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Insecticidal Effect of cinnamon oil against *Sitophilus oryzae* on rice (*Oryza sativa* L.)

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Abstract \

This study was conducted to determine the insecticidal activity of cinnamon oils (CO) against the adults of the rice weevil *Sitophilus oryzae*. Different concentrations of the tested of rice grains (Giza 4000). The results showed that weevil mortality increased with increasing doses of the cinnamon oil tested concentrations caused as high adult mortalities as compared with the other treatments tested. Meanwhile, essential oils from plants were obtained by Clevenger-type water distillation and their fumigant toxicities were tested against adults of the rice weevil, Sitophilus *oryzae*. For assaying the fumigant toxicities of the evaluated EOs, the mortality was determined after 24, 48 and 72 h from beginning of exposure and LC_{50} values of cinnamon oil were estimated. Fumigation bioassays revealed that essential oils of cinnamon had strong insecticidal activity on the experimental insect. Based on LC_{50} values, the order of toxicity of the evaluated EOs to *S. oryzae* from highest to lowest. The weevil mortality increased with increase the time of exposure and the calculated LC_{50} decreased. Cinnamon oil low LC_{50} after the different bioassay periods of 24, 48 and 72 post rice treatments. Control treatment recorded the higher damage percentage as compared to rate of 10ml/l which recorded the lower, while, treatment of 10ml/l significant higher of germination as compared to control treatment which recorded the lower germination percentage

Keywords: Rice (*Oryza sativa* L.) , *Sitophilus oryzae*, essential oils .

Introduction\

The final outputs of some crops' agricultural processes are stored grains. A major hazard to stored crops such rice, maize, wheat, and sorghum is the rice weevil, *S. oryzae* (L.) [18]. Widely distributed throughout tropical, sub-tropical, and worm zones, it is a destructive species [4,28]. Rice weevils (*S. oryzae*) have caused significant losses and damage in rice storage. The usage of chemical pesticides to manage them has resulted in restricted storage facilities and negative environmental effects [21].

Additionally, these pests' feeding results in both qualitative and quantitative losses in grain weight, nutritional content, and seed germination ability [25]. Previous experiences indicated that fumigants were often utilized to control pests in stored products. Terziev and Petkova-Geogieva [45] said chemical pesticides caused a lot of issues for our environment and health. It has been shown that plant-derived compounds are good suppliers of a range of volatiles that could be developed as substitutes for traditional pesticides. A variety of aromatic and medicinal plants have shown exceptional results in the preservation of grain supply and the control of pests, and essential oils (EOs) have recently drawn attention as an alternative to conventional pest management methods [13]. EOs is naturally occurring organic compounds with a range of biological properties, such as insecticidal, antioxidant, and antibacterial properties. The agricultural industry has embraced the use of synthetic insecticides to control these significant insect pests. However, in addition to direct toxicity to users, their indiscriminate use has led to environmental contamination, pesticide resistance, pest resurgence, and deadly effects on non-target creatures in agro-ecosystems [15]. Differently scented plant phytochemicals have insecticidal qualities and are effective against a variety of insect pests [29]. Although plant extracts have been used to control a variety of insect pests, little is known about how well they work to prevent crop damage or how they impact rice yield and beneficial insects [43].

The highly dangerous conventional gaseous fumigants are believed to be replaced by more ecologically friendly plant volatiles, such as essential oils (EOs) and phytochemicals (PCs) [27]. The most practical and cost-effective way to prevent infestation in most storage systems is to use chemical and fumigating insecticides. Natural products can also be used to manage pests associated with stored products. Various methods were used to control insects found in stored goods, such as essential oils [9]. Numerous research have documented the larvicidal, ovicidal, adulticidal, and mosquito-repelling properties of cinnamon essential oils [12]. The fruit, root and bark of the cinnamon plant are used to extract cinnamon essential oil, a safe and natural material. Cinnamaldehyde (C_9H_8O) is the most prevalent among the aromatic esters, fatty acids, aromatic aldehydes, and terpenes that make up cinnamon oil [26]. According to **Chang *et al.*** [10]**,** rice weevil is a significant pest of stored grains. More significantly, they can contaminate food with their excrement, alter the nutritional flavor of rice, and reduce its quality [19]. The use of cinnamon essential oil for pest management in agricultural production has grown widespread due to reports that it has strong insecticidal and repellant properties against rice weevil [47]. Several studies have shown that cinnamon oil can kill adult weevils under controlled fumigation circumstances, making it especially efficient in eliminating *Sitophilus oryzae* [6,22]. At specific dosages, cinnamon oil shown insecticidal properties against ants [22]. Additionally, the oil is a promising option for environmentally friendly pest control of stored grains due to its comparatively low toxicity to non-target organisms [50]. The objectivities of this study are to identify cinnamon oil insecticidal against *Sitophilus oryzae* on rice (*Oryza sativa* L.)

Materials and methods\

The previously preserved culture of *Sitophilus oryzae* was acquired from the Biology Laboratory, Faculty of Education (Bayda), Omar Al-Mukhtar University, Libya. [30]. provided the guidelines for raising adult weevils on brown rice at 25 ± 2°C and 65 ± 5% relative humidity.

Sample preparation and essential oil extraction: Using a Clevenger-type apparatus, 100g of each sample was first air dried at 25°C before being subjected to steam distillation for four hours. Using a Clevenger-type apparatus, the EOs of all dried samples (100g) were separated by steam distillation for three hours in accordance with the **British Pharmacopoeia's** [7]. recommended procedure. Before being used, the essential oils (EO) that had been extracted were dried on anhydrous sodium sulfate and kept in airtight glass vials between 4 and 5°C.

Fumigant toxicity by Eos: Vapour toxicity of the tested botanical essential oils against the adult insects of *S. oryzae* was determined via impregnated paper assay following the method of [34]. with some modifications. Glass jam jars with screw lids were used as exposure chambers. Different doses were applied to a squared circular filter paper (Whatman No. 1) 2cm X 2cm). The treated filter paper was then introduced into the jars to after they are being attached to the inner surface of the screw lid of the jar using a double face adhesive tape. Ten adults of *S. oryzae* (2 to 4 days old) were released into each jar. Insect mortalities were determined and calculated after 24, 48 and 72 hours from exposure. Three replicates were set up for each dose and control.

Weight loss and grain damage: The count-and-weight method [1] was used to calculate the weight loss of the damaged and undamaged seeds, which were counted and weighed after 60 days of treatment administration. If a weevil produced a small exit hole in the grain, the seed was considered damaged.

Weight loss (%) = Initial Weight –final Weight / Initial Weight ∗ 100

After re-weighing, the numbers of damaged grains were evaluated by counting wholesome and bored or seed with weevil emergent holes. Percentage seed damaged was also calculated as follows:-

Seed damage (%) = Number of perforated grains/ Total number of grains counted ∗ 100

Statistical analysis: The data from all the experiments were recorded and managed in a MS- excel sheet. The SPSS (16th version) was used for data analysis. The concentrations of essential oil were transformed using log transformation at the base of 10. Data were subjected to probit analysis [17]. Chi-square test was used to test for heterogeneity within the data. In case of significant heterogeneity ($p<0.05$), a heterogeneity factor was included to calculate variances and confidence limits.

Results and discussion\

A) Mortality of *Sitophilus oryzae* : Adult *Sitophilus oryzae* mortality rates after fumigation at varying cinnamon oil concentrations were 0.5, 1, 2, 4, 6, 8, and 10 ml/l (Table 1). According to the results, the control treatment had the lowest mortality rate (0.0), while the cinnamon oil at 10 ml/l had the highest mortality after 24, 48, and 72 hours (90.15, 94.9, and 100%). It was followed by cinnamon oil at 8 ml/l (76.10, 80.75, and 86.64%).When time passed, there was an increase in mortality, but when the concentration of essential oils decreased, there was a drop in mortality.

Perera and Karunaratne [35]. assessed the toxic properties of an essential oil extracted from *Ruta graveolens* L. leaves against *Sitophilus oryzae*, the rice weevil. The highest concentrations of the oil tested (150 and 200 µl) were very successful in causing 100% weevil death within an hour and over 90% within half an hour in contact and fumigation toxicity bioassays, in contrast to the control, which shown no mortality. At the lowest dose (50 µl), the effectiveness in terms of contact and fumigation toxicity was 93% and 91%, respectively, after an hour. In a fumigant test, Saheb and Mouhouche [41]. discovered that thyme and clove essential oils (EOs) were the most effective, inducing 100% mortality of *Sitophilus oryzae* when administered at a level of 240 µl /l.

Table (1). Toxicity of Cinnamon oil against Mortality (%) of *Sitophilus oryzae* adults.

Concentrations (ml/L)	Mortality (%)		
	24h	48h	72h
Control	0.00	0.00	0.00
0.5	18.72	23.55	28.99
1.0	28.21	22.15	33.20
2.0	33.14	38.12	42.61
4.0	38.52	42.54	47.87
6.0	47.69	52.26	65.46
8.0	76.10	80.75	86.64
10.0	90.15	94.9	100

Cinnamon oil worked well as a fumigant against *Sitophilus oryzae*. The mortality due to the cinnamon oil extract observed in our study could be a consequence of starvation, due to its antifeeding effect, rather than a toxic effect. AChE activity was significantly reduced when adults of *S. oryzae* were fumigated with sublethal concentrations of essential oils of *Piper nigrum* (Piperaceae) and *Cuminum cyminum* (Apiaceae), according to [11]. Monoterpenoids may be responsible for the insecticidal properties of several plant essential oils [46]. They contain fumigant action that may be important for controlling insects in stored products because of their high volatility [24]. Previously, monoterpenoids were described as contact toxicants and fumigants for a variety of insect pests [40]. According to Mossa [32], essential oils are believed to be more environmentally friendly and less detrimental to mammals than synthetic insecticides and herbicides. Zeba and Khan [51]. claim that this decrease in metabolic enzyme activity indicates a disruption in the chemical pathways of the insect, leading to abnormal physiological states that make it more difficult for them to survive. The ability of plant extracts and powders to effectively prevent weight loss and seed damage may be explained by the high insect fatality rate. This could be because, as noted by Nath *et al.* [33], the insects were prevented from depositing their eggs on the treated grains, hence reducing larval feeding and preventing weight loss and seed damage. The plant variety and duration of exposure affected the toxicity of the plant materials used in this study. Furthermore, the results demonstrated that the leaf extracts were more detrimental to the insects than the leaf powders employed for contact toxicity. Salah *et al.* [42] claim that the concentration of active chemicals in the extracts at the time of extraction may be connected to this variance in efficacy. Additionally, the changed grains hindered the insects' capacity to feed, which hindered their normal growth and development [14]. Some insects died from starvation as a result. It was discovered that the adulticidal properties of cinnamon essential oil and its components depended on exposure duration as well as dosage. Perhaps because of its aromatic nature, cinnamonaldehyde was more hazardous than linalool. Monoterpenes with a chemical skeleton containing a non-substituted phenolic moiety were discovered to have more efficacious fumigant activity and reproductive suppression against *Acanthoscelides obtectus* [39]. The monoterpene carvacrol has a broad spectrum of insecticidal activity against a variety of agricultural, stored goods, and medicinal insect pests. It also possesses fumigant activity, according to [2]. According to Kim and Ahn [23], adults of *S. oryzae*, *C. chinensis*, and *L. serricorne* are susceptible to fumigant activity from the monoterpene fenchone, estragole, and phenylpropenes (E)-anethole The lethal toxicity doses of Cinnamon oil against *Sitophilus oryzae* adults are shown in **Table (2)** The presented results showed that as the time of exposure increase the weevil mortality increased and the calculated LC_{50} decreased. The results indicated that the obtained EO of Cinnamon oil was the most effective tested. Cinnamon oil low LC50 (4.15, 0.26 and 0.13 µl/370 ml air) after the different bioassay periods of 24, 48 and 72 post rice treatments, respectively. Strong contact and repellant efficacy against store grain pests was also demonstrated by beta-caryophyllene [48].

Table (2). LC_{50} and LC_{90} (%) of Cinnamon oil against the *Sitophilus oryzae* adults.

Time (h)	LC_{50}	LC_{95} Confidence limit	χ^2 (df = 5)
24	4.15	183.63	19.97
48	0.26	3.31	79.55
72	0.13	1.01	65.18

The behavioral repellency was investigated by [36]., who discovered that the control area had a longer resting period than the treated area with clove essential oil that had both LC_{50} and

LC_{90} values. The fumigation effect of clove oil against *S. oryzae* was evaluated by [31], with LC_{50} of 17.32 and 15.34 µl at 24 and 48 hours, respectively. Plata-Rueda *et al.* [36] calculated the LC_{50}. They discovered that cinnamon oil was less hazardous than it, with LC_{50} and LC_{90} values of 11.9 and 23.4 (w/v). Clove oil concentrations needed to kill 50% of *Aedes aegypti* larvae in their third instar were 0.005% in a glass vial bioassay [8]. Clove oil concentrations of 0.267% and 0.192% LC_{50} were recorded for termite treatments based on soil and filter paper, respectively [3]. Similarly, when clove oil was applied to peas to combat *S. zeamais*, [38]. showed an LC_{50} of 224.45 µL/ml. Higher toxicity may result from the dazzling vial's closed state, where contact and a fumigation effect may have occurred, causing a high fatality rate with a small amount. Additionally, the plant species, portions used for extraction, parts used at different phases of growth, extraction techniques, chemical components in oils, concentrations, and exposure time all affected the diverse results [16].

B) Weight loss and grain damage: Results in **Table (3)** showed that control treatment recorded the higher weight loss (23.55%), as compared to Cinnamon oil at rate of 10ml/l (2.35%), also, control treatment recorded the higher damage percentage (56.41%) as compared to rate of 10ml/l which recorded (1.61%), while, treatment of 10ml/l significant higher of germination (96.63 %) as compared to control treatment which recorded the lower germination percentage (28.50%).

Table (3). Weight loss and grain damage of rice grains treated cinnamon oils against *S. ryzae*.

Concentrations (ml/l)	Weight loss (%)	Damage (%)	Germination (%)
Control	23.55	56.41	28.50
0.5	8.27	40.55	52.25
1.0	6.95	31.69	92.63
2.0	5.99	23.68	66.50
4.0	5.00	18.26	73.63
6.0	4.19	10.80	78.38
8.0	2.96	5.00	80.75
10.0	2.35	1.61	96.63

Utilizing plant extracts can lessen the possibility of *S. oryzae*-induced weight loss in rice. Yazdgerdian *et al.* [49] found that *S. oryzae* can result in weight loss of up to 30 to 40 percent, which is in line with this study. The percentage of rice that loses weight can vary based on the chemical makeup and concentration of the plant extracts, as well as the proportions of the ingredients in the mixture that can keep the rice weevils from eating the rice. Interestingly, even closely related species can have different chemical compositions and concentrations of plant extracts [49]. Both terpenoid and citronellal compounds found in pandan and kaffir leaves have been demonstrated to have strong toxicity against *S. oryzae* [5,20]**,** indicating that these plant extracts have antifeedant qualities that can be used to prevent rice weevils from feeding on rice. Our results showed the highest concentration of clove oil reducing weight loss by 4 times and damage percent by about 20 times in comparison to lowest concentration tested. It is much different if compared with control. Clove oils had a potential to reduce weight loss and damage percent of maize grains [37].

Conclusion \

These findings and previous research outputs demonstrate that essential oils could be applied as fumigants or pesticides in the future to manage pests of stored commodities that reside in protected spaces such as buildings, greenhouses, and storage bins. Therefore, more investigation is needed into the safety of the essential oils and their constituents for the environment and human health before they may be employed in a practical way as novel fumigants. Furthermore, formulation research is necessary to minimize production costs, create standards for quality control, and boost the potency and stability of products based on essential oils. The results obtained in this study demonstrate that the essential oils tested can be used to control stored grain pests and to support further studies. The toxic effects of essential oils involve many factors, among which is the entry point of toxins, and which may have contact, fumigation, and repellent effects. However, the results of this study indicate that the essential oils might be useful for managing the insect pests in storage especially *S. oryzae.*

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الملخص العربي/

التأثير الإبادي لزيت القرفة ضد حشرة *Sitophilus oryzae* على الأرز

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أجريت هذه الدراسة لتحديد النشاط الحشري لزيت القرفة ضد الحشرات البالغة من سوسة الأرز. تركيزات مختلفة من حبوب الأرز المختبرة (جيزة 4000). أظهرت النتائج أن معدل وفيات السوسة زاد مع زيادة جرعات تركيزات زيت القرفة المختبرة مما تسبب في ارتفاع معدلات وفيات البالغين مقارنة بالمعاملات الأخرى المختبرة. في الوقت نفسه، تم الحصول على الزيت العطري من النبات عن طريق تقطير الماء من نوع Clevenger واختُبرت سميتها التبخيرية ضد الحشرات البالغة من سوسة الأرز *Sitophilus oryzae*. لتحليل سمية التبخير للزيت العطري المختبر، تم تحديد معدل الوفيات بعد 24 و48 و72 ساعة من بداية التعرض وتم تقدير قيم LC_{50} لزيت القرفة. أظهرت الاختبارات الحيوية للتبخير أن الزيت العطري للقرفة لها نشاط حشري قوي على الحشرة التجريبية. بناءً على قيم التركيز المميت للنصف (LC_{50})، رُتِّبت سمية الزيوت العطرية المُقيَّمة لسوسة الأرز من الأعلى إلى الأدنى. ازدادت نسبة وفيات السوسة بزيادة مدة التعرض، وانخفض التركيز المميت للنصف (LC_{50}) المحسوب. انخفض التركيز المميت للنصف (LC_{50}) لزيت القرفة بعد فترات الاختبار الحيوي المختلفة (24 و48 و72) بعد معاملات الأرز. سجّلت معاملة الشاهد نسبة ضرر أعلى مقارنةً بمعدل 10 مل/لتر الذي سجّل نسبة إنبات أقل، بينما سجّلت معاملة 10 مل/لتر نسبة إنبات أعلى بكثير مقارنةً بمعاملة الشاهد التي سجّلت نسبة إنبات أقل.

الكلمات المفتاحية: الأرز ، سوسة الأرز ، الزيوت العطرية