Journal of Agricultural Sciences and Sustainable Development

Open Access Journal
https://jassd.journals.ekb.eg/

ISSN (Print): 3009-6375; ISSN (Online): 3009-6219

Investigating the impact of select oils on mortality and progeny production of Rhyzopertha dominica infesting wheat

Mohamed, E., M. and Abotaleb, A., O.*

Plant Protection Research Institute, Agriculture Research Center, Dokki, Giza, Egypt

Abstract

The degradation of stored wheat due to pest infestations is a significant concern, with pests such as *Rhyzopertha dominica* playing a crucial role. This study investigated the effectiveness of six essential oils against this pest in laboratory conditions. The oils were tested at five concentrations (0.5, 0.7, 1.0, 1.5, and 2.0%). Importantly, all concentrations led to considerable pest mortality and demonstrated the ability to suppress the production of pest progeny over time. The results indicated a gradual increase in mortality rates of *R. dominica* adults with higher concentrations and longer exposure times to the tested plant oils. Among the various treatments, the application of 2.0% proved to be the most effective, resulting in increased mortality and a complete elimination of pest progeny, as well as a complet reduction in the percentage of weight loss in the grains. The findings suggested that the viability of wheat grains was minimally affected by the application of the tested plant oils. At this application rate, grains exhibited no adverse effects, maintaining a normal texture, color, and appearance.

Manuscript Information:

*Corresponding authors: **Abeer O. Abotaleb**

E-mail: dabeeromar@gmail.com

Received: 18/02/2024

Revised: 11/03/2024

Accepted: 16/03/2024

Published: 01/05/2024

DOI: 10.21608/JASSD.2024.260957.1005

Keywords: Oils; stored products insects; lesser grain borer; viability; germination.

مجلة العلوم الزراعية والتنمية المستدامة

Open Access Journal
https://jassd.journals.ekb.eg/

الترقيم الدولي (مطبوع): 3009-6375 الترقيم الدولي (أونلاين): 3009-6219

تأثير بعض الزيوت المختارة على معدل الوفيات وعداد الذرية الناتجة لحشرة ثاقبة الحبوب الصغرى التي تصيب القمح

عصام مصطفى محمد، عبير عمر أبو طالب*

معهد بحوث وقاية النباتات- مركز البحوث الزراعية- الدقي- جيزة - مصر

الملخص العربى:

يشكل تدهور القمح المخزن بسبب تفشي الآفات مصدر قلق كبير، حيث تلعب الآفات مثل *Rhyzopertha dominica* دورًا حاسمًا. بحثت هذه الدراسة في فعالية ستة زيوت عطرية ضد هذه الآفة في الظروف المختبرية. تم اختبار الزيوت بخمسة تراكيز (0.5، 0.7، 1.0، 1.5، 2.0%). والأهم من ذلك، أن جميع التركيزات أدت إلى وفيات كبيرة للآفات وأظهرت القدرة على قمع إنتاج ذرية الآفات مع مرور الوقت. أشارت النتائج إلى زيادة تدريجية في معدلات وفيات البالغين من R. dominica مع التركيزات الأعلى وأوقات التعرض الأطول للزيوت النباتية المختبرة. من بين المعالجات المختلفة، أثبت تطبيق 2.0 % أنه الأكثر فعالية، مما أدى إلى زيادة معدل الوفيات والقضاء التام على ذرية الآفة، بالإضافة إلى انخفاض كامل في نسبة فقدان الوزن في الحبوب. تشير النتائج إلى أن صلاحية حبوب القمح تأثرت بشكل طفيف من خلال تطبيق الزيوت النباتية التي تم اختبارها. بمعدل الاستخدام هذا، لم تظهر الحبوب أي آثار ضارة، مع الحفاظ على الملمس واللون والمظهر الطبيعي.

بيانات البحث:

***الباحث المسئول: عبير عمر أبو طالب**

dabeeromar@gmail.com

تاريخ استلام البحث: 2024/02/18م

تاريخ إجراء التعديلات: 2024/03/11م

تاريخ القبول: 2024/03/16م

تاريخ النشر: 2024/05/01م

معرف الوثيقة:

DOI: 10.21608/JASSD.2024.260957.1005

الكلمات المفتاحية: زيوت، حشرات الحبوب المخزونة، ثاقبة الحبوب الصغرى، قابلية النمو، الإنبات.

INTRODUCTION:

Stored products, especially stored grains, constitute a critical cornerstone of food security. Nevertheless, the infiltration of various pests, encompassing insects, fungi, bacteria, mites, and rodents, subjects stored products to substantial losses and damage. In particular, insect pests play a significant role in causing losses by feeding on commodities, leading to a decline in food quality. This feeding activity further results in the contamination of food with their body parts and excreta, a reduction in seed germination, and an escalation of fungal and bacterial infections **(Ribeiro et al., 2020).**

Wheat (Triticum aestivum) holds the distinction of being the most crucial grain crop globally. In Egypt, it stands out as the primary winter cereal crop, gaining significant importance for human consumption. These insights align with data from the Food and Agriculture Organization (FAO) of the United Nations **(Alsahary 2014).**

The lesser grain borer R. dominica (F.) (Coleoptera: Bostrichidae) stands out as one of the most damaging insect pests affecting stored grain **(Hettiarachchi et al., (2020).** Globally, both the adults and larvae exhibit voracious feeding habits. While lesser grain borers can infest various cereal grains, they show a particular preference for wheat, corn, as well as rough and brown rice **(Afful, et al., 2021).**

The primary approach for managing stored product insects involves the application of synthetic insecticides **(Gad et al., 2023; Kljajić et al., 2023 & Riaz et al., 2024).** The utilization of synthetic pesticides results in the accumulation of potentially harmful substances in soil, water, and food resources **(Pestana et al., 2009),** which has prompted the exploration of cost-effective and environmentally friendly pest control methods **(Silva-Filho et al., 2014).** Essential oils (EO) offer an alternative to traditional pesticides for pest control **(Machial et al., 2010; Fouad et al., 2014),** with the advantage of high diffusion rate in the environment because of their low molecular weight and high vapor pressure **(Bakkali et al., 2008)**. Essential oils and their primary components have demonstrated varied biological activities against stored product insects, encompassing insecticidal effects **(Demeter et al., 2021; Wang et al., 2021; Basile et al., 2022)**. Essential oils present advantages such as reduced costs, lower environmental and food contamination risks, and minimal impact on beneficial organisms **(Matos- Neto et al., 2002)** Moreover, the utilization of essential oils not only diminishes the likelihood of selecting resistant insects in comparison to synthetic insecticides but also promotes a more sustainable agricultural practice **(Kéita et al., 2001; Isman, 2006).**

Hence, the objective of this study was to assess the toxicity of six essential oils against the lesser grain borer, Rhyzopertha dominica. Additionally, the impact of these oils on the viability, quantity, and quality of Egyptian wheat grains was examined.

MATERIAL AND METHODS:

Tested grains:

The current study utilized Egyptian wheat variety Sakha 93. The wheat grains underwent a sieving process to remove any irregular kernels or foreign particles. Subsequently, they were subjected to sterilization in a deep freezer at -18°C for duration of 2 weeks to eradicate any potential infestation by insect pests. Following sterilization, the grains were allowed to condition for approximately 1 week to reach a balanced moisture content.

Tested insects:

Lesser grain borer, R. dominica (F.) (Coleoptera: Bostrichidae) was obtained from well-maintained culture reared under controlled conditions of 25 ± 2 °C and 65 ± 5 % RH at the research laboratory of Stored Products Department, Plant Protection Research Institute at the Agriculture Research Center, Doki, Giza, Egypt. To establish a stock culture of R. dominica, approximately 100 pairs of adult lesser grain borer were introduced into glass jars containing 300g of wheat grains. These jars were covered with a fine piece of cotton cloth secured with a rubber band, allowing for the passage of air while preventing contamination and the escape of insects **(Sun 1947).** The weevils were provided with a diet of wheat grains and kept in an incubator approximately two weeks.

Following this period, the infested wheat grains were sifted using a 3.0 mm technical sieve to separate the parent stocks. The grains containing eggs were then returned to the jars and placed back in the incubator to facilitate breeding until new adult weevils emerged. These newly emerged adults were then selected, and weevils aged between 1 to 2 weeks were utilized for the experiments.

Essential oils used:

Six of the tested plant essential oils included cinnamon (Cinnamomum verum), clove (Syzygium aromaticum), arugula (Eruca sativa), garlic (Allium sativum), onion (Allium cepa) and cuminum (Cuminum cyminum). It purchased from Al-Hedaia group company for (El-Mahala El-Kobra, Egypt).

Toxicity activity of tested oils on adult mortality and progeny production of R. dominica:

Contact with feeding medium technique was used to determine the insecticidal effects of tested oils against R. dominica at different concentrations. The oils were prepared at concentrations of 0.5, 0.7, 1.0, 1.5, and 2.0 ml/100g of wheat grain, dissolved in acetone. Each concentration was applied in triplicate, with each replicate containing 20 grams of wheat grains in 250 mL glass jars. To administer the oil treatment, 1 ml of each concentration was added to the wheat grains, thoroughly mixed, and then left in the jars until the solvent evaporated before being used in the experiment.

A control group, representing the untreated treatment, was also included and replicated three times. Subsequently, 20 adult unsexed R. dominica weevils, aged between one to two weeks, were introduced to the treated wheat grains in 250 mL glass jars. The jars were maintained at 25 ± 2 °C and 65 ± 5 % R.H., following the method outlined by **El-Lakwah et al. (1992)**. Mortality assessments were made after 7 and 15 days. After twenty days, the adult weevils were sifted out and removed. The emergence of newly developed adults was monitored to calculate the reduction percentages in R. dominica offspring.

$$\text{Reduction \%} = \frac{\text{No. of adults emerged in control.}}{\text{No. of adults emerged in treatment.}} \times 100$$

Impact of oils on weight loss in wheat grains

In a similar experiment to estimate grain weight loss caused by R. dominica in oils-treated and control grains, jars treated with different oils levels and infested with the lesser grain borer were sieved after three months of treatment. The weight loss of the wheat grains was recorded as the loss in dry weight, applying the equation established by Harris and Lindblad (1978):

$$\text{Weight loss (\%)} = \frac{\text{Initial weight-final weight}}{\text{Initial weight}} \times 100$$

The effect test oils on germination.

Seed germination of untreated and oils treated grains were studied in the laboratory. wheat grains were treated with Lc50 of oils. Germination test was carried out after oil treatment in 9 cm diameter glass Petri dishes, each lined with two layers of Whatman No. 1 filter paper soaked with water. Twenty-five grains were placed in separate Petri dishes. Each treatment was replicated four times. The percentage germination for each treatment per concentration was recorded after 7 days and compared with the controls (**Anonymous** 1976).

$$\text{Germination \%} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds kept for germination}} \times 100$$

Statistical analysis

The obtained data were analyzed using Proc ANOVA in SAS **(Anonymous. 2003).** Estimated LC_{50} and LC_{95} were calculated according to **Finney (1971)** using LDP line program (www. Ehab soft.com).

RESULTS:

Six essential oils were tested for its insecticidal effect as protectants at various concentrations wheat for grain against the lesser grain borer insects, *R. dominica*. The evaluated biological parameters were adult mortality after 5, 7and 15 days, F_1 progeny number after 4 weeks and weight loss%. The effect of cinnamon oil on mortality, progeny production of *R. dominica* and grain weight loss% was shown in Table (1). At 1.0 % adult mortality was 60.0, 72.0 and 75.0 % after 5, 7 and 15 days respectively post exposure. Complete mortality was reached at rate of 1.5% after 5 days of exposure. Progeny production was 75.0, 63.0, 4.0 and 1.0 at 0.5, 0.7, 1.0 and 1.5% respectively compared to 108.0 for control. Reduction in F1 progeny of *R. dominica* was 30.5-99.1% for the various tested concentration. Weight loss ranged from 10.7-0.3 % for the various oil rates for *R. dominica*. While 0.0 % of weight loss after exposed for 2.0% compared with 13.8% for control. The difference between the treated and untreated control values was significant due to cinnamon oil effect.

Table (1): Impact of oil cinnamon on mortality (%) and number of progeny of *R. dominica* adults and wheat grain loss %

Con.%	Adult mortality (%)			No. of progeny	% Reduction in progeny	Weight loss (%)
	5days	7 days	15 days			
0.5	5.0±0.0	7.0±2.8	10.0±8.5	75.0±5.7b	30.5 ±3.1b	10.7±0.8b
0.7	7.0±4.4	13.3±4.5	18.3±6.6	63.0±12.7b	42.0 ±11.7b	6.9±1.1c
1.0	60.0±2.8	72.0±6.0	75.0±8.6	`4.0±2.6c	96.5±1.8a	1.0±0.8d
1.5	100.0±0.0	-	-	1.0±0.9c	99.1±0.8a	0.3±0.2d
2.0	-	-	-	0.0±0.0c	100.0±0.0a	0.0±0.0d
control	0.0±0.0	0.0±0.0	2.0±1.6	108.0±11.9a	0.0 ±0.0c	13.8±0.7a

Means followed by the same letter are not significantly different (P= 0.05)

The effect of clove oil on mortality, progeny production of *R. dominica* and grain weight loss % was shown in Table (2). Adult mortality was 50.0, 60.0 and 67.0 % at 1.5% after 5, 7 and 15 days of exposure. Complete mortality was reached at rate of 2.0 % after 7 days of exposure. A significant effects of clove oil on progeny production of *R. dominica* and weight loss. Progeny production was 79.0, 15.0, 12.0 and 4.0 post treated with 0.5, 0.7, 1.0 and 1.5% respectively compared with 108.0 adults in the control. Complete suppression of progeny production was obtained after treatment with 2% compared with 108.0 adults in the control. Reduction in F1 progeny was 27.1, 86.1, 89.0 and 96.0% for 0.5, 0.7, 1.0 and 1.5% respectively compared with 0.0 adults in the control. Complete reduction in progeny was obtained at rate of 2.0%. Weight loss 9.5, 2.0, 0.6 and 0.3% after exposed to 0.5, 0.7, 1.0 and 1.5% respectively compared with 13.8% for control.

Table (2): Impact of cloves oil on mortality (%) and number of progeny of *R. dominica* adults and wheat grain loss %

Con.%	Adult mortality (%)			NO. of progeny	% Reduction in progeny	Weight loss (%)
	5days	7 days	15 days			
0.5	3.0±1.6	10.0±0.0	13.0±1.6	79.0±2.8b	27.1±2.6c	9.5±1.7b
0.7	40.0±5.7	45.0±2.8	48.3±3.3	15.0±1.1c	86.1±1.1b	2.0±0.5c
1.0	47.0±4.4	50.0±5.7	53.0±7.2	12.0±1.4c	89.0±1.3b	0.6±0.3c
1.5	50.0±22.9	60.0±21.7	67.0±14.2	4.0±2.1c	96.2±1.9a	0.3±0.1c
2.0	98.3±2.8	100.0±1.6	-	0.0±0.0c	100.0±0.0a	0.0±0.0c
control	0.0±0.0	0.0±0.0	2.0±1.6	108.0±11.9a	0.0 ±0.0d	13.8±0.7a

Means followed by the same letter are not significantly different (*P*= 0.05)

While 0.0 % of weight loss after exposed for 2.0% compared with 13.8% for control. The effect of arugula oil on adult mortality of *R. dominica* was included in Table (3). At rate of 1.5 %, adult mortality was 42.0, 45.0 and 50.0 % after 5, 7 and 15 days of exposure. At 2.0 %, the mortality percentage reached 100% after 5 days of exposure. The number of progeny production was 12.0, 7.0 and 4.0 post treated with 0.5, 0.7 and 1.0% respectively compared with 108.0 adults in the control. Complete suppression of progeny production was obtained after treatment with 2%. Reduction in F1 progeny was ranged 89.0-96.0% for 0.5, 0.7 and 1.0% respectively compared with 0.0 adults in the control. Complete reduction in progeny was obtained at rate of 1.5%. Weight loss ranged from 1.4-0.3% for 0.5, 0.7 and 1.0 respectively compared with 13.8% for control. While 0.0 % of weight loss after exposed for 2.0% compared with 13.8% for control.

Table (3): Impact of arugula oil on mortality (%) and number of progeny of *R. dominica* adults and wheat grain loss %

Con.%	Adult mortality (%)			NO. of progeny	% Reduction in progeny	Weight loss (%)
	5days	7 days	15 days			
0.5	3.0±1.6	13.0±4.4	16.6±6.0	12.0±0.9b	89.0±0.8c	1.4±1.1b
0.7	7.0±3.3	15.0±5.0	18.3±6.0	7.0±3.3b	93.5±3.1bc	1.1±0.4b
1.0	35.0±10.0	38.3±10.9	46.6±14.2	4.0±2.2b	96.0±2.0ab	0.3±0.1b
1.5	42.0±6.0	45.0±6.7	50.0±8.6	0.0±0.0b	100.0±0.0a	0.0±0.0b
2.0	100.0±0.0	-	-	0.0±0.0b	100.0±0.0a	0.0±0.0b
control	0.0±0.0	0.0±0.0	2.0±1.6	108.0±11.9a	0.0 ±0.0d	13.8±0.7a

Means followed by the same letter are not significantly different (*P*= 0.05)

Data in Table (4) showed the effect of the garlic oil on the adult mortality of *R. dominica*. At 0.5 %, the percent mortality was 20.0, 22.0 and 28.0% after 5, 7 and 15 days of the exposure respectively. At 1.5 %, the complete mortality was observed after 5 days of exposure. Total progeny number was 21.0, 6.0, 4.0 and 2.0 for all various rates compared with 108.0 adults in the control. Complete suppression of progeny production was obtained at rate of 2%. Reduction in F1 progeny ranged 80.5-98.0% at all various concentration. Complete reduction in F1 progeny was obtained at rate of 2%. Weight loss% ranged from 1.8- 0.1% for the various concentration compared with 13.8 % for the control. While 0.0 % of weight loss after exposed for 2.0% compared with 13.8% for control. The differences between the treated and untreated (control) was significant in all parameters.

Table (4): Impact of garlic oil on mortality (%) and number of progeny of *R. dominica* adults and wheat grain loss %

Con.%	Adult mortality (%)			NO. of progeny	% Reduction in progeny	Weight loss (%)
	5days	7 days	15 days			
0.5	20.0±12.5	22.0±14.2	28.0±13.3	21.0±5.8b	80.5±5.3b	1.8±0.6b
0.7	45.0±15.2	48.0±15.9	52.0±16.9	6.0±1.8bc	94.1±1.6a	0.7±0.3bc
1.0	55.0±22.9	57.0±21.3	60.0±20.1	4.0±1.4bc	96.0±1.3a	0.3±0.2c
1.5	100.0±0.0	-	-	2 .0±1.8bc	98.0±1.7a	0.1±0.1c
2.0	-	-	-	0.0±0.0c	100.0±0.0a	0.0±0.0c
control	0.0±0.0	0.0±0.0	2.0±1.6	108.0±11.9a	0.0 ±0.0c	13.8±0.7a

Means followed by the same letter are not significantly different (*P*= 0.05)

Data in Table (5) showed the effect of onion oil on adult mortality of *R. dominica*. At 1%, the percent mortality was 20.0, 28.0 and 30.0% after 5,7 and 15 days respectively. The higher adult mortality, which it was 98.0% after 5 days of exposure to rat of 2%. Complete mortality was obtained after 7 days of exposure at rate of 2%. Total progeny number was 37.0 adults at 0.5 % compared with 108.0 adults in the control. Complete suppression of progeny production was obtained at rate of 2%. Reduction in F1 progeny 66.0-94.7%. Complete reduction was obtained at rate of 2%. Weight loss was 6.1, 1.4, 1.0 and 0.4% for 0.5, 0.7, 1.0 and 1.5 respectively. While 0.0 % of weight loss after exposed for 2.0% compared with 13.8% for control.

Table (5): Impact of onion oil on mortality (%) and number of progeny of *R. dominica* adults and wheat grain loss %

Con.%	Adult mortality (%)			No. of progeny	% Reduction in progeny	Weight loss (%)
	5days	7 days	15 days			
0.5	7.0±1.6	8.0±1.6	10.0±2.8	37.0±3.2b	66.0±3.0c	6.1±0.0b
0.7	15.0±5.0	22.0±6.0	15.0±2.8	14.0±1.5c	87.0±1.4b	1.4±0.5c
1.0	20.0±2.8	28.0±4.4	30.0±5.7	12.0±1.8c	89.0±1.6b	1.0±0.5c
1.5	27.0±9.2	32.0±9.3	42.0±8.8	6.0±3.4c	94.7±3.2a	0.4±0.2c
2.0	98.0±1.6	100.0±0.0	-	0.0±0.0c	100.0±0.0a	0.0±0.0c
Control	0.0±0.0	0.0±0.0	2.0±1.6	108.0±11.9a	0.0 ±0.0d	13.8±0.7a

Meansfollowed by the same letter are not significantly different (*P*= 0.05)

The effect of cuminum oil on adult mortality of *R. dominica* was included in Table (6). At 0.5 % concentration, adult mortality was 12.0, 20.0, and 22.0 % after 5, 7 and 15 days of exposure respectively. At 2.0 %, the mortality percentage reached 100% after 5 days of exposure. No significant effects on number of progeny production and weight loss (%) between treatment while was significant effects in reduction in F1 progeny of *R. dominica* compared to control. Progeny number was between 38.0-4 for rates 0.5, 0.7, 1, and 1.5% compared with 108.0 adults in the control. Complete suppression of progeny production was obtained at rate of 2%. Reduction in F1 progeny 65.0- 96% at 0.5, 0.7, 1, and 1.5% compared with 0.0 adults in the control. Complete reduction was obtained at rate of 2%. Weight loss (%) ranged from 7.0-0.3% for the rates of 0.5, 0.7, 1, and 1.5% compared with 13.8% in the control. While 0.0 % of weight loss after exposed for 2.0% compared with 13.8% for control.

Table (6): Impact of cuminum oil on mortality (%) and number of progeny of *R. dominica* adults and wheat grain loss %

Con.%	Adult mortality (%)			No. of progeny	Reduction in progeny %	Weight loss (%)
	5days	7 days	15 days			
0.5	12.0±1.6	20.0±2.8	22.0±4.4	38.0±23.1b	65.0±21.4b	7.0±5.7ab
0.7	23.3±3.3	27.0±4.4	32.0±1.7	22.0±4.3bc	80.0±4.0ab	4.3±0.5bc
1.0	30.0±7.6	33.0±6.6	35.0±7.6	13.0±2.5bc	88.0±2.ab	0.8±0.3bc
1.5	35.0±12.5	38.0±10.9	45.0±10.0	4.0±1.5bc	96.3±1.4a	0.3±0.1bc
2.0	87.0±13.3	97.0±3.3	100.0±0.0	0.0±0.0c	100.0±0.0a	0.0±0.0c
Control	**0.0±0.0**	**0.0±0.0**	**2.0±1.6**	**108.0±11.9a**	**0.0 ±0.0c**	**13.8±0.7a**

Means followed by the same letter are not significantly different (*P*= 0.05)

The expected concentrations caused 50 and 95% mortality for *R. dominica* adults post exposure to six different oils 5 days post exposure are presented in Table 7. The efficacy of these six essential oils varies depending on their type. The results showed that the essential oils of garlic, cinnamon, clove, cuminum, arugula, and onion required concentrations of 0.8, 0.9, 1.1, 1.13, 1.3, and 1.4 g/100g respectively to achieve 50% mortality of *R. dominica* adults.

Table (7): The expected concentrations (ml/100gm) caused 50 and 95% mortality for *R. dominica* adults post exposure to six deferent oils 5 days post exposure

Treatments	Lc 50	Lc 95
	ml/100gm	
Cinnamon	0.9	1.5
Cloves	1.1	2.9
Arugula	1.3	2.74
Garlic	0.8	1.8
Onion	1.4	3.2
Cuminum	1.13	3.0

Data obtained to assess the percentage of germination of treated wheat grains is presented in Table 8. Germination rates of wheat grains treated with garlic, cinnamon, clove, cuminum, arugula, and onion oils at LC95, along with untreated (control) grains, were observed after a storage period of three months. Overall, the viability of wheat grains was minimally impacted by the application of the tested plant oils. There was a non-significant effect on the germination percentage of wheat grains treated with clove, cuminum, and arugula oils compared to the control treatment after a 3-month storage period ($P < 0.05$).

Table (8): Effect of six essential oils on the germination% of wheat grains post-exposure to lethal exposure times at the 95% level of *R. dominica* adults

Treatments	Germination (%)
Cinnamon	79.0±1.3c
Cloves	86.0±4.8abc
Arugula	84.0±4.8abc
Garlic	82.0±4.0bc
Onion	76.0±3.5c
Cuminum	90.0±3.5ab
Control	**93.0±1.3a**
LSD	**9.6**

Means with the same letter in the same column are not significantly different. *LSD =The least significant difference

DISCUSSION:

The management of storage insect pests predominantly relies on synthetic pesticides. Nevertheless, the rapid development of resistance in targeted insects, along with adverse effects on humans, non-target organisms, and the environment, highlights the pressing necessity to explore safer alternatives to these xenobiotics. Essential oils (EOs) and their bioactive compounds have garnered significant attention as potential botanical pesticides **(Chaudhari et. al. 2021).** The present study investigated the contact toxicity of six essential oils (cinnamon, clove, arugula, garlic, onion, and cumin) against *R. dominica* adults, a common pest in stored products. The assessment utilized a contact method to measure the mortality rates of these oils at different concentrations and different exposure durations. The results revealed a progressive increase in mortality rates of *R. dominica* adults with higher concentrations and longer exposure times to the tested plant oils. Consequently, the mortality of these weevils was observed to be associated with both concentration and duration of exposure. Similar findings have been supported by various studies conducted by different authors. For instance, **Yang et. al., (2020)** demonstrated the insecticidal efficacy of extracts from cinnamon bark and fennel fruit against adults of *Lasioderma serricorne*. Another study by **Kim et. al., (2001)** suggested the possible application of materials derived from *Foeniculum vulgare* fruit for the control of stored-product insects. **Chaubey, (2008)** evaluated seven essential oil extracts, identifying black cumin oil as highly effective against the coleopteran insect *Callosobruchus chinensis* through fumigation. The chronic toxicity of these essential oils, when used as fumigants, led to reduced damage to stored grains. Furthermore, the effectiveness of essential oils against stored-product insects was observed to be influenced by their chemical composition, which, in turn, is affected by factors such as source, season, ecological conditions, extraction method, time, and the plant part used **(Lee et. al., 2001; Nikolaou, 2021;)**. The reproduction retarding effects of bio-pesticides have also been explained against storage pests (**Tunc et. al., 2000 & Tripathi et. al., 2002).**

Results of the present study showed that the toxicity of all tested oils depended on the concentration and time of exposure. Based on the LC50 values after 5-days of exposure, all tested oils were effective on *R. dominica*. The toxicity values of the tested plant oils were arranged according to their median lethal concentrations LC_{50} in the following descending order: garlic oil < cinnamon oil < clove oil < cuminum oil < arugula oil < onion oil. The difference observed among the insect mortalities due to these oils was due to differences in their volatiles, confirmed with **Ashokkumar et. al., (2020).** According to **Ileke et. al., (2020)** The efficacy of garlic oil may be attributed to its potent and pungent odors, which could have a toxic effect by disrupting the normal respiratory activity of the weevils. This disruption may lead to asphyxiation and eventual death. **Doucet & Retnakaran, (2012)** reported that Essential oils derived from plants are notably lipophilic, enabling them to penetrate the cuticle of insects. This characteristic could be an additional factor contributing to the potency of the oils. In this way, besides their fragrance, the plant material might have also functioned as a contact poison. Our study suggests that the oils acted as contact/stomach poisons for *R. dominica*.

Exposing adult females to wheat grains previously treated with plant oils at various concentrations resulted in a significant reduction in the reproductive potential compared to the control group. The results showed a gradual increase in the reduction percentage of *R. dominica* progeny with higher concentrations of the tested plant oils. Furthermore, at the 2% concentration, all tested oils completely prevented adult emergence. Notably, arugula oil, at a concentration of 1.5%, led to the complete elimination of progeny. These findings suggest that the suppression of F1 adult emergence is likely attributed to the toxicity of the oils to eggs or younger larvae as concluded by **Yang et. al., (2010)** Employing garlic oil against *S. oryzae* adults resulted in a decrease in oviposition and the suppression of adult emergence. This could be attributed to the application of oils, which covered the outer layer (testa) of the grains, acting as a form of food poisoning for the adult insects. Additionally, the oils may have successfully penetrated into the endosperm and germ layers of wheat grains, thereby inhibiting oviposition and larval development., this suggestion are also supported by the finding of **Arannilewa et. al., (2006)** While employing the petroleum ether extract of four medicinal plants against the maize weevil, *Sitophilus zeamais*, the results were consistent with **Chaubey, (2007)** who reported that the essential oil derived from *Anethum graveolens* (dill oil), decreased the oviposition potential of *T. castaneum*. **Upadhyay et. al., (2007)** discovered that increasing the concentration of *Anethum graveolens* essential oil significantly inhibited oviposition and suppressed the reproductive potential of *Callosobruchus chinensis*. In addition, **Ofuya et al., (2010)** and **Ileke and Olotuah, (2012)** reported, fumigant toxicity of crushed bulbs of *Allium sativum* on freshly laid eggs of *C. maculatus* on cowpea seeds completely prevented adult emergence.

The findings from this study revealed that treating wheat grains with various concentrations of plant oils led to a significant reduction in grain weight loss compared to the control. The experiments demonstrated that the concentrations of the six essential oils (cinnamon, clove, arugula, garlic, onion, and cumin) preserved both the quantity and quality of wheat grains. Additionally, they completely prevented egg deposition by the pest, providing 100% protection for the wheat grains. This suggests that the plant oils, including cinnamon, clove, arugula, garlic, onion, and cumin, play an indirect role in safeguarding the grains. **Ofuya et. al., (2010)** found that crushed bulbs of *A. sativum* caused 30% or more protection of seed weight after fumigation of the freshly laid eggs of *C. maculatus*. **Sailan et. al., (2009)** found that, The decrease in weight loss observed in the treated wheat grains with eight monoterpenes at LC50 and LC95 rates can be attributed to the elevated mortality of adults following treatment with the tested oils. These findings align with the results reported by various authors who assessed weight loss in wheat grains resulting from infestations by certain stored pests. **Ahmad et. al., (2019)** stated that grains treated with *A. sativum* oil exhibited reduced damage from the weevils. **Reyad et. al., (2020)** who reported that weight loss was gradually reduced with increase of oil concentration. **Rajesh et. al., (2008)** discovered that the oil extracted from *Aegle marmelos* minimized weight loss in fumigated gram and wheat samples infested with *C. chinensis* and protected wheat from *R. dominica*, *S. oryzae*, and *T. castaneum*. Also, **Tabu et. al., (2012)** found that, oils of *Brassica juncea*, *Linum usitatissimum* and *Guizotia* *abyssinica* were able to reduce chickpea weight loss.

Findings indicated that the application of the tested plant oils had minimal impact on the viability of wheat grains. At this application rate, the grains exhibited no adverse effects, maintaining their normal texture, color, and appearance. The present results are in agreement with the findings of **Arab et. al., (2022)** who stated the germination percentages from 0 to 180 days post-storage showed slight differences between the control and the oil treatments. This observation aligns with findings previously reported by various authors. According to **Zayed et al., (2020),** anise oil exhibited a mild inhibitory effect on the germination percentage of wheat grains. The essential oil's impact on seed germination was assessed concerning stored seeds, and the results showed no significant inhibition compared to the control when using *Citrus maxima* essential oil **Visakh et al., (2022).** On the contrary, the essential oil derived from Ferulago angulata exhibited no reduction in wheat germination. The treated wheat seeds showed no decreases in germination at the tested concentrations, as reported by **Ebrahimifar et al., (2021).**

REFERENCES:

Abo Arab, R. B., El-Tawelah, N. M., Abouelatta, A. M., & Hamza, A. M. (2022). Potential of selected plant essential oils in management of Sitophilus oryzae (L.) and Rhiyzopertha dominica (F.) on wheat grains. Bulletin of the National Research Centre, 46(1), 192.

Afful, E., Cato, A., Nayak, M. K., & Phillips, T. W. (2021). A rapid assay for the detection of resistance to phosphine in the lesser grain borer, Rhyzopertha dominica (F.)(Coleoptera: Bostrichidae). Journal of Stored Products Research, 91, 101776.

Ahmad, F., Iqbal, N., Zaka, S. M., Qureshi, M. K., Saeed, Q., Khan, K. A., ... & Awar, M. B. (2019). Comparative insecticidal activity of different plant materials from six common plant species against Tribolium castaneum (Herbst) (Coleoptera: Tenebrionidae). Saudi Journal of Biological Sciences, 26(7), 1804-1808.

Alsahary, I. (2014). Wheat production to decline by 2% in 2014. Retrieved from Egypt independent.com/news/fao-wheat-production-decline-2.

Anonymous. 2003. SAS Statistics and graphics guide, release 9.1. SAS Institute, Cary, North Carolina 27513, USA.

Anonymous.1976. Germination method part-I agriculture and horticulture seeds. Seed Science and Technology, 4:120 .

Arannilewa, S.T.; Ekrakene, T. and Akinneye, J. O. (2006): Laboratory evaluation of four medicinal plants as protectants against the maize weevil, Sitophilus zeamais Mots. Africa J. Biotechnol. 5(21): 2032-2036.

Ashokkumar, K., Murugan, M., Dhanya, M. K., & Warkentin, T. D. (2020). Botany, traditional uses, phytochemistry and biological activities of cardamom [Elettaria cardamomum (L.) Maton]–A critical review. Journal of ethnopharmacology, 246, 112244.

Bakkali, F., Averbeck, S., Averbeck, D., Idaomar, M., 2008. Biological effects of essential oils – a review. Food Chem. Toxicol. 46, 446–475.

Basile, S., Badalamenti, N., Riccobono, O., Guarino, S., Ilardi, V., Bruno, M., & Peri, E. (2022). Chemical composition and evaluation of insecticidal activity of Calendula incana subsp. maritima and Laserpitium siler subsp. siculum essential oils against stored products pests. Molecules, 27(3), 588.

Chaubey, M.K. (2007): Insecticidal activity of Trachyspermum a mmi (Umbelliferae), Anethum graveolens (Umbelliferae) and Nigella sativa (Ranunculaceae) essential oils against stored-product beetle Tribolium castaneum (Herbst) (Coleoptera: Tenebrionidae). Africa J. Agric. Res. 2 (11): 596-600.

Chaubey, M. K. (2008). Fumigant toxicity of essential oils from some common spices against pulse beetle, Callosobruchus chinensis (Coleoptera: Bruchidae). Journal of oleo science, 57(3), 171-179.

Chaudhari, A. K., Singh, V. K., Kedia, A., Das, S., & Dubey, N. K. (2021). Essential oils and their bioactive compounds as eco-friendly novel green pesticides for management of storage insect pests: Prospects and retrospects. Environmental Science and Pollution Research, 28, 18918-18940.

Demeter, S., Lebbe, O., Hecq, F., Nicolis, S. C., Kenne Kemene, T., Martin, H., ... & Hance, T. (2021). Insecticidal activity of 25 essential oils on the stored product pest, Sitophilus granarius. Foods, 10(2), 200.

Doucet, D., & Retnakaran, A. (2012). Insect chitin: metabolism, genomics and pest management. In Advances in insect physiology (Vol. 43, pp. 437-511). Academic Press.

Ebrahimifar, J., Jamshidnia, A., Sadeghi, R., & Ebadollahi, A. (2021). Repellency of Ferulago angulata (Schlecht.) Boiss essential oil on two major stored-product insect pests without effect on wheat germination. International Journal of Tropical Insect Science, 41, 217-223.

El-Lakwah, F.A.; Darwish, A.A. and Khaled, O. M. (1992). Effectiveness of dill seed powder (Anethum graveolens) on some stored product insects. Ann. Agric. Sci. Moshtohor, 34(4): 2031-2037.

Finney, D.F. (1971). Probit Analysis. Cambridge University Press, London. pp. 256.

Fouad, H.A., Faroni, L.R.D., Tavares, W.S., Ribeiro, R., Freitas, S.S., Zanuncio, J.C., 2014. Botanical extracts of plants from the Brazilian Cerrado for the integrated management of Sitotroga cerealella (Lepidoptera: Gelechiidae) in stored grain. J. Stored Prod. Res. 57, 6–11.

Gad, H. A., Al-Ayat, A. A., Hassuba, M. M., & Abdelgaleil, S. A. (2023). Effectiveness of binary combinations of abamectin and deltamethrin with two inert dusts for the management of Trogoderma granarium Everts on wheat grains. Journal of Stored Products Research, 100, 102071.

Harris, K.L. and Lindblad, C.J. (1978): Postharvest grain loss assessment method. American Association of

Cereal Chemists, St. Paul., Minnesota, USA, pp 193.

Hettiarachchi, J. M., Dissanayaka, D. M. S. K., & Wijayaratne, L. K. W. (2020). Influence of grain fractions on the progeny adult emergence of the lesser grain borer, Rhyzopertha dominica (F.)(Coleoptera: Bostrychidae) in stored rice varieties and pulses.

Ileke, K. D. and Olotuah, O. F. (2012): Bioactivity of Anacardium occidentale (L) and Allium sativum (L) powders and oils extracts against cowpea bruchid, Callosobruchus maculatus (Fab.) [Coleoptera: Chrysomelidae]. Inter. J. Biol. 4 (1): 96-103.

Ileke, K. D., Idoko, J. E., Ojo, D. O., & Adesina, B. C. (2020). Evaluation of botanical powders and extracts from Nigerian plants as protectants of maize grains against maize weevil, Sitophilus zeamais (Motschulsky) [Coleoptera: Curculionidae]. Biocatalysis and agricultural biotechnology, 27, 101702.

Isman, M.B., 2006. Botanical insecticides deterrents, and repellents in modern agriculture and an increasingly regulated world. Ann. Rev. Entomol. 51, 45–66.

Kéita, S.M., Vincent, C., Schimit, J.P., Arnason, J.T., Bélanger, A., 2001. Efficacy of essential oil of Ocimum basilicum L. and O. gratissimum L. applied as an insecticidal fumigant and powder to control Callosobruchus maculates (Fab.) (Coleoptera: Bruchidae). J. Stored Prod. Res. 37, 339–349.

Kim, D., A. Y. Joon, K. Dh and A. YJ. 2001. Contact and fumigant activities of constituents of Foeniculum vulgare fruit against three coleopteran stored-product insect. PestManagement-Sci. 57(3): 301-306.

Kljajić, P., Andrić, G., & Golić, M. P. (2023). Evaluation of long-term residual activity of insecticides against Acanthoscelides obtectus (Say) on common bean in laboratory tests. Journal of Stored Products Research, 103, 102156.

Lee, B., C. Wonsik, L. Sungeun, P. Byeoungsoo, L. Bh, C. Ws, L. Se and P. Bs. 2001. Fumigant toxicity of essential oils and their constituent compounds towards the rice weevil, Sitophilus oryzae (L.). Cropprotection. 20(4): 317-320.

Machial, C.M., Shikano, I., Smirle, M., Bradbury, R., Isman, M.B., 2010. Evaluation of the toxicity of 17 essential oils against Choristoneura rosaceana (Lepidoptera: Tortricidae) and Trichoplusia ni (Lepidoptera: Noctuidae). Pest Manage. Sci. 66, 1116–1121.

Matos-Neto, F.C., Zanuncio, J.C., Picanco, M.C., Cruz, I., 2002. Reproductive characteristics of the predator Podisus nigrispinus fed with an insect resistant soybean variety. Pesqui. Agropecu. Bras. 37, 917–924.

Nikolaou, P., Marciniak, P., Adamski, Z., & Ntalli, N. (2021). Controlling stored products' pests with plant secondary metabolites: A review. Agriculture, 11(9), 879.

Ofuya, T.I.; Olotuah, O.F. and Ogunsola, O.J. (2010): Fumigant toxicity of crushed bulbs of two Allium species to Callosobruchus maculatus (Fabricius)

(Coleoptera: Bruchidae). Chilean J. Agric. Res. 70 (3): 510-514.

Pestana, J.L.T., Loureiro, S., Baird, D.J., Soares, A.M.V.M., 2009. Fear and loathing in the benthos: responses of aquatic insect larvae to the pesticide imidacloprid in the presence of chemical signals of predation risk. Aquat. Toxicol. 93, 138–149.

Rajesh, K.; Ashok, K.; Chandra, S. P.; Nawal, K. D. and Raju, S. (2008): Insecticidal activity Aegle marmelos (L.) correa essential oil against four stored grain insect pests. Inter. J. Food Safety. 10: 39-49.

Reyad, N. F., AL-GHAMDI, H. A., Abdel-Raheem, M. A., & Al-Shaeri, M. A. (2020). The effects of botanical oils on the red palm weevil, Rhynchophorus ferrugineus olivier (Coleoptera: curculionidae). Applied Ecology & Environmental Research, 18(2).

Riaz, T., Jalil, F., Najeeb, A., Minhas, T., & Shakoori, F. R. (2024). Comparative effectiveness of deltamethrin, imidacloprid and emamectin benzoate alone and in binary blends to control Trogoderma granarium: Effect on macronutrients. Journal of Stored Products Research, 105, 102233.

Ribeiro, de Araújo I. A. T., da Silva, R., da Silva, A. G., Milet-Pinheiro, P., Paiva, P. M. G., Navarro, D. M. D. A. F., ... & dos Santos Correia, M. T. (2020). Chemical characterization and insecticidal effect against Sitophilus zeamais (maize weevil) of essential oil from Croton rudolphianus leaves. Crop protection, 129, 105043.

Sailan, E.A.A.; Magdy, M.I.E. and Samir, A.A.M. (2009). Effectiveness of monoterpenes against Sitophilus oryzae (L.) and Tribolium castaneum (Herbst) in stored wheat. J. Pest Control Environ. Sci. 17 (1/2): 61-76.

Silva-Filho, R., Santos, R.H.S., Tavares, W.S., Leite, G.L.D., Wilcken, C.F., Serrão, J.E., Zanuncio, J.C., 2014. Rice–straw mulch reduces the green peach aphid, Myzus persicae (Hemiptera: Aphididae) populations on Kale, Brassica oleracea var. acephala (Brassicaceae) plants. PLoS One 9, e4174.

Sun, Y.P. (1947). An analysis of some important factors affecting the results of fumigation tests on insects. Minn. Agric. Exp. St. Techn. Bull., 177: 104.

Tabu, D.; Selvaraj, T.; Singh, S.K. and Mulugeta, N. (2012). Management of Adzuki bean beetle Callosobruchus chinensis (L.) using some botanicals, inert materials and edible oils in stored chickpea. Inter. J. Agric. Technol. 8 (3): 881-902.

Tripathi, A.K., V. Prajapati, N. Verma, J.R. Bahl, R.P. Bansal, S.P Khanuja and S. Kumar. (2002) Bioactivities of the leaf essential oil of Curcuma longa (var. ch-66) on three species of stored-product beetles (Coleoptera). J. Econ. Entom. 95(1): 183-189.

Tunc, L.B., M. Berger, F. Erler and F. Dagli. (2000). Ovicidal activity of essential oils from five plants against two stored product insects. J. Stored. Prod. Res. 36: 161-168

Upadhyay, R. K.; Gayatri J. and Neeraj, Y. (2007): Toxicity, repellency and oviposition inhibitory activity of some essential oils against Callosobruchus chinensis. J. Appl. Basic. 33 (1): 21-26.

Visakh, N. U., Pathrose, B., Narayanankutty, A., Alfarhan, A., & Ramesh, V. (2022). Utilization of pomelo (Citrus maxima) peel waste into bioactive essential oils: Chemical composition and insecticidal properties. Insects, 13(5), 480.

Wang, Ni, Z. J., X., Shen, Y., Thakur, K., Han, J., Zhang, J. G., ... & Wei, Z. J. (2021). Recent updates on the chemistry, bioactivities, mode of action, and industrial applications of plant essential oils. Trends in Food Science & Technology, 110, 78-89.

Yang, F. L., Liang, G. W., Xu, Y. J., Lu, Y. Y., & Zeng, L. (2010). Diatomaceous earth enhances the toxicity of garlic, Allium sativum, essential oil against stored-product pests. Journal of Stored Products Research, 46(2), 118-123.

Yang, Y., Isman, M. B., & Tak, J. H. (2020). Insecticidal activity of 28 essential oils and a commercial product containing Cinnamomum cassia bark essential oil against Sitophilus zeamais Motschulsky. Insects, 11(8), 474.

Zayed, G. M. M., Soliman, M., & Hussain, H. B. H. (2020). Bioactivity and chemical composition of anise (Pimpinella anisum) on Rhyzopertha dominica (Coleoptera: Bostrichidae) compared to malathion. Egyptian Journal of Plant Protection Research Institute. 3 (1): 268 - 280