The insecticidal activity of some essential oils and their effect on biochemical parameters of fall armyworm, *Spodoptera frugiperda* (J.E. Smith)

El- Gabaly, A. R., Marwa M. Mousa, Mohamed F. Abdel Aziz

Plant Protection Research Institute, Agricultural Research Center (ARC), Dokki, Giza, Egypt

mfathy99935@gmail.com

Abstract: Fall armyworm (FAW)**,** *Spodoptera frugiperda* is a polyphagous insect causing damage to several crops. In the present work, the toxicity of four plant oils, namely: ginger (*Zingiber officinale*), turmeric (*Curcuma longa*), thyme (*Thymus vulgaris*) and lemon (*Citrus limon*) against second and fourth instar larvae of FAW at different concentrations under laboratory conditions was evaluated. In each treatment, healthy sixth instar of FAW larvae that survived after treatment of fourth instar larvae with LC_{50} concentration were taken for biochemical analyses. The results showed that lemon oil achieved superior toxic efficacy with LC_{50} and LC_{25} values as 0.259 and 0.096 % for second larval instar and 0.542 and 0.084 % for fourth larval instar, respectively, while the least effect was recorded with LC_{50} and LC_{25} values of turmeric oil as 0.941 and 0.257% for 2^{nd} larval instar, and 1.688 and 0.38% for 4^{th} larval instar, respectively. Regarding the effects on enzyme activity level, total proteins and total carbohydrates recorded a significant decrease in all treatments with the tested oils. The highest *and lowest enzyme activity of acetylcholinesterase was observed after treated with thyme and lemon oils, respectively.* While, no significant differences were observed in the activity of alpha esterase enzyme between the treatments of turmeric, ginger and thyme oils, and inhibition of glutathione S-transferase enzyme activity was occurred in all treatments. The activities of protease, amylase and lipase enzymes were decreased after using the four tested oils compared to control. Therefore, the results of this work demonstrated the effectiveness of the tested oils in combating FAW under laboratory conditions, and it can be used in field application as a safe and effective alternative and as a part of the integrated pest management program.

Keywords*:* *Spodoptera frugiperda, essential oils, Zingiber officinale, Curcuma longa, Thymus vulgaris, Citrus limon.*

1.Introduction:

Fall army worm (FAW), *Spodoptera frugiperda* (J.E. Smith) is an invasive damaging pest causing great losses in crops. This polyphagous pest is considered a major threat to various economically important crops, such as maize, sorghum, rice, wheat, beans, cotton, potatoes, and tomatoes, causing significant yield and quality losses. The pest's wide host range, high fecundity, and resistance to pesticides, contribute to its devastating impact on agricultural production **(Cruz *et al.*, 2010 and De Almeida *et al.*, 2002).** *Spodoptera frugiperda* is usually controlled by synthetic insecticides that had significant drawbacks including environmental residues, health hazards, resistance development and non-target effects **(Yu, 1991).** Because of these effects of the synthetic insecticides, the management of this pest with natural, safe, effective alternative strategy is very important goal to reduce the dangerous impacts on plantations and surrounding environment.

Many plants are reportedly possessing natural substances with pest-control potential, that could form a good alternative to insecticides, therefore many researchers **(Hernandez and Leon, 1994; Tembo *et al.*, 2018 and Mukanga *et al.*, 2022)** reported that our nature is rich in plants possessing bioactive compounds acting as natural pesticides**.** Plant oils originate from the secondary metabolism of plants and consist of mixture of complex chemical substances that act as plant defense with low toxicity for animals and human, as well as had antiviral, fungicidal, bactericidal, insecticidal and repellent action. **Barbosa *et al.*, 2018** demonstrated that the oils of turmeric, palmarosa and clove showed best potential control of *S. frugiperda* from the lowest concentrations corresponding to 25 µL mL^{-1}. Numerous researchers have demonstrated the effectiveness of various plant extracts and essential oils in combating insects **(Zhao *et al.* , 1998; Isman, 2006; Sadek , 2003, and Silva *et al.* 2009).**

The present work aims to evaluate the lethal and sub-lethal effects of four plant oils namely; ginger (*Zingiber officinale)*, turmeric (*Curcuma longa)*, thyme (*Thymus vulgaris* L.) and lemon (*Citrus limon* L.) on the second and fourth larval instars of *S. frugiperda* under laboratory conditions, and also their biochemical effect against treated larvae.

2.Material and methods:

2.1.Insect rearing:

Spodoptera frugiperda (FAW) egg masses were generously provided by the Plant Protection Research Institute in Dokki, Giza, Egypt. Egg masses were kept at 26±2º C and 65±5% relative humidity until hatching. The newly emerged larvae were fed on fresh castor bean (*Ricinus communis*) leaves. The insect colony was sustained in the laboratory environment without the use of any insecticides according to **El-Defrawi *et al.*,1964.**

2.2.Essential oils used:

Four plant oils; ginger (*Zingiber officinale* Rosco, Fam.: Zingiberaceae), turmeric (*Curcuma longa*, Fam.: Zingiberaceae), thyme (*Thymus vulgaris* L., Fam.: Lamiaceae) and lemon (*Citrus limon* L., Fam.: Rutaceae) were sourced from National Research Center, Dokki, Giza, Egypt. These oils were extracted from the leaves, flowers and stems of these plants as 100% concentration.

2.3.Bioassay experiments:

The toxicity of *Z. officinale*, *C. longa*, *T. vulgaris* and *C. limon* oils against the 2nd and 4th larval instars of *S. frugiperda* was determined using the leaf-dipping method. Four concentrations of each oil (10%, 5%, 1.25%, & 0.625%) were prepared in distilled water with a small amount of Tween-20 (10 mg/l) (as surfactant agent). Fresh castor bean leaves were dipped in each concentration for 30 seconds and air- dried for half an hour at room temperature. The control leaves were immersed in water containing tween-20. Treated leaves were placed in jars (500 ml capacity). Ten larvae of *S. frugiperda* were transferred to each jar, and each treatment were replicated three times. The percentage of mortality was recorded after 3 and 7 days of exposure. The sublethal concentrations (LC_{50} & LC_{25}) were estimated by probit analysis methods.

2.4.Biochemical assays:

The 4th larval instar of *S. frugiperda* treated with LC_{50} of ginger, turmeric, thyme and lemon oils using dipping technique (**Abo El-Ghar *et al.* 1994)** of caster bean leaves and feeding for 48 h. then the larvae feed on untreated leaves; another group of larvae fed on untreated leaves (dipped in distilled water containing tween-20). Sixth instars larvae of healthy collected from the surviving treated and untreated larvae for biochemical studies.

Analysis of enzymes, proteins and carbohydrates:

2.4.1.Acetylcholinesterase (AchE) activity:

The measurement of AchE activity was conducted using the methodology outlined **by Simpson *et.al.* (1964)**, with acetylcholine bromide (AchBr) serving as the substrate.

2.4.2.Amylase activity:

The measurement of digestive enzymes followed a modified version of **Ishaaya and Swirski's (1976)** method, as adapted by **Amin (1998)**.

2.4.3.Lipase activity:

Lipase activity is measured using the Spectrum diagnostic kit, available at www.spectrum-diagnostics.com. The process involves the enzymatic breakdown of a synthetic substrate (DGMRE) by lipase, resulting in the formation of a colored product, methylresorufin. The rising absorbance of the red methylresorufin is then monitored photometrically.

2.4.4.Total proteins:

Total proteins were determined by the method of **Bradford (I976).**

2.4.5.Total carbohydrates:

Total carbohydrates determined according to **Crompton and Birt (1967).**

2.4.6.Glutathione S-transferase (GST):

GST enzyme activity determined according to **Habig *et al.* (I974).**

2.5.Statistical analysis:

Percentage mortality of larvae *S. frugiperda* corrected using Abbott's formula **(Abbott, 1925)** and then using software LDP Line to calculated LC_{50} values by using probit- analysis **Finney (1971)**. Data of the activity enzymes were analysis using one-way ANOVA by software Costat system, Version 6.311**(Costat, 2006)** followed by duncan's multiple range **(Duncan, 1955)**.

3.Results and discussion:

3.1.Effect of tested oils on second and fourth larval instars of *S. frugiperda*:

The data in Tables (1 and 2) show the efficacy of the tested compounds represented by LC_{50} and LC_{25} against the second and fourth larval instars of *S. frugiperda*. From the obtained results, it can be proven that lemon oil showed great success as the best toxicant compared to other tested oils, where LC_{50} and LC_{25} values were 0.259 and 0.096 % on second larval instar and 0.542 and 0.084 % on fourth larval instar, respectively, followed by thyme oil then ginger oil and finally turmeric oil with LC_{50} of 0.349, 0.702 and 0.941% for second larval instar and 0.686, 1.521 and 1.688% for fourth larval instar, respectively. Thus, these results revealed that the least effective oil against the larvae of the two tested larval instars (second and fourth) is turmeric oil.

The current results align with those reported by (**Moustafa *et al*., 2023)** who reported that *Cymbopogon citratus* essential oil showed high larvicidal activity against *Spodoptera littoralis* , and (**Knaak *et al.*, 2013)** found that *C. citratus* and *Zengiber officinale* oils have value of LC_{50} =0.19 and 0.25 µL/cm² , respectively , furthermore, (**El-Aw *et al.*, 2021)** who recommended that the most effective essential oils in controlling *S. frugiperda* larvae are *Z. officinale* and *C. citratus* and reported that LC_{50} value for the cotton leafworm was 0.108% after 72 hours of treatment of fourth instar larvae with thyme oil (*Thymus vulgaris*). Recently, (**Abdullah *et al.*, 2024** and **Amadi *et al.*, 2024)** reported that *Z. officinale* oil can serve as insecticides to control *S. littoralis* and *S. frugiperda*, especially when mixed with paraffin oil. Also, (**Passara *et al.*, 2021)** who reported that *Curcuma longa* oil registered the highest anti-feedant effect for *Spodoptera litura* larvae at 0.25% concentration.

Table 1. Toxicity of the essential tested oils against second-instar larvae of *S. frugiperda*

Treatments (oils)	LC_{50} %	Lower limit	Upper limit	Slope ± SE	LC_{25} %	Index
Lemon	0.259	0.079	0.417	1.56±0.316	0.096	100
Thyme	0.349	0.069	0.667	1.229±0.237	0.099	74.212
Ginger	0.702	0.494	0.939	1.742±0.205	0.288	36.895
Turmeric	0.941	0.418	1.508	1.195±0.216	0.257	27.524

Table 2. Toxicity of the essential tested oils against fourth-instar larvae of *S. frugiperda*

	LC_{50} %	Lower limit	Upper limit	Slope ± SE	LC_{25} %	Index
Lemon	0.542	0.105	1.075	0.833±0.171	0.084	100
Thyme	0.686	0.152	1.282	0.912±0.188	0.125	79.009
Ginger	1.521	0.694	2.732	0.874±0.164	0.257	35.634
Turmeric	1.688	0.934	2.785	1.042±0.167	0.38	32.109

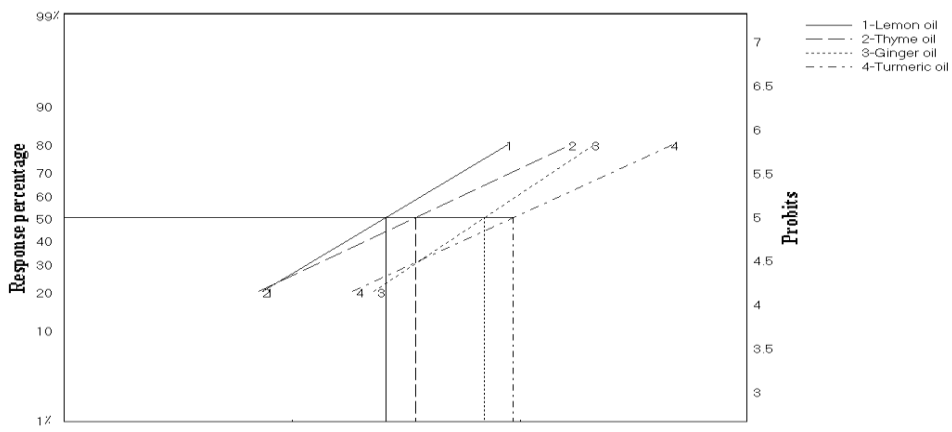

Fig. (1): The effectiveness of the tested oils on the second larval instar of FAW

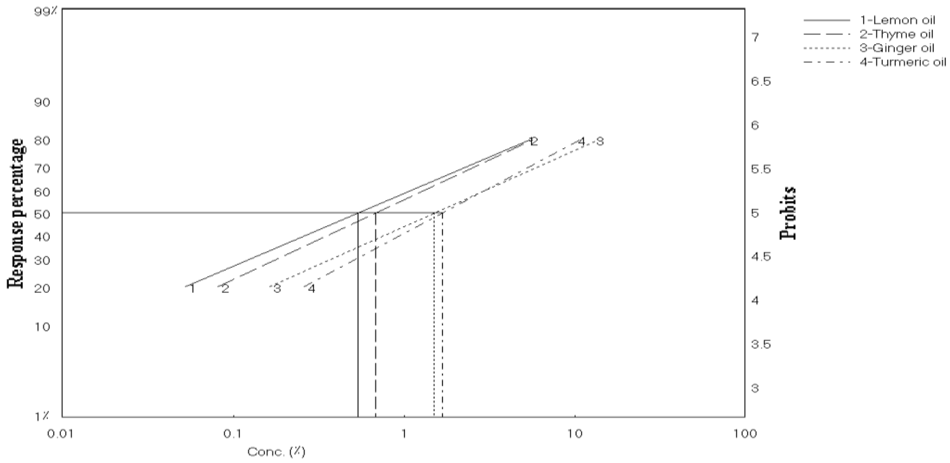

Fig. (2): The effectiveness of the tested oils on the fourth larval instar of FAW

3.2.Biochemical changes:

Impact of LC_{50} values of the tested oils on total protein and carbohydrate levels, in additional to acetylcholinesterase and alpha-esterase activities, in sixth instar larvae derived from treated fourth instar larvae of *S. frugiperda* as shown in Table (3).

3.3.Total proteins:

The content of total proteins in *S. frugiperda* larvae were analyzed. The results in Table (3) indicated that total proteins were significantly increased in untreated larvae as 54.87 mg/ g.b.wt , compared with other treatments. There is no significant between turmeric and ginger oils and showed the lowest activity were 43.10 and 39.80 mg/ g.b.wt, respectively followed by thyme and lemon oils were 49.90 and 47.23 mg/ g.b.wt, respectively. Moreover, **(Abdullah *et al.*, 2024)** reported that total protein was increased when treated larvae of *S. littoralis* was treated with *ginger* oil.

Table 3: Impact of LC_{50} concentrations of the tested oils on total protein, total carbohydrate, AchE activity, and alpha-esterase activity in *S. frugiperda*

Treatments (oils)	Total proteins (mg/ g.b.wt)	Total carbohydrates (mg/ g.b.wt)	AchE (µg AchBr /min/ g.b.wt)	Alpha esterase (µg α-naphthol/min/ g.b.wt)
Turmeric	43.10 ± 1.12 c	24.70 ± 0.42 bc	155.33 ± 1.20 bc	1084.00 ± 8.33 b
Ginger	39.80 ± 0.99 c	25.67 ± 0.18 ab	152.00 ± 1.53 c	1044.67 ± 5.78 bc
Thyme	49.90 ± 0.38 b	22.90 ± 0.26 c	179.33 ± 4.91 a	1090.00 ± 15.28 b
Lemon	47.23 ± 0.61 b	20.77 ± 1.04 d	84.33 ± 1.86 d	1236.00 ± 22.72 a
Untreated	54.87 ± 1.88 a	27.70 ± 0.91 a	162.33 ± 1.45 b	1011.67 ± 14.24 c

Significant differences do not exist between means that have the same letter in the same column.

3.4.Total carbohydrates:

Data show that, larvae in every treatment were lower in total carbohydrates compared to untreated which amounted to 27.70 mg/ g.b.wt , although there was no significant difference between untreated and treated larvae with ginger oil & lemon oil treatment for larvae which has significant decrease in total carbohydrates, compared to other oils as 20.77 mg/ g.b.wt Table (3).

3.5.Acetylcholinesterase:

Thyme oil treatment for larvae recorded the highest enzyme activity of acetylcholinesterase as 179.33 µg AchBr /min/ g.b.wt, while lemon oil recorded the lowest enzyme activity as 84.33 µg AchBr /min/ g.b.wt. No significant difference in enzyme acetylcholinesterase activity between turmeric oil & untreated , as well as between turmeric oil & ginger oil . The obtained data are consistent with (**El-Aw *et al.*, 2021)** who found that addressing cotton leafworm's fourth larval instar with thyme oil led to the suppression of the enzyme acetylcholinesterase. In addition , (**Tharamak *et al.*, 2020)** reported that, treated larvae of *Spodoptera litura* by thymol led to increase of acetylcholinesterase activity, while glutathione S-transferase enzyme showed no significant difference.

3.6.Alpha esterase:

Results presented in Table (3) show that treatment with LC_{50} of lemon oil recorded a substantial increase in alpha esterase enzyme activity as 1236.00 µg α-naphthol/min/g b.wt., while there were no significant in alpha esterase activity between the three treatments of turmeric oil, ginger oil and thyme oil (1084.00. 1044.67 and 1090.00 µg α-naphthol/min/ g.b.wt, respectively) and the control (101.67 µg α-naphthol/min/ g.b.wt). Recently, (**Moustafa *et al.*, 2023)** reported that *Cymbopogon citratus* essential oil was significantly stimulates the activity of α- and β-esterase.

Table 4: Impact of LC_{50} concentrations of the tested essential oils on the activities of GST, proteases, amylase, and lipase enzymes in *S. frugiperda*.

Treatments (oils)	GST (mmol sub.conjugated/m g.b.wt)	Proteases (µg alanine /min / g.b.w	Amylase (µg glucose / min / g.b.wt)	Lipases (mU/ g.b.wt)
Turmeric	44.23 ± 0.65 b	97.97 ± 2.55 c	93.90 ± 0.78 a	124.00 ± 2.65 a
Ginger	39.37 ± 0.88 c	81.93 ± 3.55 d	91.50 ± 0.76 a	119.33 ± 1.53 a
Thyme	53.70 ± 1.48 a	135.33 ± 1.20 a	87.87 ± 0.41 b	91.83 ± 1.76 c
Lemon	34.67 ± 0.80 d	122.00 ± 1.53 b	78.73 ± 1.83 c	107.00 ± 2.65 b
Untreated	36.53 ± 1.03 cd	136.00 ± 3.21 a	94.70 ± 0.89 a	126.67 ± 7.64 a

Significant differences do not exist between means that have the same letter in the same column.

Glutathione S-transferase (GST), proteases, amylase and lipase activity were determined after 48 hours of treatment with the four tested oils and the data are shown in Table 4.

3.7.Glutathione S-transferase (GST):

The activity of GST enzyme (Table 4) showed that, thyme oil has significant increase of enzyme activity followed by turmeric oil (53.70 and 44.23 mmol sub.conjugated / min/ g.b.wt, respectively). On the contrary, no significance differences were observed post exposure treatments with ginger oil and the untreated, or between lemon oil and the untreated. The obtained results are in agreement with those of (**Moustafa *et al.*, 2021** & **Moustafa *et al.*, 2023)** who reported that GST activity was decreased post-exposure the second-instar larvae of *S. littoralis* to *Cymbopogon citratus* oil and showed significantly effect on detoxification enzymes. (**Abdullah *et al.*, 2024)** who found that use *Z. officinale* oil against *S. frugiperda* caused inhibition of GST activity.

3.8.Proteases:

Regarding to Protease activity (Table 4) there were notable variations between the four oils that were examined and the highest and lowest enzyme activity after treating with thyme oil and ginger oil as 135.33 and 81.93 µg alanine/min/ g.b.wt, respectively, while no significant variation was recorded between thyme oil and untreated.

3.9.Amylase:

As for Amylase enzyme activity (Table 4) it was decreased after the treatment with the four tested oils compared to the untreated ones, although there were no clear differences between treatment with turmeric oil, ginger oil and untreated (93.90, 91.50 and 94.70 µg glucose / min/ g.b.wt, respectively) and the enzyme's lowest activity, following treatment with lemon oil, was 78.73 µg glucose/min/g.b.wt. These findings are supported by (**Yacoub, 2013)** who reported that the enzymes trehalse and amylase were significantly impacted by plant extracts.

3.10.Lipases:

Finally as for the results of lipase activity (Table 4) it was similar to that of amylase activity, there were non-significant differences between treatment with turmeric oil, ginger oil and untreated (124.00, 119.33 and 126.67 mU/ g.b.wt, respectively) while, the lowest enzyme activity was recorded with larvae treated with thyme oil, followed by lemon oil as 91.83 and 107.00 mU/ g.b.wt, respectively.

Conclusion

The toxicity of four plant oils was examined (ginger (*Z. officinale*), turmeric (*C. longa*), thyme (*T.

vulgaris) and lemon (*C. limon*)) on second and fourth instar larvae of *Spodoptera frugiperda* was evaluated in this study. The LC_{50} values of each oil were presented to the larvae in their fourth instar. then, after larvae reached the sixth instar, healthy larvae were taken for biochemical analysis. The findings indicated that lemon oil achieved superior toxic efficacy for second and fourth larval instar with LC_{50} values as 0.259 and 0.542% respectively, On the contrary, turmeric oil had the least effective with LC_{50} values as 0.941 and 1.688% , respectively. Also, biochemical analysis results revealed varying differences between the treatments and the control. Therefore, the results demonstrated the efficacy of tested oils in controlling fall army worm under laboratory conditions, and has the potential for application in field as a safe and effective alternative strategy.

References

Abbott, W. S. (1925). A method of computing the effectiveness of an insecticide. J. Econ. Entomol, 18(2), 265-267.

Abdullah, R. R. H., Aziz, W. Z., Shoman, S. A., and Harraz, N. H. (2024). Impact of mineral paraffin oil as an additive on the efficacy of garlic and ginger essential oils as natural insecticides against cotton leafworm and fall armyworm. Journal of Entomology and Zoology Studies, 12(5), 109-117.

Abo El-Ghar, G.E.S.; H.S.A. Radwan; Z.A. El-Bermawy and L.T.M. Zidan (1994). Histopathological effects of abamectin, thuringiensis and diflubenzuron on the midgut of *Spodoptera littoralis* (Lepidoptera: Noctuidae) larvae. Bull. Ent. Soc. Egypt, 21: 41-52.

Amadi, G. I., R. B. Ukoroije and S. O. Dimkpa (2024). Efficacy of five botanicals in the management of fall armyworm, *Spodoptera frugiperda* JE Smith (1993) (Lepidoptera: Noctuidae) larvae on some maize varieties in port harcourt, Rivers State, Nigeria. International Journal of Entomology and Nematology Research, 8(1), 1-15.

Amin, T.R. (1998). Biochemical and physiological studies of some insect growth regulators on the cotton leafworm, *Spodoptera littoralis* (Boisd.). Ph.D. thesis, Faculty of science, Cairo Univ.

Barbosa, S. B., B. B. Dias, M. S. Guerra and G. H. da Costa Vieira (2018). Applying plant oils to control fall armyworm (*Spodoptera frugiperda*) in corn. Australian Journal of Crop Science, 12(4), 557-562.

Bradford, M.M. (1976). A rapid and sensitive method for the quantitation of microgram quantities of proteins utilizing the principle of protein-dye binding. Anal. Biochem., 72:248-254.

Costat. (2006). Costat Statistical Software: Micro Computer Program Analysis Version 4.20. In: Cohort Software Berkeley, CA, USA.

Crompton, M. and L.M. Birt (1967). Changes in the amounts of carbohydrates, phosphagen, and related compounds during the metamorphosis of the blowfly, *Lucilia cuprina*. J. Insect Physiol.,13:1575-1595.

Cruz,I.; M.L.C Figueiro; R.B. Silva and J.E. Foster (2010). Efficiency of chemical pesticides to control *Spodoptera frugiperda* and validation of pheromone trap as a pest management tool in maize crop. RBMS. 10:107-122.

De Almeida S.R.; R.W. de-Souza Aguiar; S.M.J. Vieira; H.G. de Oliveira and A.M. Holtz (2002). Biology review, occurrence and control of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in corn in Brazil. Bio. Sci.18:41-48.

Duncan, D. B. (1955). Multiple range and multiple F tests. Biometrics, 11(1), 1-42.

El- Defrawi, M. F.; A. T. Toppozada; A. Salama and S.A. El- Kishen (1964). Toxicological studies on the Egyptian cotton leaf worm *Prodenia litura* F. 11. Reversion of Toxaphine resistance in the Egyptian cotton leaf worm. J. Econ. Entom. 57:593-595. 1964

El-Aw, M. A. M., K. A. Draz, E. A. El Naggar and F. H. Abd Elsalam (2021). Ovicidal, larvicidal and biochemical effects of thyme, *Thymus vulgaris*, on the cotton leafworm, *Spodoptera littoralis* (Boisd.). Journal of Plant Protection and Pathology, 12(5), 389-394.

Finney, D.J. (1971). Probit analysis, Cambridge University Press. Cambridge, UK.

Habig,W.H.; M.J. Pabst and W.B.Jakoby(I974). Glutathione S-transferase . the first enzymatic step in mercapturic acid formation.J.Biol. Chem.,249:7130-7139.

Hernandez B. and J.E. Leon (1994). Neglected crops: from a different -perspective. FAO Plant Production and Protection Series. No. 26, FAO. Rome. Italy.

Ishaaya, I. and E. Swirski (1976). Trehalase, invertase and amylase activities in the black scale, *Saissetia oleae*, and their relation to host adaptability. J. Insect Physiol.,16:1025-1029.

Isman, M.B. (2006). Botanical insecticides, deterrents and repellents in modern agricultural and an increasingly regulated world. Annual Review of Entomology. 51, 45-66.

Knaak, N., S. L. F. Wiest, T. F. Andreis and L. M. Fiuza (2013). Toxicity of essential oils to the larvae of *Spodoptera frugiperda* (Lepidoptera: Noctuidae). Journal of Biopesticides, 6(1), 49-53.

Moustafa, M. A. M., M. Awad, A. Amer, N. N. Hassan, E. D. S. Ibrahim, H. M. Ali, M. Akrami and M. Z. M. Salem (2021). Insecticidal activity of lemongrass essential oil as an eco-friendly agent against the black cutworm *Agrotis ipsilon* (Lepidoptera: Noctuidae). Insects, 12(08), 737.

Moustafa, M. A. M., N. N. Hassan, N. A. Alfuhaid, A. Amer, and M.Awad (2023). Insights into the toxicity, biochemical activity, and molecular docking of Cymbopogon citratus essential oils and citral on *Spodoptera littoralis* (Lepidoptera: Noctuidae). Journal of Economic Entomology, 116(4), 1185-1195.

Mukanga, M.; M. Owen; C. Gilson; M. Matimelo; K.Mumba; N.D.Mabote; S.Vincent; I. Nethenga; M. Lpulula; S.M.Tembo and K. Lwinya (2022). Bio-efficiency of crude aqueous leaf extracts against the fall army worm (*Spodoptera frugiperda)* and maize ear rots in Zambia. Advance in Biology Research, 3(1): 38-49.

Passara, H., J.Pumnuan and K.Thipmanee (2021). Effectiveness of plant essential oils derived from *Curcuma longa*, *Illicium verum*, *Ocimum tenuiflorum*, and *Foeniculum vulgare* for controlling common cutworm (*Spodoptera litura*). IOP Conference Series: Earth and Environmental Science, 858(1), 012009.

Sadek, M.M. (2003). Antifeedant and toxic activity of *Adhatoda vasica* leaf extract against *Spodoptera littoralis* (Lepidoptera: Noctuidae), Journal of Applied Entomology, 127:396-404.

Silva, W.C.; H.E. Souza, H. Heinzen; M.V., M. CesioMato; F. Albrecht; J.L. Azevedo and N.M. Barros (2009). Toxicity of *Piper aduncum* L. (Piperales: Piperacaea) from the amazon forest for the cattle tick *Rhipicephalus* (*Boophilus*) *Microplus* (Acari:Ixodidae). Veterinary Parasitology, 164:267-274.

Simpson, D.R.; D.L. Bulland and D.A. Linquist (1964). A semi microtechnique for estimation of cholinesterase activity in boll weevils. Ann. Ent.Soc. Amer., 57: 367-371

Tembo, Y.; A.G. Mkind; P.A. Mkenda; N.Mpumi; R.Mwanauta; P.C. Stevenson ; P.A. Ndakide and S.R. Belmain (2018). Pesticidal plant extracts improve yield and reduced insect pests on legume crop without harming beneficial arthropods. Front Plant Sci. 9, 1425.

Tharamak, S., T.Yooboon, A. Pengsook, A. Ratwatthananon, N. Kumrungsee, V. Bullangpoti and W. Pluempanupat (2020). Synthesis of thymyl esters and their insecticidal activity against *Spodoptera litura* (Lepidoptera: Noctuidae). Pest Management Science, 76(3), 928-935.

.

Yacoub, S. S. (2013). Toxic and antifeeding activities of certain plant extracts and their effects on biological and biochemical aspects of the cotton leafworm *Spodoptera littoralis* (boisd.). *Egyptian Journal of Agricultural Research*, *93*(3), 925-939.

Yu, S.J. (1991). Insecticide resistance in the fall army worm, *Spodoptera frugiperda* (J.E. Smith) . Pesticide Biochemistry and Physiology. 39(1): 84-91.

Zhao B.; G.G. Grant; D. Langevin; L. Macdonald (1998). Deterring and inhibiting effects of quinolizidine alkaloids on spruce budworm (Lepidoptera: Torticidae) oviposition. Environmental Entomology, 27: 984-992

النشاط الإبادي الحشري لبعض الزيوت العطرية وتأثيرهم على الدلائل البيوكيميائية لدودة الحشد الخريفية

علي ربيع محمد الجبلي، مروة محمد موسى، محمد فتحي عبد العزيز

معهد بحوث وقاية النباتات، مركز البحوث الزراعية، الدقي، الجيزة – مصر

الملخص العربي:

دودة الحشد الخريفية هي حشرة متعددة التغذية تسبب أضرارًا للعديد من المحاصيل. في الدراسة الحالية، تم تقييم سمية أربعة زيوت عطرية نباتية، وهي الزنجبيل (*Zingiber officinale*)، والكركم (*Curcuma longa*)، والزعتر (*Thymus vulgaris*) والليمون (*Citrus limon*) ضد يرقات العمرين الثاني والرابع من دودة الحشد الخريفية بتركيزات مختلفة تحت الظروف المعملية. في كل معاملة تم اخذ يرقات العمر السادس السليمة لدودة الحشد الخريفية التي نجت بعد معاملة يرقات العمر الرابع بتركيز LC_{50} لإجراء التحاليل البيوكيميائية. اوضحت النتائج أن المعاملة بزيت الليمون حققت أعلي سمية حيث بلغت قيم LC_{50} وLC_{25} ٠,٢٥٩ و٠,٠٩٦٪ للعمر اليرقي الثاني و٠,٥٤٢ و٠,٠٨٤٪ للعمر اليرقي الرابع على التوالي بينما كانت المعاملة بزيت الكركم الأقل فعالية حيث بلغت قيم LC_{50} و LC_{25} ٠,٩٤١ و٠,٢٥٧٪ للعمر اليرقي الثاني و١,٦٨٨ و٠,٣٨٪ للعمر اليرقي الرابع على التوالي. أما فيما يتعلق بالتأثيرات على مستوى نشاط الإنزيمات، فقد سجلت البروتينات الكلية والكربوهيدرات الكلية انخفاضًا معنويًا في جميع المعاملات بالزيوت العطرية المختبرة. وكان أعلى وأدنى نشاط إنزيمي لأستيل كولين استريز عند معاملة اليرقات بزيت الزعتر والليمون على التوالي. بينما لم يتم ملاحظة أي اختلافات معنوية في نشاط انزيم ألفا استريز بين زيت الكركم والزنجبيل والزعتر وحدث تثبيط لنشاط إنزيم GST في جميع المعاملات. كما انخفضت أنشطة إنزيم البروتياز والأميليز والليباز بعد المعاملة بالزيوت الأربعة المختبرة مقارنة باليرقات غير المعاملة. لذلك، أثبتت نتائج هذا العمل فعالية الزيوت العطرية المختبرة في مكافحة دودة الحشد الخريفية في ظل الظروف المعملية، ويمكن استخدامها في التطبيق الحقلى كبديل آمن وفعال وتدخل ضمن برنامج المكافحة المتكاملة لمكافحة الآفة.