**Effect of Some Eco-friendly Botanical Oils on the Development of *Tribolium castaneum***

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**Abstract**

 The red flour beetle, *Tribolium castaneum*, is a significant pest of stored products globally. The continuous use of synthetic pesticides for its management has led to resistance development and environmental concerns. Botanical oils, derived from plants, offer an eco-friendly alternative. This study evaluates the efficacy of selected plant-based botanical oils on the development of *T. castaneum*. Results indicate that certain oils possess potent insecticidal properties, suggesting their potential in integrated pest management programs.

**Keywords-** Eco-friendly alternatives, *Tribolium castaneum,* stored products

**1. Introduction**

 Stored product pests, including *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae), pose severe challenges to global food security by infesting grains, flour, and other stored commodities. These pests cause direct and indirect losses by feeding, contaminating products, and facilitating the growth of fungi. The extensive reliance on synthetic insecticides for managing *T. castaneum* populations has resulted in pesticide resistance, environmental pollution, and human health hazards. Botanical oils, derived from various plant species, represent a sustainable alternative to synthetic pesticides. These oils are biodegradable, less toxic to non-target organisms, and exhibit diverse modes of action, making them effective against a broad spectrum of pests. Previous studies have demonstrated the insecticidal, repellent, and developmental inhibitory properties of botanical oils against stored product pests. However, the specific effects of these oils on the developmental stages of *T. castaneum* remain underexplored.

This study investigates the efficacy of selected plant-based botanical oils in inhibiting the development of *T. castaneum*. By identifying effective botanical oils, this research aims to contribute to the development of environmentally friendly pest management strategies.

**2. Materials and Methods-**

**2.1 Study Location**

 The study was conducted in a controlled laboratory environment, maintained at 27 ± 2°C, 65 ± 5% relative humidity, and a photoperiod of 12:12 (L:D).

**2.2 Test Insect**

 A laboratory strain of *T. castaneum* was used. The insects were reared on wheat flour mixed with 5% (w/w) brewer's yeast. Only healthy, unsexed adult beetles aged 7-10 days were selected for experiments.

**2.3 Botanical Oils**

The following plant-based botanical oils were evaluated:

1. Neem oil (*Azadirachta indica*)
2. Eucalyptus oil (*Eucalyptus globulus*)
3. Castor oil (*Ricinus communis*)
4. Clove oil (*Syzygium aromaticum*)
5. Lemongrass oil (*Cymbopogon citratus*)

The oils were procured from certified organic suppliers and stored at 4°C until use.

**2.4 Preparation of Oil Solutions**

 Stock solutions of each oil were prepared by dissolving 10 ml of oil in 90 ml of acetone to obtain a 10% solution. Working solutions (2%, 4%, 6%, 8%, and 10%) were prepared by diluting the stock solution with acetone.

**2.5 Bioassay**

 A contact toxicity bioassay was conducted using treated filter paper. Filter papers (Whatman No. 1) were cut into 9 cm diameter circles and impregnated with 1 ml of oil solution. The papers were air-dried for 30 minutes to allow acetone to evaporate. Control papers were treated with acetone only. Each treated filter paper was placed in a Petri dish (9 cm diameter). Ten adult beetles were released into each dish. The dishes were covered and kept in the laboratory conditions mentioned earlier. Each treatment was replicated five times.

**2.6 Developmental Assessment**

 Eggs laid by treated adults were collected daily and observed for hatching. The larvae were monitored for molting and pupation, while pupae were observed for adult emergence. Developmental parameters, including egg-to-adult survival rate and developmental duration, were recorded.

**3. Methodology**

1. **Experimental Design:** A completely randomized design (CRD) was employed, with five oil concentrations and five replicates per treatment.
2. **Data Collection:** Mortality of adult beetles was recorded at 24, 48, and 72 hours post-exposure. Developmental inhibition was assessed by tracking the progression of eggs to adults.
3. **Statistical Analysis:** Data were analyzed using ANOVA, followed by Tukey's HSD test for mean separation at p < 0.05. Probit analysis was used to determine lethal concentration (LC50) values.

**4. Results**

**4.1 Adult Mortality**

 All tested botanical oils exhibited significant contact toxicity against *T. castaneum*. Mortality rates increased with oil concentration and exposure time. Neem oil demonstrated the highest efficacy, achieving 100% mortality at 10% concentration within 48 hours. (Table-1)

**Table 1. Mortality of *T. castaneum* Adults at Different Concentrations**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Oil Type** | **Concentration (%)** | **Mortality (%) at 24h** | **Mortality (%) at 48h** | **Mortality (%) at 72h** |
| Neem | 2 | 40 | 60 | 75 |
|  | 10 | 80 | 100 | 100 |
| Eucalyptus | 2 | 25 | 40 | 60 |
|  | 10 | 50 | 70 | 85 |
| Castor | 2 | 20 | 30 | 50 |
|  | 10 | 45 | 60 | 70 |
| Clove | 2 | 35 | 55 | 70 |
|  | 10 | 70 | 90 | 100 |
| Lemongrass | 2 | 30 | 50 | 65 |
|  | 10 | 60 | 80 | 90 |

#### 4.2 Developmental Inhibition

 The oils significantly impacted the developmental stages of T. castaneum. Neem and clove oils showed the most pronounced effects, reducing egg-to-adult survival rates by 80-90% at higher concentrations. Developmental duration was prolonged in treatments with eucalyptus and lemongrass oils. (Table-2)

**Table 2.** Developmental Inhibition of **T. castaneum**

|  |  |  |  |
| --- | --- | --- | --- |
| **Oil Type** | **Concentration (%)** | **Egg-to-Adult Survival Rate (%)** | **Developmental Duration (Days)** |
| Neem | 2 | 50 | 34 |
|  | 10 | 10 | 42 |
| Eucalyptus | 2 | 65 | 36 |
|  | 10 | 20 | 40 |
| Castor | 2 | 70 | 35 |
|  | 10 | 30 | 39 |
| Clove | 2 | 40 | 33 |
|  | 10 | 15 | 41 |
| Lemongrass | 2 | 60 | 34 |
|  | 10 | 25 | 38 |

**LC50 Values**

 Probit analysis revealed that neem oil had the lowest LC50 value (1.8%), followed by clove oil (2.3%), indicating their superior potency.

**5. Discussion**

 The findings underscore the potential of plant-based botanical oils as alternatives to synthetic pesticides for managing *T. castaneum*. Neem oil’s high efficacy aligns with its well-documented insecticidal properties, attributed to azadirachtin and other bioactive compounds. Similarly, clove oil’s effectiveness can be linked to eugenol, a compound known for its insecticidal and repellent activity.

 Eucalyptus and lemongrass oils, while less effective in causing immediate mortality, exhibited developmental inhibitory effects. This suggests their potential utility in disrupting the life cycle of *T. castaneum*. The variation in oil efficacy may result from differences in their chemical compositions and modes of action.

 Botanical oils offer several advantages, including safety for non-target organisms and minimal environmental persistence. However, their commercial application requires addressing challenges such as formulation stability, cost-effectiveness, and large-scale production.

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