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Roll of three essential oils and their Nano against *Ephestia cautella* (Lepidoptera-Pyralidae) under laboratory and store conditions

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Abstract : In this work, the essential oils (bulk &nano phase) of Purslane, Mustard and Castor oil were tested for their toxicity, ovipositional deterrent and persistent against larvae and adult of almond moth, *E. cautella* under laboratory and store conditions. The most effective oil was Purslane oil (bulk and nano) followed by Mustard and the least one was Castor against larvae of *E. cautella*. At high concentration, the percentages of larval mortality recorded 70.04, 31.10 & 20.13% and reached 93.61, 79.10& 59.39% in case of Purslane, Mustard and Castor(bulk &nano phase), respectively. Nano- Purslane had strong insecticidal efficacy and was significantly highly effective tested oil against almond moth. The number of laid eggs decreased with increasing tested oils concentrations. The tested oils vapours (bulk and nano phases) had bioresidual effectiveness which progressively decreased with the increase of lapsing storage periods. Mostly a complete inhibition of moth's emergence was recorded in case of nano-Purslane. This can be attributed to the sterilizing effect of Purslane oil in both phases (bulk and nano) on the moths as well as its toxicity to the deposited eggs and adult emergence during storage intervals up to 125 days.
Keywords: Almond moth, essential oils, Purslane, Mustard, Castor oil, repellent activity,

Introduction

The main worldwide pest of stored foods is the almond moth or tropical warehouse moth *Ephestia cautella* .It exists both in tropical and mild zones and usually assaults grains, nuts, dried fruits and a great variety of other stored products [1]. The larva (caterpillar) is the destructive stage and its feeding contaminates stored products with faecal pellets and silk webbing. The adult moths do not feed.

Many of plant essential oils were screened for their effects on metabolic, physiological and behavioral functions of insects[2]. They also have fumigant toxicity and repellent activity against a variety of insects specially stored product insects[3-16]. In agriculture, nanopesticides, nanofungicides and nanoherbicides are perfectly applied[17-23].

This work aims to study the effect of some essential oils comparing with nano- essential oils against almond moth, *Ephestia cautella* infestations under laboratory and during storage.

Materials and Methods

Tested Insect

Larvae of *E. cautella* were used in the experiments. The target insects were reared under laboratory conditions on semi-artificial diet (fine wheat with some adherent endosperm) with 20% glycin and 5% yeast powder. All cultures and experiments were held at 26 ± 2 °C and 70-80% R.H. with 14 hours light and 10 hours dark[24].

Tested essential oils (bulk and nano)

The essential oils of Purslane, Mustard and Castor oil were used in the bioassay tests. The tested essential oils were obtained by steam distillation of dried plants[25]**.** The tested oil emulsions were prepared as follows: 5 drops of Triton X-100 as emulsifier were mixed thoroughly with 5ml of each tested oil, and then water was added to obtain the desired concentrations (2%) in percent of (v/v). The emulsifier was mixed at the corresponding concentrations and used as check.

Encapsulation of nano particles is a method over which a chemical is slowly but efficiently released to the specific host for insect pests control. "Release mechanisms include dissolution, biodegradation, diffusion and osmotic pressure with specific pH"[26]**.** Encapsulated of the three tested oils (Castor oil, Mustard and Purslane*)* nano-emulsion is prepared by high-pressure homogenization of 2.5% surfactant and 100% glycerol, to create stable droplets which that increase the retention of the oil and cause a slow release of the nanomaterial and prolong the protection time against insects[27]**.** Four concentrations were prepared (3, 1.5, 0.5 and 0.05 %) for each tested bulk essential oils and in case of nano- essential oils, the tested concentrations were (0.1, 0.5, 0.05, and 0.005 %).

Larvicidal activity of tested oils (bulk & nano)

The insecticidal activities of tested oils (bulk & nano) were experimented at tested concentrations against the 3rd instar larvae of *E. cautella*. The foam granules sprayed with the tested oils (bulk & nano) were mixed with wheat (2g foam / 100 g wheat) according to[5]. For each tested concentration, four glass jars as replicates were used. Subsequently, ten 3rd instar larvae were introduced into each glass jar and was covered with muslin for appropriate ventilation. Twelve replicates as control larvae were kept under the same conditions without any essential oils treatments.Mortality was evaluated after seven days of exposure in the treated and untreated control. All tests were carried at 27±2°C and 65±5% relative humidity (RH). The number of dead larvae in each jar was assessed and the percentages of mortality were calculated. The experiment was repeated 4 times.

The ovipositional deterrent effects of the tested oils

The foam granules sprayed with the tested oils (bulk & nano) were mixed with wheat (2g foam / 100 g wheat) according to[5]. The ovipositional deterrent of the tested oils was experimented by placing two pairs of mixed sex of almond moth adults(2-3 days old) with treated or untreated wheat grains with foam particles in glass jars (250 cc capacity) covered with muslin (no-choice). The moths were left to lay eggs, and then the numbers of deposited eggs on treated or untreated grains/ female were counted in the tested jars. For each tested concentration, four glass jars as replicates were used and the test was repeated three times[4].

The persistence effect of tested oils in the store

The persistence effect of tested oils (bulk and nano) on foam as surface protectant was evaluated during storage intervals (25 over 125 days) against *E. cautella* moths' infestation. Hundred gram of heat sterilized wheat grains were introduced to gunny sacks (10x10 cm each) closed each with a string. The foam granules (about 1 cm in diameter) were sprayed with treatments, dried and provided as a layer between sacks. Then, two pairs of newly emerged moths were placed in a jar (2 l capacity with two gunny sacks) . After egg laying, the dead moths were removed. The emerged adult moths were counted after tested intervals.

Data were displayed to analysis of variance (ANOVA) and means were compared by a least significant different test.

Results and Discussion

In the present study, the larvicidal activity of tested essential oils (bulk &nano) was studied against *E. Cautella* after seven days of exposure (Tables 1 &2). The mortality percentages increased with the increase in concentration. The extreme efficacy of tested oils was recorded in case of Purslane oil (bulk &nano) followed by Mustard against *E. Cautella* larvae. The larval mortality percentages were (70.04, 51.21, 31.12, and 11.61 %**)** at (3, 1.5, 0.5 and 0.05 %) concentrations, respectively in case of Purslane oil (bulk). The mortality percentages of the treated larvae with nano- Purslane at concentrations (0.1, 0.5, 0.05, and 0.005 %) recorded **(**93.61, 71.54, 52.32 and 30.31%), respectively (Table 2). Castor oil was the least impact against *E. Cautella* larvae.

Table 1: Percentage mortality of tested bulk essential oils against *E. cautella* larvae under laboratory conditions

Bulk oil	concentrations	% of larval mortality
Castor oil	3.0	20.13
	1.5	14.22
	0.5	10.13
	0.05	7.41
Mustard	3.0	43.11
	1.5	31.10
	0.5	23.12
	0.05	15.21
Purslane	3.0	70.04
	1.5	51.21
	0.5	31.12
	0.05	11.61
Control	0.0	0.0
F test		22.5
LSD 5%		10.1

Table 2: Percentage mortality of tested nano essential oils against *E. cautella* larvae under laboratory conditions

Nano oil	concentrations	% of larval mortality
Castor oil	0.1	59.39
	0.5	43.86
	0.05	39.19
	0.005	18.21
Mustard	0.1	79.10
	0.5	60.21
	0.05	15.01
	0.005	3.34
Purslane	0.1	93.61
	0.5	71.54
	0.05	52.32
	0.005	30.31
Control	0.0	0.0
F test		22.2
LSD 5%		10.1

The nano oils were more effective than the bulk phase against larval stage of *E. Cautella***.** The larvicidal effect (mortality percentage) of treated oils may attribute to their chemical components. Various chemical components of Purslane have been isolated like terpenoids, flavonoids, alkaloids, sterols and others. Flavonoids possess biological activities like antibacterial, antivirus and anti- inflammation properties[28]**.**

Also, the major constituents of black mustard seeds are sinigrin and myrosin and its essential oil contains more than 90% allyl- isothiocyanate (AITC)[29]**.** Fumigation of (AITC) extracted from *Armoracia rusticana* showed strong toxicity (100% mortality) against the adults of four tested species of stored product insects[30]**.** One day after fumigation with Cinnamon, Horseradish and Mustard oils, at 0.7 mg /cm_2, were strong toxic against *Lasioderma serricorne* adult beetles[31]. After 168 hrs, Mustard oil was highly toxic against *Bruchidius incarnatus* beetles followed by clove and cumin with mortality percentages (76%, 63% and42.8%), respectively[13]**.**

Table 3: Ovipositional deterrent effect of tested bulk oils against *E. cautella* moth

Bulk oil	**Mean number of eggs/female ±S.E.**		
	Concentration 0.5%	1.5%	3%
Castor oil	220.9±9.7	174.2±3.1	87±7.9
Mustard	198.7±7.8	154.4±1.6	68±3.8
Purslane	108.7+5.4	90.4±1.5	46.4±3.4
Control	300±7.9		
F value **LSD**	43.3. 19.40		

Table 4: Ovipositional deterrent effect of tested nano oils against *E. cautella* moth

Nano oil	**Mean number of eggs/female ±S.E.**		
	Concentration 0.005%	0.05%	0.1%
Castor oil	97.8±7.1	64.4±1.4	59.8±2.9
Mustard	77.0±7.8	49.0±7.7	36.1±1.8
Purslane	22.9+1.4	18.4±8.1	6.1±2.8
Control	300±4.9		
F value **LSD**	33.00 18.12		

Efficacies of tested oils (bulk and nano) as ovipositional deterrent against *E. cautella* moth were experimented (Table 3 &4). The number of laid eggs decreased with increasing tested oils concentrations. Bulk-Purslane was the most significantly effective oil as ovipositional deterrent against *E. cautella* adults with 46.4±3.4, 90.4±1.5 and 108.7+5.4 **eggs/female** at 3, 1.5 &0.5% concentrations, respectively compared with control (300±7.9 eggs/female)(Table 3). While, Purslane as nano-phase became highly significantly more effective as sterilizer against adult moths with 6.1±2.8, 18.4±8.1 and 22.9+1.4 eggs/female at 0.1,0.05 &0.005% concentrations, respectively in comparison with other tested nano-oils. The nano-phase of both Mustard and Castor had moderate ovipositional deterrent effect in comparison with control (Table4). There was no significant effect between Mustard and Castor nano-oils at 0.05% conc. These results are in agreement with[32] who experimented the efficacy of groundnut and mustard oil against *Callosobruchus maculates* infested urd bean. The period of development, adult emergence and number of laid eggs decreased with increasing tested oil concentration. Also, treated broad bean seeds with mustard oil and *Paecilomyces fumosoroseus* completely inhibited laid eggs of *Bruchidius incarnates* during 20,40,and 60 days of storage .Covering gunny bags with foam treated with mustard oil and *P. fumosoroseus* gave promising protection against *B. incarnatus* infestation for 120 days during storage[13]**.**

The tested oils vapours (bulk and nano phases) had bioresidual efficiency which progressively decreased with the increase of lapsing storage periods (Figs 1&2). During tested storage intervals, the percentage of emerged moths were greatly significantly suppressed with Purslane oil (bulk and nano) comparing with untreated control. After 125 days of storage, the percentage of emerged moths reached 33 and 9 % in case of Purslane oil (bulk and nano) comparing with untreated control (95 &93%), respectively under store condition. Mostly a complete inhibition of moth's emergence was recorded in case of nano-Purslane. This can be attributed to the sterilizing effect of Purslane oil in both phases (bulk and nano) on the moths as well as its toxicity to the deposited eggs and adult emergence during storage intervals up to 125 days. Oil of *Acorus calamus* had ovicidal, repellent and protectant properties against *C. chinensis* infestation .And giving a high degree of protection up to a period of 135 days at 1ml/kg concentration[33]. Covering the gunny sacks with treated foam with clove and eucalyptus oils were more effective than the other applications (treated sacks or foam inside sacks) against infestation of *C. maculatus* up to 4 months during storage[5]. The efficacy of the nanoparticles and free garlic essential oil against *T.castaneum* adults was tested[34] . They found that the control efficacy of nanoparticles of garlic essential oil was (80%) followed by free garlic oil (11%). The effective components of nanoparticles turn into extremely efficient due to their delayed and constant release. So, Integration of essential oils into a planned release nano-formulation stop fast vaporization and degradation, enhances persistence and, maintain the lower effective dosage/application[35]**.**

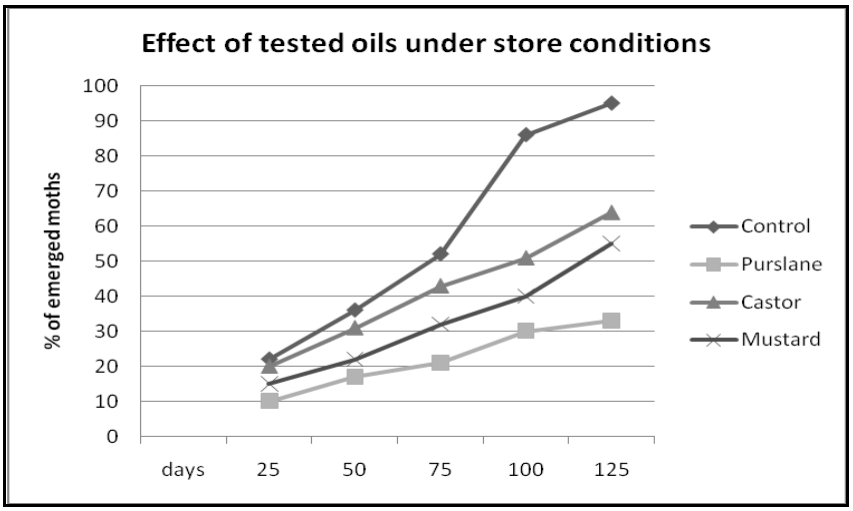

Fig (1). Effect of bulk essential oils against *E. cautella* under store conditions

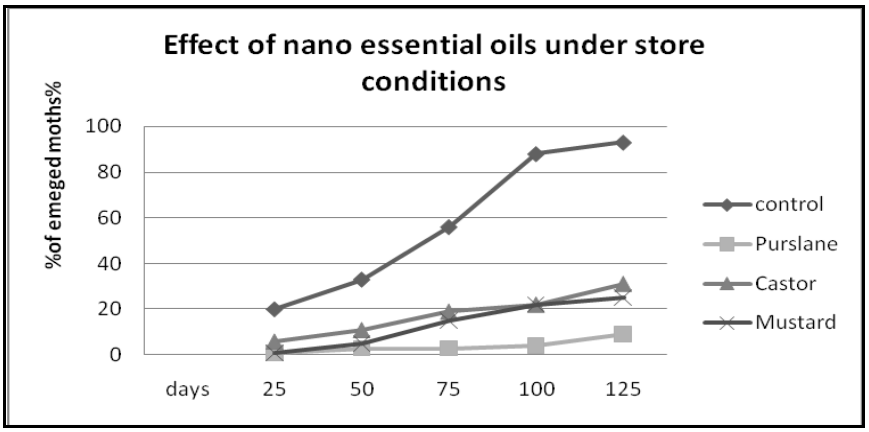

Fig 2.* Effect of nano-essential oils against E. cautella *under store conditions

It can be concluded that treated foam with Purslane oil either bulk or nano phase and covering gunny sacks provided several effects (toxic, ovipositional deterrent, suppressing *E. Cautella* and persist for appreciable periods) for protecting the wheat grains under store condition.

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