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Antifeedant properties of extracts derived from different parts of some medicinal plants against the granary weevil, *Sitophilus granarius* Linnaeus, and 1758 (Coleoptera: Curculionidae)

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Abstract
The different solvent extracts (*viz.* Chloroform, Hexane and Methanol) obtained from leaves and flowers of Common Dandelion, *Taraxacum officinale* and St. John's Wort, *Hypericum perforatum* were researched for antifeedant activity against the wheat weevil, *Sitophilus granarius*. All the six different extracts showed antifeedant activity at four different concentrations. The methanol extracts of leaves of *Taraxacum officinale* and *Hypericum perforatum* exhibited significant activity at 4% concentration. The numbers of seed holes produced were only 16.67 and 21.00 respectively, which are significantly less than the number of seed holes produced in control group, 102.00 and 97.33 respectively. The treatment with methanol extracts of flowers of both the plants significantly reduced the number of feeding holes to 18.00 and 22.67 respectively in comparison to the control group values of 100.00 and 99.00. All the efficiencies are dose dependent. The mean results with SEM (mean ± SE) were statistically significant at 1% level ($p<0.01$) for three treatments.

Keywords: antifeedant, medicinal plant, the granary weevil

Introduction

Of the five primary insect pests, the granary weevil or the wheat weevil (*Sitophilus granarius* Linnaeus, 1758), the rice weevil (*Sitophilus oryzae* Linnaeus, 1763), the maize weevil (*Sitophilus zeamaise* Motschulsky, 1855), and the lesser grain borer (*Rhyzopertha dominica* Fabricius, 1792) may well be called grain weevils. The fifth primary pest, the Angoumois grain moth (*Sitotroga cerealella* Olivier, 1789), so destructive to wheat and corn, may be called a grain moth. Other insects likely to be found in grain may be called simply beetles, moths, and meal-worms. Their presence usually does not indicate a condition likely to affect the grain trade, if the grain, after it has reached the elevator, is screened and fanned to remove these insects (Davis and Bry, 1985; Devaraj and Srilatha, 1993; Sahayaraj, 1998) [1-3]. The granary weevil, *Sitophilus granarius* Linnaeus, 1758 is one of the most common and destructive primary insect pests of stored grain (Fava and Gaino, 1996) [4]. The control of this insect population in the world depends primarily on insecticides and fumigants, which has caused undesirable effects on non-target organisms, the feeding environment and human health problems (Hagstrum *et al*., 1999) [5]. The increasing concern about the level of pesticide residues in foods has prompted researchers to look for synthetic pesticide alternatives (Hamza *et al*., 2016; Karakas, 2018) [6, 7]. Their indiscriminate use has led to the development of resistant pest species as well as different environmental and human health problems. Recently, attention has been paid to the use of higher plant products in different parts of the world as new chemotherapeutics in plant protection. Plant products have potential in pest management due to their phytotoxicity, systemicity, readily biodegradability and the stimulating nature of the host metabolism. Widespread until the 1940s, these natural pesticides replaced modern synthetic pesticides that looked cheaper, easier, and longer lasting at the time. Botanical pesticides are growing in popularity once again, and some plant products are used as green pesticides around the world (Sexena, 1987; Thomas,*et al*., 2002; Saljoqi *et al*., 2006) [8-10]. Fumigants should be biologically active, volatile enough to be removed through ventilation, not absorbed by the grain, and not flammable or corrosive. Currently, few chemicals are available for use as fumigants that meet all these restrictions. The use of methyl bromide, the most effective fumigant, will soon be restricted due to its potential ozone depletion properties. What's more, it's highly toxic to warm-blooded animals, including humans (Huang and Subramanyam, 2005) [11]. The use of widely used phosphine fumigation may be limited because resistance of stored grain beetles to phosphine has been discovered in more than 45 countries. Additionally, phosphine has been suggested to be genotoxic to occupationally exposed fumigators. Due to the increasing disadvantages in the continuous use of today's conventional fumigants, an effort is required to develop new compounds to replace those currently used. Essential oils are potential sources of alternative compounds to fumigants currently used. Essential oils have low toxicity for warm-blooded animals, high volatility, and toxicity to stored grain insect pests (Hamza *et al*., 2016) [6].

The purpose of the study was to find out the effectiveness of some medicinal plants against the granary weevil, *S. granarius* adults for their antifeedant insecticidal properties.

Materials and Methods

Test insect

The granary or wheat weevil, *Sitophilus granarius* Linnaeus, 1758 was reared in a 1 L wide-mounted glass jars containing (250 g) soft wheat grains. Mouth of the jars covered with a fine mesh cloth for ventilation and to prevent escape of the weevils. Cultures were maintained in an incubator at 27 ± 1 °C and 60 ± 5 % relative humidity. Insects used in all experiments were 1 to 7 day old adults.

All experimental procedures were carried out under the same environmental conditions as the cultures. The wheat granary weevil adults were obtained from the stock culture of the laboratory of the Plant Protection Department, Faculty of Agriculture, and Ankara. The life cycle can be completed in as little 30 to 40 days during the culture conditions but takes considerable longer in cooler conditions. Adult granary weevils can live up to eight months and can produce up to four generations per year.

Test plants

In this study, antifeedant effects of leaf and flower extracts from common dandelion, *Taraxacum officinale* Weber ex F.H. Wiggers, 1780 (Asteraceae) and St. John's Wort, *Hypericum perforatum* Linnaeus, 1753 (Hypericaceae) were tested against the granary weevil, *S. granarius*. These medicinal plants were obtained from an herbal shop of Ankara.

Plant preparation

The leaves and flowers of the *T. officinale* and *H. perforatum* were dried separately at a temperature of 50-55 ºC and were coarsely ground. Each powdered sample was extracted successively with chloroform, hexane and methanol in Soxhlet apparatus. The solvent from each extract was removed under vacuum and weighed quantity was re-dissolved in acetone to prepare the stock solution. Different concentrations were prepared from the stock by diluting in acetone. The stock solutions were stored in a refrigerator at 4 ºC.

Antifeedant tests

All the extracts were assessed for antifeedant activity against *S. granarius* adults. Soft wheat grains (100 g) were sprayed with different concentrations (*viz*. 0.5, 1, 2 and 4 %) of each extract (*i.g.* chloroform-leaf/flower, hexane-leaf/flower, and methanol-leaf/flower) and air dried for twenty minutes and then put into 500 ml glass jars.

Twenty numbers of 12 hr starved adult *S. granarius* released on the treated wheat grains and mouth of the jars covered with a fine mesh cloth for ventilation and to prevent escape of the weevils and stored culture conditions. There were three replications for each treatment and control. The insects were then allowed to feed for 24 hr and the numbers of feeding holes in wheat grains were recorded. The wheat grains in control group were sprayed with acetone only.

Statistical assessment

The results are expressed as Mean ± SEM (Standard Error of the Mean) and data were statistically analysed by one-way ANOVA, with the level of significance set at $p<0.01$.

Results and Discussion

The present study reveals that different solvent extracts of *T. officinale* and *H. perforatum* have more or less antifeedant effects on the test insect, *S. granarius*. There is however, diversity in the range of activity among the extracts with three different solvents. The most effective bioactive plant species is *T. officinale*, the methanol extract of it exhibited very significant effect against *S. granarius*. The number of seed holes after treatment with 4.0% methanol extract of *T. officinale* was only 20.33 whereas in control the number was 102.00. The other two extracts, *viz.* chloroform and hexane extract, also showed very promising result. In each concentration of treatment there was significant reduction in feeding ($p<0.01$). The number of seed holes of chloroform extract of leaves of *T. officinale* at 4, 2, 1 and 0.5% concentrations were 18.67, 20.33, 24.00 and 32.33 respectively. The hexane extract of leaves also gave excellent results (Table 1). *H. perforatum* leaves also had very strong antifeedant results; here too, the methanol extract (4%) gave the best results (Table 2).

In case of flower extracts, the *T. officinale* showed very promising results. Here also, the methanol extract was found to be best. The number of seed whole after treatment with methanol extract at 4% was 24.00, which was significantly less than the other treatment. The other solvents *viz.* chloroform and hexane also possesses very good antifeedant property (Table 1). Different solvent extracts of flowers of *H. perforatum* at various concentrations were also found to have very dominating antifeedant activity (Table 2).

In all the treatments the numbers of seed holes produced by the insects were less than those of control ($p<0.01$).

Table 1: Antifeedant activity of leaves and flowers of *T. officinale* against the granary weevil, *S. granaries*

Concentrations (%)	Seed Holes (n) / 24 hr					
	Chloroform		Hexane		Methanol	
	Leaf	Flower	Leaf	Flower	Leaf	Flower
4.0	18.67±0.33	23.67±0.33	17.67±0.33	23.33±0.86	16.67±0.33	18.00±1.00
2.0	20.33±0.33	26.00±0.00	20.33±0.33	24.00±1.00	18.67±0.33	21.33±0.67
1.0	24.00±1.00	31.33±0.67	23.67±0.67	26.67±0.33	20.33±0.33	24.33±0.33
0.5	32.33±1.20	43.33±1.86	30.33±0.67	38.00±0.58	28.67±0.33	35.33±1.86
Control	102.00±1.00	100.00±0.60	102.00±1.00	100.00±0.60	102.00±1.00	100.00±0.60
SH (P<0.01)	3.14	2.99	3.34	4.33	2.33	4.03

Significant at 1% level since ($p<0.01$). Each result is the Mean ± SE for three replicates. SH: Seed Hole.

Table 2: Antifeedant activity of leaves and flowers of *H. perforatum* against the granary weevil, *S. granaries*

Concentrations (%)	Seed Holes (n) / 24 hr					
	Chloroform		Hexane		Methanol	
	Leaf	Flower	Leaf	Flower	Leaf	Flower
4.0	23.33±0.88	26.67±0.33	21.33±0.33	23.67±0.33	21.00±0.33	22.67±0.33
2.0	28.67±0.33	37.00±1.00	26.00±0.58	28.67±0.67	26.00±0.58	28.67±0.33
1.0	33.33±0.67	47.00±1.00	31.33±0.88	38.33±0.67	30.33±0.67	37.67±1.20
0.5	38.33±0.67	56.33±0.67	35.33±0.33	54.67±0.33	32.33±1.20	52.67±0.33
Control	97.33±0.67	99.00±1.00	97.33±0.67	99.00±1.00	97.33±0.67	99.00±1.00
SH (P<0.01)	2.71	3.69	3.71	3.33	2.99	2.81

Significant at 1% level since ($p<0.01$). Each result is the Mean ± SE for three replicates. SH: Seed Hole.

Interesting findings were reported by different scientist on *Cymbopogon citratus* but with different insect species. Devaraj and Srilatha (1993) [2] found very effective the extracts of *C. citratus* increased mortality of the maize weevil, *Sitophilus zeamais* as compared to control group. Ofuya and Okuku (1994) [12] reported the insecticidal activity of acetone extract of *C. citratus* against *Aphis craccivora* and caused significant nymphal mortality and inhibited reproduction. Viglianco *et al*. (2008) [13] carried out investigation on some plant extracts to evaluate their repellency and feeding deterrency to control *S. oryzae*. They used three plants (*Alaysia polystachia*, *Solanum argentium* and *Tillandsia recurvata*) for their studies. They reported hexane extract of *S. argentium* with strongest repellent effects (class IV) against *S. oryzae* whereas, ethanol and chloroform extracts of all plants recorded moderate repellency. Hamza *et al*. (2016) [6] described that the examination of the volatile oils extracted from plant materials as well as bioassay for evaluating the fumigant toxicity against the granary weevil *S. granarius*. Results showed that Thuja, Eucalyptus and Peppermint oils could be applicable to the management of populations of *S. granarius*. On biological control that can be applied against insects, Karakas (2017) [14] showed that ethanol extracts of five plants materials i.e. chervil (*Anthriscus cerefolium*), bay (*Laurus nobilis*), sage (*Salvia officinalis*), fennel (*Foeniculum vulgare*) and rosemary (*Rosmarinus officinalis*) against wheat granary weevil, *Sitophilus granarius* L. were tested to determine their insecticidal properties. The results revealed that all of the tested materials with some variations had repellent and lethal effects against the pest as compared with the untreated check. Considering the % mortality of the insect as a main index, rosemary proved to be the most effective of these five plant materials, showed 60.5 % mortality, followed by sage (46.6 %) and chervil (31.4 %), while bay (19.2 %) was found less effective followed by fennel (26.4 %).

The findings of all these studies support that aromatic or medicinal plant extracts can be used as a nutritional inhibitor or antifeedant, repellent and toxic in the biological control of insects.

In this study, in which the effect of herbal preparations that may have antifeedant effects on wheat weevils was investigated, it is thought that there may be different bioactive compounds with antifeedant effects in the plant extracts used. Current findings suggest that the leaves and flowers of these plants have certain bioactive ingredients that require further research to determine the exact mode of action of these active ingredients and their effects on non-target organisms.

Conclusion

Medicinal plants have a variety of chemicals that can be isolated and used for the control of stored grain product insects. These medicinal plants will produce environmentally sensitive chemicals that have no harmful effects on non-target organisms.

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