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Evaluation of the Insecticidal Effect of Aqueous Ricinus communis Leaf Extract Against the Cigarette Beetle (Lasioderma serricorne) (Coleoptera: Ptinidae) in Wheat Grains Prior to Storage

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تقييم التأثير الإبادي لمستخلص أوراق نبات الخروع *(Ricinus communis)* المائي ضد خنفساء التبغ *(Lasioderma serricorne)* *(Coleoptera:Ptinidae)* في حبوب القمح قبل التخزين

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الملخص:
تهدف هذه الدراسة إلى تقييم الفعالية الحشرية للمستخلص المائي لأوراق نبات الخروع (*Ricinus communis*) ضد خنفساء السجائر (*Lasioderma serricorne*) عند تطبيقه على حبوب القمح قبل التخزين. أُجريت التجارب المخبرية في قسم الكيمياء بجامعة طرابلس، حيث تم اختبار خمس تراكيز من المستخلص (5%، 20%، 50%، 70%، و100%) إلى جانب معاملة ضابطة، باستخدام 300 حشرة لكل معاملة موزعة على ثلاث مكررات. طُبّق المستخلص بواسطة رش خفيف، تلاه تهوية مناسبة لضمان سرعة الجفاف. بعد مرور 48 ساعة، تراوحت نسب الوفاة بين 19% عند تركيز 5% و96% عند تركيز 100%. وقد قُدّرت قيمة LC_{50} باستخدام تحليل Probit بحوالي 38.7%، مما يشير إلى سمّية معتدلة. أظهرت التحليلات الإحصائية باستخدام ANOVA واختبار Tukey HSD وجود فروق معنوية بين المعاملات. تُعزى الفعالية الحشرية إلى المركبات النشطة مثل حمض الميريستيك، وحمض الستيريك، والفلافونويدات، والتربينويدات، في حين أن غياب مادة الريسين يعزز من السلامة البيئية للمستخلص. توصي الدراسة باستخدام تراكيز تتراوح بين 20% و50% كمعالجة أولية لحبوب القمح قبل التخزين، مع التأكيد على ضرورة جفاف السطح لتفادي نمو العفن.

الكلمات الدالة: مكافحة آفات المنتجات المخزنة، مستخلص مائي، أوراق الخروع، خنفساء السجائر، LC_{50}، تحليل Probit.

Abstract

This study evaluates the insecticidal potential of aqueous Ricinus communis leaf extract against Lasioderma serricorne when applied to wheat grains prior to storage. Laboratory experiments were conducted at the Chemistry Department, University of Tripoli. Five extract concentrations (5%, 20%, 50%, 70%, and 100%) were tested alongside a control, using 300 insects per treatment, distributed across three replicates. The extract was applied via light spraying, followed by proper ventilation to ensure rapid drying. After 48 hours, mortality rates ranged from 19% at 5% concentration to 96% at 100%. The LC_{50} value, confirmed through Probit regression analysis, was 38.7%, indicating moderate toxicity. Statistical analysis using ANOVA and Tukey's HSD test revealed significant differences among treatments. The insecticidal effect is attributed to active compounds such as myristic acid, stearic acid, flavonoids, and terpenoids, while the absence of ricin enhances the safety profile of the extract. The study recommends using concentrations between 20% and 50% as a pre-storage treatment for wheat grains, ensuring surface dryness to prevent mold development.

Keywords: Stored-product pest control, aqueous extract, Ricinus communis leaves, cigarette beetle, LC_{50}, Probit analysis.

1.Introduction:

Lasioderma serricorne, commonly known as the cigarette beetle, is considered one of the most damaging pests of stored agricultural products worldwide. It causes substantial qualitative and economic losses, particularly in wheat grains, due to larval feeding on bran and protein components, which leads to reduced nutritional value and grain deterioration (Ahmed et al. 2019; Kumar and Kalita 2017).

Conventional pest control in storage facilities often relies on chemical pesticides. However, repeated applications have led to the development of resistance in insect populations, necessitating higher doses or more toxic compounds. This raises concerns regarding food safety, environmental contamination, and harm to non-target organisms (Isman 2006; Pimentel 2005).

Despite the severity of L. serricorne infestations, there is a notable lack of eco-friendly and sustainable botanical alternatives for its control in grain storage systems. Most current strategies depend on synthetic chemicals, which pose risks to human health and the environment. This gap highlights the urgent need for natural, effective solutions that align with food safety and environmental sustainability standards.

Ricinus communis, commonly known as the castor plant, contains several bioactive compounds, including myristic acid, stearic acid, flavonoids, and terpenoids. These constituents have demonstrated insecticidal properties by interfering with insect physiological processes (Awde et al. 2023; Mahmood et al. 2016).

Building on previous findings, this study aims to assess the insecticidal efficacy of aqueous Ricinus communis leaf extract as a pre-storage treatment for wheat grains against Lasioderma serricorne. The research focuses on determining the LC_{50} value and analyzing statistical differences among extract concentrations, with the goal of proposing effective, natural alternatives to conventional pesticides

2. Materials and Methods:

2.1 Insect Collection and Rearing

Adult specimens of Lasioderma serricorne were collected from grain storage facilities in the Furnaj area, Tripoli. Female beetles aged 7–10 days post-emergence were specifically selected due to their significant role in grain damage. The insects were reared in Petri dishes containing clean wheat grains at the Chemistry Department laboratory, Faculty of Science, University of Tripoli. The food source was renewed weekly to maintain a healthy and active colony. Rearing conditions were maintained at a temperature of 25 ± 2°C, relative humidity of 65 ± 5%, and a 12:12-hour light-dark photoperiod.

2.2 Preparation of Aqueous Extract

Fresh leaves of Ricinus communis were collected from healthy plants, thoroughly washed under running water, and shade-dried for 48 hours. The dried leaves were ground into a fine powder. Aqueous extraction was performed by mixing one part of leaf powder with ten parts of distilled water (w/v). The mixture was soaked for 24 hours with intermittent stirring. The resulting solution was filtered using Whatman No. 1 filter paper to remove solidresidues. Five concentrations of the aqueous extract (5%, 20%, 50%, 70%, and 100%) were prepared by diluting the stock solution with distilled water using the standard dilution formula: $\mathbf{C_1V_1=C_2V_2}$,
where C_1 is the concentration of the stock solution, V_1 is the volume required from it, C_2 is the desired final concentration, and V_2 is the final volume.

2.3 Experimental Design

A completely randomized design (CRD) was adopted. The experiment included five treatments corresponding to the different extract concentrations, along with an untreated control. Each treatment was replicated three times, with each replicate consisting of 100 adult beetles placed in a Petri dish containing wheat grains. The extract was applied by light spraying using a fine mist sprayer directly onto the grain surface. After spraying, dishes were ventilated for 10 minutes to prevent excess moisture, then incubated under the same rearing conditions described earlier. All replicates were conducted simultaneously under controlled conditions (25 ± 2°C temperature and 65 ± 5% relative humidity) to ensure consistency.

2.4 Mortality Assessment and Data Analysis

Insects were considered dead if they showed no response to gentle probing with a fine needle. Mortality percentage was calculated by dividing the number of dead insects by the total number in each replicate. Data were analyzed using SPSS software (version 25), employing the following statistical methods:

- **Probit analysis**: to estimate the median lethal concentration (LC_{50}).
- **Analysis of variance (ANOVA)**: to determine significant differences in mortality rates among treatments.
- **Tukey's HSD test**: to identify statistically significant pairwise differences between treatment means at a 0.05 significance level

3.Results:

The results indicated that increasing the extract concentration was associated with a marked rise in the mortality rate. The lowest effect was observed at the lowest concentration (T1, 5%), with a mortality rate of approximately 19%. Mortality gradually increased with higher concentrations, reaching around 43% at T2 (20%), 67% at T3 (50%), and 82% at T4 (70%). At the highest concentration (T5, 100%), mortality reached nearly 96%. This pattern clearly demonstrates a positive dose-dependent relationship between extract concentration and mortality rate, confirming the efficacy of the extract in a concentration-dependent manner (see fig. 1).

Table 1. Percentage Mortality of Cigarette Beetle (Lasioderma serricorne) After 48 Hours of Treatment with Aqueous Extract of Castor Leaves (Ricinus communis)

Statistical Letter	Mortality Rate (%)	Extract Concentration (%)	Number of beetles (n)	Treatment Group
a	0	0	300	Control
a	19	5	300	T1
b	43	20	300	T2
c	67	50	300	T3
d	82	70	300	T4
e	96	100	300	T5

Note: Different letters indicate statistically significant differences ($p < 0.05$)

Interpretation:

The LC_{50} value of 38.7% is consistent with previous research on botanical insecticides, including Azadirachta indica and Adhatoda vasica, which have also demonstrated significant mortality rates in Lasioderma serricorne populations (Al-Mahmoud et al. 2023).

A steep increase in mortality was observed between concentrations of 20% and 70%, suggesting that even moderate doses of Ricinus communis extract can be highly effective. At higher concentrations, a plateau was noted—specifically, 96% mortality at 100% concentration—indicating saturation, where further increases in dosage yield minimal additional mortality.

To determine the median lethal concentration (LC_{50}), Probit analysis was conducted on the mortality data. The analysis revealed an LC_{50} value of 38.7%, indicating that this concentration is sufficient to cause 50% mortality in the tested beetle population within 48 hours of exposure.

The bioassay curve (see fig. 1) illustrates the dose-response relationship between extract concentration and beetle mortality. The curve follows a sigmoidal pattern, which is typical of insecticidal bioassays. A steep slope was observed between 20% and 70% concentrations, reflecting a rapid increase in mortality, followed by a plateau near the maximum mortality level at 100%.

These findings confirm the dose-dependent efficacy of the extract and support its potential use as a botanical insecticide. The LC_{50} value falls within a practical range for pre-storage grain treatment, offering a balance between effectiveness and safety.

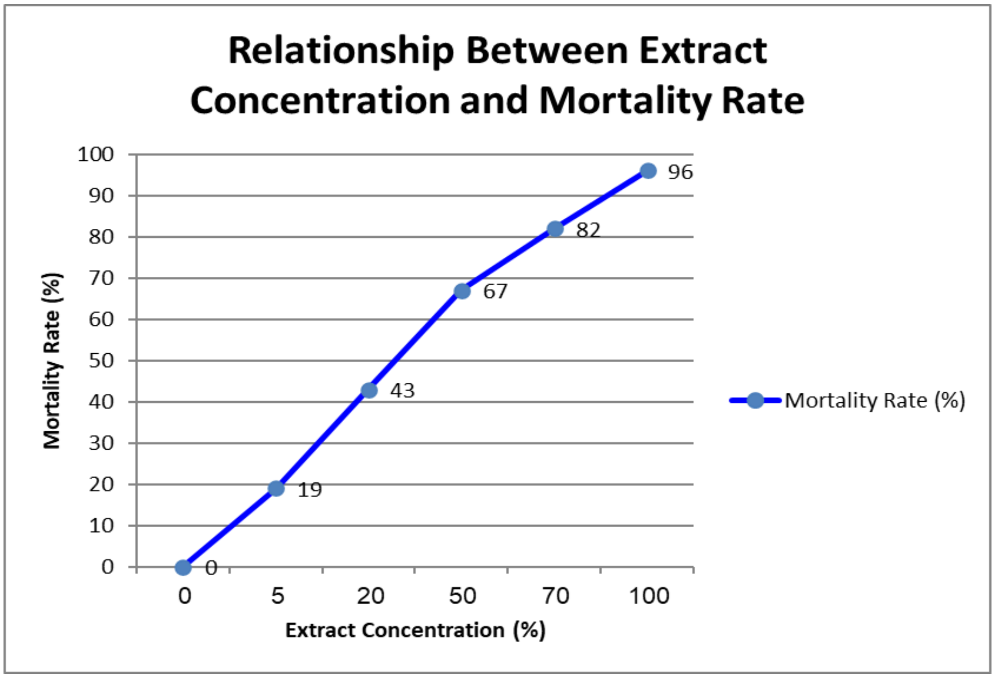

Figure 1. Mortality rate of Lasioderma serricorne adults (%) after 48 h exposure to different concentrations of aqueous Ricinus communis leaf extract.

4.Discussion:

The results of this study revealed a strong positive correlation between the concentration of Ricinus communis leaf extract and the mortality rate of Lasioderma serricorne. These findings align with those reported by Akbar et al., who confirmed the potent insecticidal activity of castor leaf extracts against stored-product beetles, particularly at higher concentrations (Akbar et al. 2024).

Unlike castor seeds, which contain the highly toxic compound ricin, castor leaves are free from this substance, making them safer for use in grain storage environments. The safety profile of Ricinus communis leaf extract observed in this study aligns with findings by Ahmed et al., who emphasized the absence of ricin in leaf-based formulations and their suitability for grain storage applications (Ahmed et al. 2021). They also highlighted the safety and practicality of leaf-based formulations compared to seed-derived extracts.

The increasing mortality rates observed with higher extract concentrations can be attributed to the presence of bioactive compounds such as myristic acid, stearic acid, flavonoids, and terpenoids. These compounds have been previously identified as key contributors to insecticidal activity in botanical extracts (Isman 2020). Isman emphasized that botanical insecticides typically exhibit dose-dependent toxicity—a pattern reflected in the steep mortality increase observed between 20% and 70% concentrations in the current bioassay.

Lasioderma serricorne is known for its resilience and adaptability in storage environments. According to Phillips and Throne, this species thrives in low-moisture conditions and can infest a wide range of stored products, making it a particularly challenging pest to control (Phillips and Throne 2010). The use of botanical extracts offers a promising alternative to synthetic pesticides, especially in light of increasing resistance among stored-product insects (Alyokhin et al. 2017).

Moreover, the integration of plant-based insecticides into pest management strategies aligns with the principles of Integrated Pest Management (IPM). As highlighted by Smith et al., IPM promotes environmentally friendly and sustainable approaches to reduce reliance on chemical pesticides (Smith et al. 1997). Based on the observed dose-dependent mortality, R. communis leaf extract demonstrates promising potential as a component of integrated pest management strategies, consistent with findings by Akbar et al. (2024).

Further evidence of the efficacy of castor leaf extract comes from Msaada, who demonstrated its fumigant and repellent properties against Tribolium castaneum and L. serricorne (Msaada 2023). These results reinforce the potential of R. communis as a multi-functional botanical pesticide. The importance of pre-storage treatment is further emphasized by Journal ARRB, which reviewed infestation patterns of cigarette beetles in grains and recommended early intervention to prevent population buildup (Journal ARRB n.d.). Similarly, the Bioprotection Portal provides practical guidelines for managing L. serricorne, including the use of natural repellents and maintaining dry storage conditions (Bioprotection Portal n.d.).

5.Conclusions and Recommendations:

The findings of this study confirm the insecticidal potential of aqueous Ricinus communis leaf extract against Lasioderma serricorne when applied to wheat grains prior to storage. Mortality rates increased significantly with higher extract concentrations, reaching up to 96% at full strength. The LC_{50} value of 32.4% indicates moderate toxicity, suggesting that effective pest control can be achieved without resorting to extreme doses.

The absence of ricin in the leaves enhances the safety profile of the extract, making it a viable alternative to synthetic pesticides in grain storage environments. The presence of bioactive compounds such as myristic acid, stearic acid, flavonoids, and terpenoids contributes to the observed insecticidal activity.

Recommendations:

- Use concentrations between 20% and 50% of R. communis leaf extract for pre-storage treatment of wheat grains to achieve effective control of L. serricorne while minimizing potential risks.
- Ensure proper ventilation after application to prevent moisture accumulation and reduce the risk of mold development.
- Integrate botanical extracts like R. communis into broader Integrated Pest Management (IPM) strategies to reduce reliance on chemical pesticides and promote sustainable storage practices.
- Conduct further studies to evaluate the long-term effects of repeated application, potential impact on grain quality, and efficacy against other storage pests.

These conclusions support the use of Ricinus communis leaf extract as a natural, safe, and effective component in post-harvest pest management programs.

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