicity of essential oils of *F. gummosa*, *E. cardamomum* and *S. officinalis* on adults of *S. granarius*. In the next section, two species of *Sitophilus* were compared with regard to fumigant toxicity of essential oil of *S. officinalis*. In this study, the effect of *R. officinalis* on *E. kuehniella* and *T. castaneum* was researched. All of tests were studied after 24 h. This study was one of the first studies on the insecticidal properties of *F. gummosa*, *E. cardamomum* and *S. officinalis*.

**Materials and methods**

**Essential oils extraction**

Resins of *F. gummosa* and leaves of *S. officinalis* were collected in September 2009 from Kordestan and Kashan, Iran. Leaves of *R. officinalis* were collected from the garden of the Medicinal Plants Research Center of Shahed University, Tehran, in July, 2009. Also seeds of *E. cardamomum* were purchased from medicinal shop in Tehran in May 2009. All the collected plants materials were shade dried at room temperature. Then, the dried materials were subjected to hydrodistillation using Clevenger type distiller (Cavalcanti et al. 2004). For the extraction of essential oils, 50 g of each air-dried plant material was put in water (1:12, w:v) for distillation during 4 h. Extracted essential oils were dried via anhydrous sodium sulphate and stored at 4°C in darkness. Pure essential oils were used in all tests.

**Rearing of insects**

The insects’ colonies were reared under 27 ± 1°C and 65 ± 5% RH and darkness condition. For rearing *T. castaneum* and *E. kuehniella*, flour and for *S. granarius* and *S. oryzae* wheat and rice grains were used, respectively.
Fumigant bioassay

The fumigant toxicity of essential oils on the adults of *T. castaneum*, *S. granarius* and *S. oryzae* (1–7-day old) and third larvae of *E. kuehniella* (2-day old) were tested in glass vials (70 mL) and in each of them 10 insects were released. Filter paper disks (Whatman No. 1) were cut into 2 cm in diameter and were attached to undersurface of screw caps of glass vials. Filter papers were impregnated with series of concentrations of each essential oil. After 24 h, the treated insects were transferred to untreated vials. Four replicates were run for each concentration and for control groups. There was no mortality in control. The 50% and 90% lethal concentrations (LC<sub>50</sub> and LC<sub>90</sub>) values were assessed by Probit analysis (Finney 1971) using SAS software (SAS Institute 1997).

Results

Effect of three essential oils on *S. granarius*

In Table 1, the effect of essential oils of *F. gummosa*, *E. cardamomum* and *S. officinalis* on the adults of *S. granarius* after 24 h was reported. Values of LC<sub>50</sub> of *F. gummosa*, *E. cardamomum* and *S. officinalis* were 44.25, 220.76 and 342.97 μL L<sup>-1</sup> air, respectively. The results showed *F. gummosa* was more effective than other essential oils on *S. granarius*.

Effect of *S. officinalis* on *Sitophilus* species

After 24 h, LC<sub>50</sub> values of the essential oil of *S. officinalis* on *S. granarius* and *S. oryzae* was 342.97 and 311.09 μL L<sup>-1</sup> air (Table 2). Table 2 indicates that susceptibility of two species of *Sitophilus* spp. is approximately similar.

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<th>n&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Df</th>
<th>LC&lt;sub&gt;50&lt;/sub&gt; (μL L&lt;sup&gt;-1&lt;/sup&gt; air)</th>
<th>LC&lt;sub&gt;90&lt;/sub&gt; (μL L&lt;sup&gt;-1&lt;/sup&gt; air)</th>
<th>Slope ± SE</th>
<th>χ&lt;sup&gt;2&lt;/sup&gt;</th>
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<tr>
<td></td>
<td>F. gummosa</td>
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<td>E. cardamomum</td>
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<td>220.76</td>
<td>353.94</td>
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<td>(322.53–405.38)</td>
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<td>S. officinalis</td>
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<td>5.06 ± 0.87</td>
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<td>342.97</td>
<td>614.05</td>
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<td>(314.30–375.42)</td>
<td>(519.68–845.64)</td>
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|<sup>1</sup>Number of individuals.

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<th>n&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Df</th>
<th>LC&lt;sub&gt;50&lt;/sub&gt; (μL L&lt;sup&gt;-1&lt;/sup&gt; air)</th>
<th>LC&lt;sub&gt;90&lt;/sub&gt; (μL L&lt;sup&gt;-1&lt;/sup&gt; air)</th>
<th>Slope ± SE</th>
<th>χ&lt;sup&gt;2&lt;/sup&gt;</th>
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<td>5.06 ± 0.87</td>
<td>2.69</td>
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<td>342.97</td>
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<td>(314.30–375.42)</td>
<td>(519.68–845.64)</td>
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<tr>
<td></td>
<td>S. oryzae</td>
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<td>6.01 ± 1.07</td>
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<td>311.09</td>
<td>508.09</td>
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<td>(285.19–333.93)</td>
<td>(446.94–652.25)</td>
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|<sup>1</sup>Number of individuals.
Effect of *R. officinalis* on *E. kuehniella* and *T. castaneum*

Table 3 shows the effect of essential oil of *R. officinalis* on third larvae of *E. kuehniella* and adult of *T. castaneum* after 24 h. Values of LC$_{50}$ of *R. officinalis* on *E. kuehniella* and *T. castaneum* were 100.52 and 103.28 µL L$^{-1}$ air.

**Discussion**

In this study, we investigated the effect of some essential oils on some major stored pests. Rajendran and Sriranjini (2008) reported that plant materials are good choice for fumigant assay because of their low toxicity to mammals, fast degradability and regional availability.

The obtained results of this study indicated that the essential oils of *F. gummosa*, *E. cardamomum*, *S. officinalis* and *R. officinalis* on management of stored pests’ density are effective.

In the current study, the essential oil of *R. officinalis* showed equal toxicity on third larvae of *E. kuehniella* and adults of *T. castaneum*. Mahmoudvand et al. (2011b) stated that *R. officinalis* essential oil had fumigant toxicity on *Callosobruchus maculatus* (F.) (Col.: Bruchidae). Calculated LC$_{50}$ of *R. officinalis* in the report of Mahmoudvand et al. (2011b) was 46.81 µL L$^{-1}$. This illustrated that sensitivity of *C. maculatus* was approximately two-folds of tested objects of *E. kuehniella* and *T. castaneum*. Mahmoudvand et al. (2011a) stated that essential oil of *R. officinalis* had a good effect on moths of *P. interpunctella*. There are a few reports about the insecticidal effect of *F. gummosa*, *E. cardamomum* and *S. officinalis* on insects. The outcomes clearly showed that *F. gummosa* effect is higher than *E. cardamomum* and *S. officinalis* on adults of *S. granarius*. Essential oil of *S. officinalis* had a good toxicity on *S. granarius* and *S. oryzae*. Similar to our results, Rastegar et al. (2009) stated that in treating *T. castaneum* with *S. officinalis*, the LC$_{50}$ value of fumigant assay was 46.77 µL L$^{-1}$ after 24 h. These results indicated that *T. castaneum* is more susceptible than *S. officinalis* in facing *S. officinalis*. In this study, the effect of essential oil of *F. gummosa* on *S. granarius* was investigated, too. Insecticidal activity of *F. gummosa* had been reported by Hosseinpour et al. (2009), heretofore. In that research, LC$_{50}$ value of *F. gummosa* on *T. castaneum* at 24 h was 225.3 µL L$^{-1}$ (Hosseinpour et al. 2009). According to the results of the present study and Hosseinpour et al. (2009), the susceptibility of *T. castaneum* to *F. gummosa* was lower than *S. granarius*. The physiological difference between these insects could be the reason of this variation. Fumigant toxicity of *E. cardamomum* on *T. castaneum*, *C. maculatus* and moths of *E. kuehniella* was found by Abbasipour et al. (2010b).

In this study, the efficacy of this essential oil on *S. granarius* was stronger than moths

| Table 3. Fumigant toxicity of *Rosmarinus officinalis* essential oil on third instar larvae of *Ephestia kuehniella* and adults of *Tribolium castaneum* after 24 h. |
|-------|---|-------------|---------------------|-----------------|-------------|
|       | n | Df | LC$_{50}$ (µL L$^{-1}$ air) | LC$_{90}$ (µL L$^{-1}$ air) | Slope ± SE | χ$^2$ |
| *E. kuehniella* | 280 | 5 | 100.52 (93.08–108.21) | 166.67 (144.65–220.17) | 5.83 ± 1.03 | 6.11 |
| *T. castaneum* | 280 | 5 | 103.28 (92.63–113.91) | 228.01 (199.72–271.60) | 3.72 ± 0.34 | 9.41 |

1Number of individuals.
of *E. kuehniella* and *C. maculatus* and weaker than *T. castaneum* in the research of Abbasipour et al. (2010b).

In conclusion, the tested essential oils of this study clearly showed variation of insects in susceptibility to plants. The essential oils of *F. gummosa*, *E. cardamomum* and *S. officinalis* are effective as fumigant toxin on *S. granarius*. Among these, *F. gummosa* was stronger than others and toxicity of *S. officinalis* was lower than others. The weakness efficacy of *S. officinalis* was seen about *S. oryzae* and *S. granarius*. Also, the good effect of the essential oil of *R. officinalis* on the third instar larvae of *E. kuehniella* and adults of *T. castaneum* was in agreement with previous reports in this topic. Although the toxicity of *S. officinalis* on *T. castaneum* and *Sitophilus* spp. was not clear, all essential oils examined in the present study exerted good toxicity on stored-product pests and can be used for management of these pests.

References


