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Bioactivity Impact of Essential Oils *Allium sativum* L. and *Citrus reticulata* L. Against Stored Product Insects *Tribolium castaneum* (Herbst) and *Rhyzopertha dominica* (F.)

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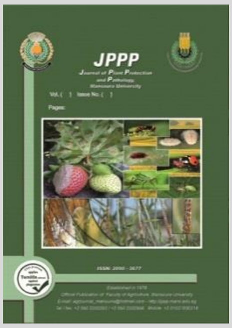

ABSTRACT

This study was conducted to estimate the impact of contact and fumigation toxicity of garlic (*Allium sativum* L.) and mandarin (*Citrus reticulata* L.) essential oils against two of stored product insects *Tribolium castaneum* (Herbst) and *Rhyzopertha dominica* (F.) for 1, 2 and 3 days after exposure under laboratory conditions. Results showed that garlic was more effective than mandarin, where contact LC_{50} after 3d was 0.336 mg/mL compared to 5.49 mg/mL for mandarin on *T. castaneum* (Herbst) and 0.343 mg/mL, 4.130 mg/mL on *R. dominica* (F.) at the same investigation period. The same trend was observed for fumigation where LC_{50} of garlic were 0.789, 0.386 µL /L air against *T. castaneum* (Herbst) and *R. dominica* (F.) respectively and 7.778, 6.305 µL/L air of mandarin against *T. castaneum* (Herbst) and *R. dominica* (F.) after 3days respectively. Gas chromatography-mass spectrometry (GC-MS) analysis showed that the major compounds of garlic essential oil were diallyl sulfide (9.5%), diallyl disulfide (27.9%),dimethyl tetrasulfide (2.9%), allyl methyl trisulfide (17.7%), and diallyl trisulfide (16.8%). In mandarin the main components were tricarbonyl [methyl 6-vinylidenehepta 2,4-dien-1-oate]iron (52.8 %), dimethyl hexane (15.28%), p-cymene (5.45 %), limonene (3.88 %) and ɣ terpinene (9.47 %). The results elucidated that, essential oils may be a promising safe alternatives to synthetic chemical insecticides for control stored product insects either by contact or fumigation treatment and compatible with integrated pest management.

Keywords: Essential Oils**;** Stored Product**;** Contac**;** Fumigation**;** Toxicity

INTRODUCTION

Stored-product pests usually cause a imposing economic loss by eating the stored products, especially food and industrial crops besides their harmful to human health due to release pollutants, which then helps fungi and bacteria easy to breed. Therefore, it is sureness that food production needs to increase by 60-80% to face the expected population growth (Alexandratos and Bruinsma, 2012; FAO, 2013; Gerland *et al.*, 2014).

The red flour beetle, *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae), is an important harvested product pest which widely distributes all over the world causing great damage to stored grain product (Campbell *et al.*, 2004; Garcìa *et al.*, 2005; Fedina and Lewis, 2007).

The lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae), is a worldwide insect of stored grains which feed on the germ and endosperm of kernels. *R. dominica* (F.) can also feed on a wide range of materials such as legumes, stored pharmaceuticals, leather stuffing, mud plaster, packaging materials made from wood, paper, bound books, and cork (Edde, 2012).

Common control strategies to manage stored product pests are mainly based on the use of synthetic insecticides and fumigants. Indeed, this method has effectively decreased the infestation of the pests in silos. Although, the excessive using of such broad-spectrum synthetic insecticide against the target insects cause a several bereaved effects on the long run (Biondi *et al.*, 2012). Such as insects resistance development, media contamination, toxicity to non-target organisms, highly human risk assessment and phytotoxicity (Aktar *et al.*, 2009; Kumar, 2012; Fountain and Wratten, 2013). Currently, many sustainable alternatives trials have been tested for the control of the stored product insects as botanical extracts as a tool for pest control, applying the integrated pest management (IPM) approach (Campolo *et al*. 2014). Also, many laboratories worldwide have intensified research into essential oils and their constituents, to exploit their pesticidal properties via to develop a novel effective botanical insecticides (Grumezescu, 2017).

Botanical insecticides have offer a good alternatives more than conventional insecticides for application into in crop protection systems through out direct contact or entry into the insect respiratory system (Nerio *et al*., 2010; Kumar 2012, 2013; Beier *et al*., 2014; Pavela and Benelli, 2016). More of botanical extract from different plant species, including citrus species and their constituents have been studied to evaluate their insecticidal activity against stored product pests (Nerio *et al*., 2009; Yildirim *et al*., 2013). previous studies had demonstrated the activity of essential oils against stored product insects such as diethyl ether extracts of *Atractylodes lancea* rhizomes were found to have fumigant activity against 3 product insects *Oryzaephilus surinamensis*, *Sitophilus oryzae*, and *Liposcelis paeta* adults (Lü and He, 2010). In addition to the above, there are four compounds

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(atractylodin, atractylodinol, atractylenolides II and III) isolated from *Atractylodes lancea* have insecticidal activities against the red flour beetles (Chen *et al*., 2015). Essential oils from the peels of *C. reticulata* Blanco are known to have contact, fumigation, and feeding deterrent activities on various insects that attack stored products such as red flour beetle *T. castaneum* (Herbst) (Saleem *et al*., 2013) and lesser grain borer, *R. dominica* (F.) (Forouzan *et al*., 2013). The main component of essential oils are terpenes, specifically monoterpenes (Regnault-Roger and Hamraoui, 1995 and Ahn *et al*., 1998), which are the principal compounds responsible for the bioactivity against insects.

Therefore, the present study aims to investigate; 1. Differences in bioactivity of contact and fumigation effect between the essential oils from garlic *A. sativum* and mandarin *C. reticulate* against two of stored product insects *T. castaneum* (Herbst) and *R.dominica* (F.). 2. Chemical composition of the tested essential oils by gas chromatography-mass spectrometry (GC/MS) analysis.

MATERIALS AND METHODS

Tested materials

Essential oils of garlic (*A. sativum*) cloves and mandarin (*C. reticulate*) peel, were supplied by Hashem Brothers Company for Essential Oils and Aromatic Products (Kafr-Elsohby, Qalyoubeya, Egypt).

Tested insects

T. castaneum (Herbst) and *R. dominica* (F.) were kindly obtained from stock colonies maintained at the laboratory of Stored Products Insects Reseach Department, Sakha Agricultural Research Station, Plant Protection Reseach Institute, Agricultural Research Center (ARC), Egypt. The cultures were kept at 28 ± 2 C, 65 ± 5% relative humidity and light: dark photoperiod of 16:8 hrs. *T. castaneum* (Herbst) was reared on wheat flour medium in 250 mL jars, while *R. dominica* (F.) was reared on a mixture of 95% whole wheat grains, and 5% Brewer's yeast. Adult insects were obtained by sieving this feeding substrate.

Bioassay

Contact: Serial concentrations for both tested essential oils were obtained by dilute 1ml of crude oil in 100 ml acetone to obtain standard solution then, (0.25, 0.5, 1, 1.5 and 2 mg/Kg (mg a.i per Kg media) of garlic oil and (2, 4, 6, 8 and 10 mg/Kg) from mandarin were prepared from the standard solution. Subsequently, concentrations were used to treat 20 g of tested medium for each insect, as 1ml for each replicate. Each concentration was replicated four times, jars were covered with muslin cloth and kept under the same laboratory conditions as for rearing the insects. Whereas the control category received acetone only, after acetone evaporation ten numbers of unsexed adults of *T. castaneum* (Herbst) and *R. dominica* (F) were released into each jar, accumulative mortality counts were recorded at 1, 2, and 3 days after treatment (Finney, 1971).

Fumigation: Six cm diameter circular pieces of filter papers (Whatman No. 1) impregnated with concentrations of 0.25, 0.5, 1, 1.5, and 2 µl/L air for garlic and 2, 4, 6, 8, and 10 µl/L air for mandarin oil. Each treated filter paper was attached to the undersurface of the screw cap of plastic gars (250 mL capacity). Ten adults of *T.castaneum* (Herbst) or *R. dominica* (F) were transferred into the jars and closed with their screw caps with the attached treated filter paper for each concentration. Pieces of the same diameter as treatment filter paper (Whatman, No-1) treated with acetone only served as control. Four replicates for treatment and control were used. Mortality was recorded after 1, 2, and 3 days post the commencement of exposure according to the method described by (Suthisut *et al*., 2011).

GC/MS analysis of the essential oils

The chemical composition of the essential oils were analyzed by gas chromatography-mass spectrometry (GC/MS) using the model (HP5890- USA) provided with an HP column (60 m × 0.25 mm, 0.25 µm film thickness) (HP-5 ms). The initial temperature was 60 °C and the maximum temperature was 250 °C for 65.3 min. The injector temperature was 240 °C. Relative percentage amounts were calculated from peaks' total area by apparatus software. The compounds were identified by matching the mass spectra data with those held in a computer library (Wiley 275.L), according to (Swigar and Silverstein 1981) and (Adams 1997). All analysis steps were carried out in the laboratory of Hashem Brothers Company for Essential Oils and Aromatic products, Kafr-Elsohby, Qalyoubeya, Egypt.

Statistical analysis

The results were analyzed by one-way analysis of variance ANOVA followed by the Least Significant Difference Test for mean separation. P values of ≤0. 05 were considered significant. The experiments were performed in triplicate, data presented are the mean ± SE. The lethal concentration for 50% mortality (LC50) was determined by log-probit analysis, and the data were analyzed by determining chi-square values and degrees of freedom. The analysis of data was performed with SPSS program version 24.0 for Windows (SPSS Inc., IBM Corp.).

RESULTS AND DISCUSSION

Results

Toxicity of *A. sativum* and *C. reticulata* against *T. castaneum* (Herbst) and *R.dominica* (F.)

In the present study both *A. sativum* and *C. reticulata* essential oils exhibited strong insecticidal activity against *T. castaneum* and *R. dominica* adults with significant difference between treated concentrations along the test period.

Contact

Results of the present study showed that *A. sativum* essential oil had high efficiency against both tested insects along the experiment period, where LC50 value decreased with increasing exposure period as shown in Table (1and 2). The mortality percentage of *A. sativum* at the highest concentration (100 mg/kg) mg a.i per Kg wheat was (96.6, 96.6, and 100%) after one, two, and three days of exposure, respectively on *T. castaneum*.

Table 1. Adulticial bioactivity of *A. sativum* and *C. reticulata* essential oils against *T. castaneum* after different exposure periods

Treatment		LC_{50} Value (mg/ml)	Confidence limits 95 %		Slope value	Chi-Square (X^2)
			Lower	Upper		
A. sativum	1 day	0.794	0.631	0.944	1.291	2.526
	2 days	0.448	0.263	0.586	0.875	1.075
	3 days	0.336	0.095	0.489	0.620	2.081
C. reticulata	1 day	8.859	7.644	11.058	1.739	0.125
	2 days	8.030	6.946	9.704	1.648	0.763
	3 days	5.498	4.235	6.618	1.079	0.270

Table 2. Adulticial bioactivity of *A. sativum* and *C. reticulata* essential oils against *R. dominica* after different exposure periods

Treatment		LC_{50} Value (mg/ml)	Confidence limits 95 %		Slope value	Chi-Square (X^2)
			Lower	Upper		
A. sativum	1 day	0.380	0.450	0.734	0.245	0.235
	2 days	0.342	0.055	0.572	0.383	2.773
	3 days	0.343	0.039	0.532	0.490	0.577
C. reticulata	1 day	13.099	9.401	69.181	1.147	0.855
	2 days	7.014	4.136	14.766	0.600	1.487
	3 days	4.130	0.506	5.804	0.511	1.360

While, *C. reticulata* essential oil showed contact toxicity by (63.3, 70, and 83.3 %) at (500 mg/Kg) after the same investigation periods. For *R. dominica* mortality was (86.6, 100, and 100 %) for *A. sativum* essential oil and (40, 56.6, and 73 %) for *C. reticulata* after 1, 2, and 3 days of exposure respectively as shown in (Fig 1,2).

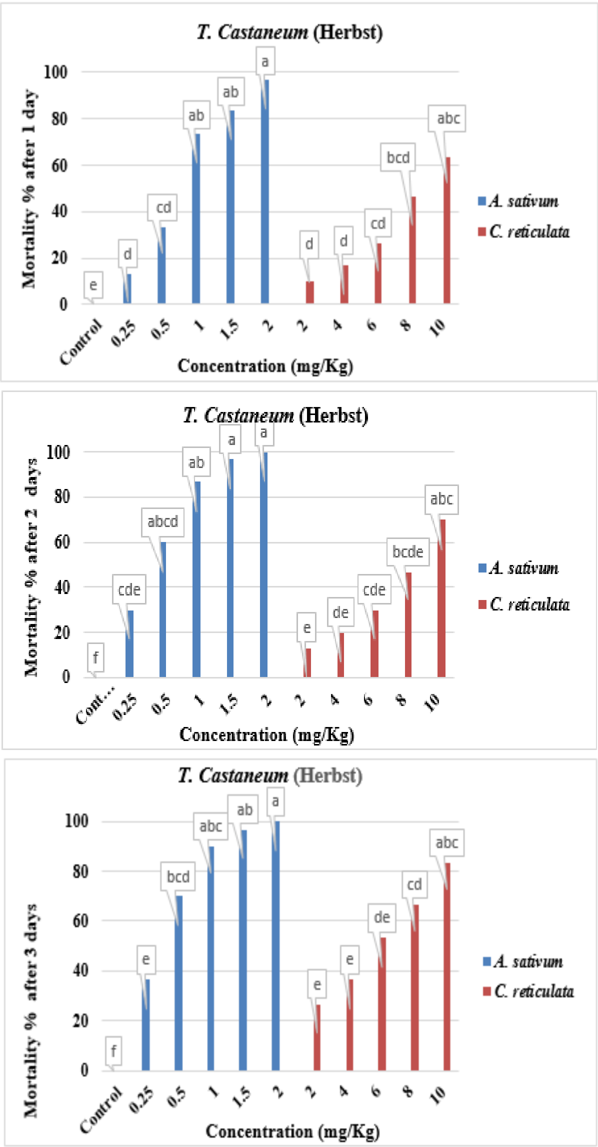

Fig. 1. Relationship between essential oils concentrations and mortality of *T.Castaneum*, after 1, 2 and 3 days of contact toxicity treatment relative to control

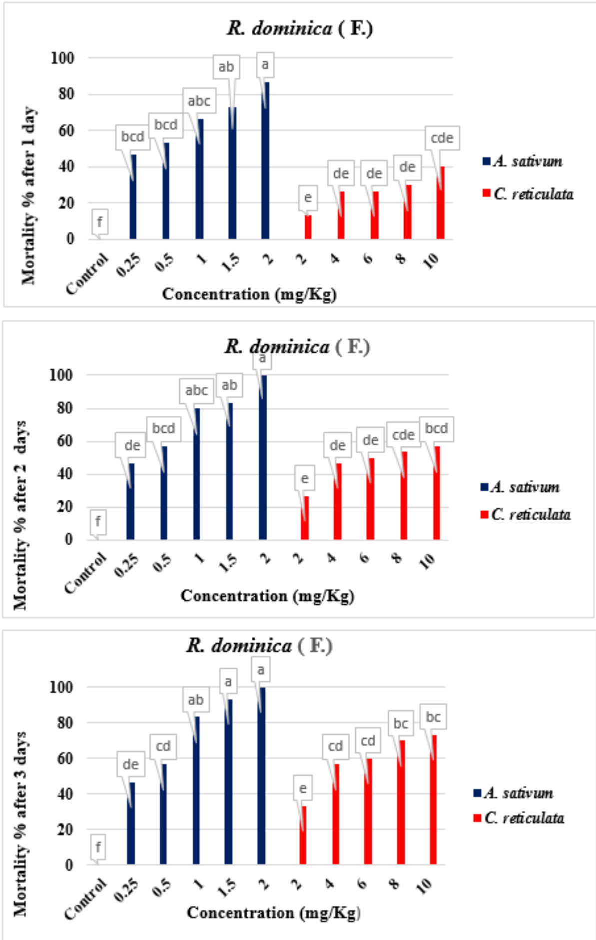

Fig .2. Relationship between essential oils concentrations and mortality of *R. dominica* after 1, 2 and 3 days of contact toxicity treatment relative to control

Fumigant: Fumigant toxicity of *A. sativum* and *C. reticulata* essential oils against adults of *T. castaneum* is shown in Table (3) where LC_{50} value of *A. sativum* was 3.288, 1.751, and 0.789 µl/l air and 14.037, 10.831 and 7.778 µl/l air for *C. reticulate* after 24, 48, and 72 h respectively. Fumigant toxicity of *A. sativum* and *C. reticulata* essential oils against *R. dominica* (F.) are presented in Tables (4), where LC_{50} values of *A. sativum* was 1.857, 0.960 and 0.386 µl/l air and 17.046, 10.141 and 6.305 µl/l air for *C. reticulata* respectively after 24, 48 and 72 h. Besides, *A. sativum* and *C. reticulata* showed a potent fumigant activity against adults of *T. castaneum* (Herbst) and *R. dominica* (F.) at different concentrations and exposure times as shown in Figs. (3&4).

Chemical composition of the tested essential oils

The chemical constituents of *A. sativum* and *C. reticulata* essential oils are shown in Table (5). The main components constituents of *C. reticulata* were detected, tricarbonyl [methyl 6-vinylidenehepta 2,4-dien-1-oate]iron (56.4%) and followed by dimethyl hexane (15.28%), limonene (5.45%) and 1,3,6 octatriene (3.88%) respectively.

The two major components of *A. sativum* essential oil were diallyl disulfide(27.9%), allyl methyl trisulfide (17.7%), diallyl trisulfide (16.8%), diallyl sulfide (9.5%), allyl methyl disulfide(8.3%), allyl (E)-1-propenyl disulfide (3.7%), dimethyl trisulfide (2.9%), allyl (Z)-1-propenyl disulfide(2.2%),2-Vinyl-4H-1,3-dithiine(1.8%),dimethyl disulfide(1.4%), 4-Methyl-1,2,3-trithiolane(1.2%), diallyl tetrasulfide (1%) respectively.

Table 3. Fumigant toxicity of *A. sativum* and *C. reticulata* essential oils against *T. castaneum* adults after different exposure periods

Treatment		LC_{50} Value (µl/L air)	Confidence Limits 95 %		Slope value	Chi-Square (X^2)
			Lower	Upper		
A. sativum	1 day	3.288	2.163	39.887	1.275	1.719
	2 days	1.751	1.222	4.834	0.697	0.767
	3 days	0.789	0.147	1.173	0.434	1.274
C. reticulate	1 day	14.037	11.056	28.106	2.428	2.032
	2 days	10.831	9.159	14.968	2.035	0.819
	3 days	7.778	6.602	9.619	1.422	0.668

Table 4. Fumigant toxicity of *A. sativum* and *C. reticulata* essential oils against *Rhizopertha dominica* adults after different exposure periods.

Treatment		LC_{50} Value (µl/L air)	Confidence Limits 95 %		Slope value	Chi-Square (X^2)
			Lower	Upper		
A. sativum	1 day	1.857	1.453	2.952	1.108	2.545
	2 days	0.960	0.551	1.318	0.611	0.662
	3 days	0.386	0.184	0.679	0.311	0.311
C. reticulate	1 day	17.046	11.641	19.383	1.636	0.205
	2 days	10.141	8.237	15.794	1.381	0.429
	3 days	6.305	5.027	7.720	1.099	1.408

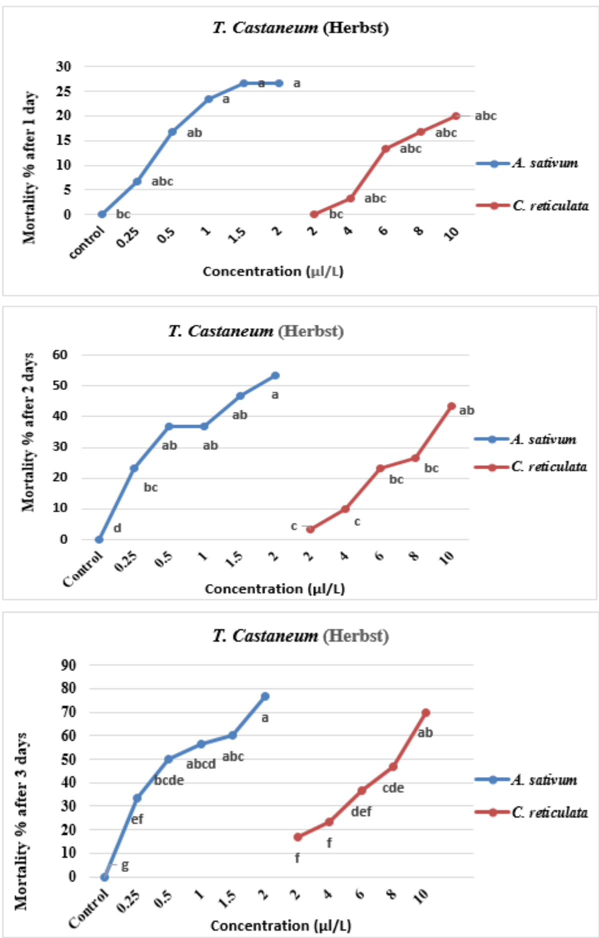

Fig .3. Fumigant toxicity of *A. sativum* and *C. reticulata* essential oils against *T. Castaneum*, after 1, 2 and 3 days of treatment relative to control

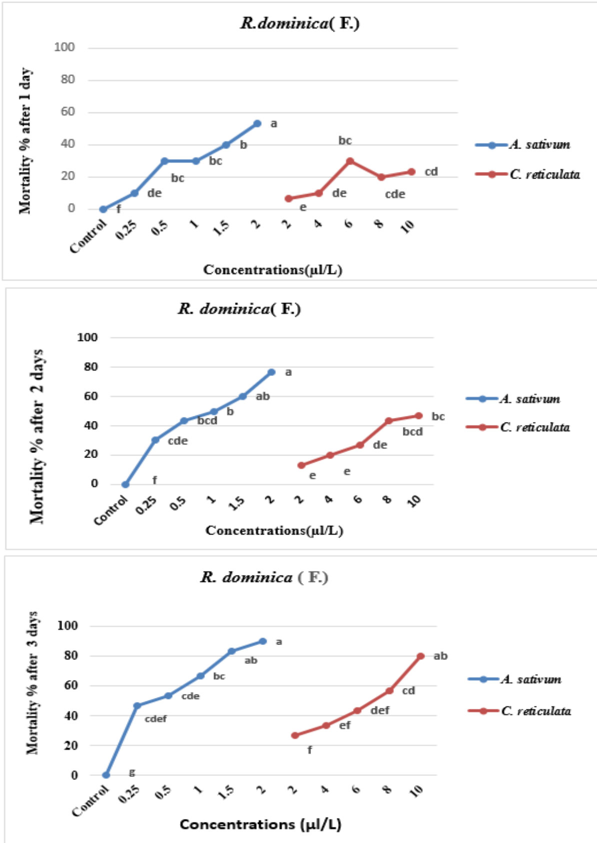

Fig. 4. Fumigant toxicity of *A. sativum* and *C. reticulata* essential oils against *R. dominica*, after 1, 2 nd 3 days of treatment relative to control

Table 5. Identified compunds by GC-MS of essential oils component for *A.sativum* and *C. reticulata*

Compound	Percent Composition %	Molecular formula	Retention time (min)
A.sativum			
Dimethyl disulfide	1.4	$C_2H_6S_2$	12.32
Diallyl sulfide	9.5	$C_6H_{10}S_2$	14.25
Allyl methyl disulfide	8.3	$C_4H_8S_2$	15.26
Dimethyl trisulfide	2.9	$C_2H_6S_3$	16.13
Diallyl disulfide	27.9	C6H10S2	18
Allyl (Z)-1-propenyl disulfide	2.2	$C_4H_8S_2$	18.21
Allyl (E)-1-propenyl disulfide	3.7	$C_6H_{10}S_2$	18.33
Allyl methyl trisulfide	17.7	$C_4H_8S_3$	18.96
4-Methyl-1,2,3-trithiolane	1.2	$C_3H_6S_3$	19.21
2-Vinyl-4H-1,3-dithiine	1.8	$C_6H_8S_2$	20.23
Diallyl trisulfide	16.8	$C_6H_{10}S_3$	21.68
Diallyl tetrasulfide	1	C6H10S4	25.66
C. reticulate			
Dimethyl hexane	15.28	C_8H_{18}	1.81
α pinene	1.04	$C_{10}H_{16}$	3.06
β pinene	1.02	$C_{10}H_{16}$	3.49
p-cymene	5.45	$C_{10}H_{14}$	4.07
Limonene	3.88	$C_{10}H_{16}$	4.14
ɣ terpinene	9.47	$C_{10}H_{16}$	4.59
Tricarbonyl[methyl 6-vinylidenehepta 2,4-dien-1-oate]iron	52.8	$C_{13}H_{12}FeO_5$	12.05
Tricarbonyl[methyl 6-vinylidenehepta 2,4-dien-1-oate]iron	3.60	$C_{13}H_{12}FeO_5$	12.08

Discussion

Botanical insecticides have long been described as alternatives to synthetic chemical insecticides for pest management because it has little threat to the environment and human health. The obtained results demonstrated that tested essential oils tend to control both stored product insects with a significant difference between them and with the preferableness of garlic essential oil on mandrin. *A. sativum* and *Citrus reticulate* showed contact and fumigation toxicity at both tested insects after 24, 48, and 72 h of exposure. *T. castaneum* was the most tolerant insect having the least mortality rate for both contact and fumigation toxicity than *R. dominica.* The toxicity and fumigation index of both essential oils are related to concentration and exposure time. The chemical composition of *C. reticulata* is in agreement with earlier studies from different regions all over the world on citrus oils (Lota *et al.*, 2000; Chutia *et al*., 2009; Hosni *et al*., 2010). Also, the chemical composition of garlic essential oil is in agreement with those of Satyal *et al*.(2017) and Mossa *et al.* (2018) who reported that garlic oils from various geographical locations have shown qualitative similarities, but quantitative differences in the concentrations of organosulfur compounds. Isman, 2000 demonstrated that monoterpenoids could affect the octopaminergic system in insects, preventing the binding of the neurotransmitter 3H-octopamine on specific receptors, causing a total breakdown of the nervous system. Our results are in agreement with Rajasekharreddy and Rani, (2010) who found that the application of the crude plant extracts, *C. sinensis* and *C. aurantium*, caused 76% mortality to *R. dominica* after 72 hrs post-treatment while *T. castaneum* produced comparatively less toxicity in the contact application method while different results were obtained with the fumigation treatments. Also, Saleem *et al.* (2013) reported that seeds of citrus fruit showed insecticidal effects on adults *Triboluim castaneum* after 24, 48, and 72 h exposure. Tripathi *et al.* (2003) found that essential oils derived from orange peel and seeds are known to have a toxic effect on lesser grain borer, *Rhyzopertha dominica* (F), and red flour beetle, *Triboluim castaneum* (Herbst). For fumigation, our finding results is paralleled to (Kim *et al*., 2003; Haouas *et al*., 2012; Campolo *et al*., 2014) they reported that citrus essential oils have a toxic effect due to their fumigation activity, which increases with time. Fouad and Camara, (2017) found that *C. reticulata* proved to have contact and fumigation toxicity to *S. zeamais* adults after 24 h of exposure with (LC50 71.18 mL/mLand 41.92 mL/L of air, respectively). Our results are in line with Mahdi and Behnam, (2018) who reported that the essential oil of orange leaves *Citrus sinensis* (L.) has fumigant toxicity against *R. dominica* (F.). Extracted essential oils from garlic have already been marketed as pest control products for both contact and fumigant toxicity as shown in this study. Where Ho *et al.* (1996) demonstrated that Garlic oil, has an insecticidal effect against both *T. castaneum* and S. *zeamais* and potentially a potent protectant for grain and other stored products.

One of the main active compound of garlic essential oil allicin showed a repellent effect against two stored product pests (Rahman and Motoyama, 2000). Also, Lu *et al.* (2013) reported that allicine had significant fumigation toxicity against different development stages especially for *T. castaneum, Oryzaephilus surinamensis*, and *Cryptolestes ferrugineus*. Our results are in accordance with earlier studies of Epidi and Odili, (2009) who reported that garlic has proved to have an insecticidal effect against *Sitophilus zeamais* and *Tribolium castaneum.*

Also, Işıkber *et al.* (2009) reported that garlic essential oil proved to be a promising agent against the eggs of *Tribolium confusum* insects. Yang *et al.* (2010) reported that garlic essential oil and its component, especially diallyl trisulfide, have potent fumigant activity against *T. castaneum* and might be useful for managing stored products insects in enclosed warehouses. Ahmad *et al.* (2019) reported that garlic has proved to be an effective botanical insecticide against the *T. castaneum* when mixed with seed. One of the most relevant studies in exploring the mode of action of essential oil was by Shah *et al.* (2020) who reported that diallyl trisulfde is the main component of garlic essential oil had insecticidal efficacy on chitin characteristics and RNAi-mediated, knockdown of chitin synthase A gene in *S. cerealella* adult which indicate low-toxic, eco-friendly of such substances in pest-control products.

CONCLUSION

Overall, the data represented in the current study concluded that the tested essential oils from two different families *A. sativum* and *C. reticulata* showed a potent contact and fumigant toxicity against two stored grain insects. Their use is safe, environmentally friendly, cheap, and versatile. It is may be a promising agents and a safe alternatives to synthetic insecticides for many of the destructive stored grains insects and compatible with integrated pest management programs.

REFERENCES

Adams, R.P. (1997). Identification of essential oil components by gas chromatography/mass spectroscopy. Allured Publishing Co., Carol Stream, IL javascript:void, 8:671–672.

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

Ahn, Y.I.; S.B. Lee; H.S. Lee; and G.H. Kim (1998). Insecticidal and acaricidal activity of caravacrol and (-thujaplicine derived from *Thujopsis dolabrata* var. *hondai* sawdust. J. Chem. Ecol., 24: 1-90.

Aktar, M.W.; D. Sengupta and A. Chowdhury (2009). Impact of pesticides use in agriculture: Their benefits and hazards. Interdiscip. Toxicol., 2: 1–12.

Alexandratos, N. and J. Bruinsma (2012). World Agriculture towards 2030/2050:The 2012 Revision. ESA Working 12-30pp. FAO, Rome.

Beier, R.C.; J. A. Byrd; L.F. Kubena; M.F. Hume; J. L. McReynolds; R. C. Anderson and D.J. Nisbet (2014). Evaluation of linalool, a natural antimicrobial and insecticidal essential oil from basil: Effects on poultry. Poult. Sci.93: 267–272.

Biondi, A.; N. Desneux; G. Siscaro and L. Zappala (2012). Using organic-certified rather than synthetic pesticides may not be safer for biological control agents: selectivity and side effects of 14 pesticides on the predator *Orius laevigatus*. Chemosphere, 87(7):803–812.

Campbell, J.F.; F.H. Arthur; M.A. Mullen and L.T. Steve (2004). Insect management in food processing facilities. Adv. Food Nutr. Res., 48: 239-295.

Campolo, O.; A. Malacrinò; L. Zappalà; F. Laudani; E. Chiera; D. Serra; M. Russo and V. Palmeri (2014). Fumigant bioactivity of five citrus essential oils against *Tribolium confusum* Phytoparasitica, 42(2): 223-233.

Chen, H.P.; L.S. Zheng; K.Yang; N. Lei; Z.F. Geng; P.Ma; Q. Cai; S.S. Du and Z.W.Deng (2015). Insecticidal and repellant activities of polyacetylenes and lactones derived from *Atractylodes lancea* rhizomes. Chem. Biodivers., 12 (4): 593-598.

Chutia, M.; P.D. Bhuyan; M.G. Pathak; T.C. Sarma; P, Boruah (2009). Antifungal activity and chemical composition of *Citrus reticulata* Blanco essential oil against phytopathogens from North East India. Food Sci. Technol., 42: 777-780.

Edde, P.A. (2012). A review of the biology and control of *Rhyzopertha dominica* (F.) the lesser grain borer. J. Stored Prod. Res., 48: 1–18.

Epidi, T.T. and E. O. Odili (2009). Biocidal activity of selected plant powders against *Tribolium castaneum* (Herbst) in stored groundnut (*Arachis hypogaea* L.). Afr. J. Environ. Sci. Technol., 3: 1-5.

FAO, (2013). The State of Food Insecurity in the World,The Multiple Dimensions of Food Security. FAO, Roma.

Fedina, T.Y. and S.M. Lewis (2007). Effect of *Tribolium castaneum* (Coleoptera: Tenebrionidae) nutritional environment, sex, and mating status on response to commercial pheromone traps. J. Econ. Entomol., 100: 1924–1927.

Finney, D. J. (1971). Probit Analysis, Cambridge: Cambridge University Press.

Forouzan, M.; M. Rezaei; A. Eivazi and M. Hassanzadeh (2013). Fumigant toxicity of essential oils from *Citrus reticulata* Blanco fruit peels against *Rhyzopertha dominica* F. (Col.: Bostrichidae). Sci. Agric., 1: 67-69.

Fouad H. and C.A. Camara (2017). Chemical composition and bioactivity of peel oils from *Citrus aurantiifolia* and *Citrus reticulata* and enantiomers of their major constituent against *Sitophilus zeamais* (Coleoptera: Curculionidae), Journalof Stored-Products Research, 73: 30-36.

Fountain, E.D. and S.D. Wratten (2013). Conservation biological control and biopesticides in agricultural, Reference Module in Earth Systems and Environmental Sciences Encyclopedia of Ecology (Second Edition), Journal of Elsevier, 1:377-381.

Garcìa, M. ;O.J. Donael; C.E. Ardanaz; C.E. Tonn and M.E. Sosa (2005). Toxic and repellent effects of Bacchar is salicifolia essential oil on *Tribolium castaneum* Pest Manag. Sci., 61: 612–618.

Gerland, P.; A.E. Raftery; H.Sev cíkova; N. Li; D. Gu; T. Spoorenberg and L. Alkema (2014). World population stabilization unlikely this century. J. Sci., 346: 234-237.

Grumezescu, A.M. (2017). New pesticides and soil sensors. Academic Press.

Haouas, D.; P.L. Cioni; M. Ben Halima-Kamel; G. Flamini and M.H. Ben Hamouda (2012).Chemical composition and bioactivities of three Chrysanthemum essential oils against *Tribolium confusum* (du Val) (Coleoptera: Tenebrionidae). Journal of Pest Science, 85: 367– 379.

Ho, S. H.; L. Koh; Y. Ma; Y. Huang and K. Y. Sim (1996). The oil of garlic, *Allium sativum* L. (Amaryllidaceae), as a potential grain protectant against *Tribolium castaneum* (Herbst) and Sitophilus zeamais Motsch. Postharvest Biology and Technology, 9:41-48.

Hosni, K.; N. Zahed; R. Chrif; I. Abid; W. Medfei; M. Kallel; N.B. Brahim and H. Sebei (2010). Composition of peel essential oils from four selectedTunisian Citrus species: evidence for the genotypic influence. Food Chem. 123, 1098-1104.

Işıkber, A.A.; N. Ozder and O. Sağlam (2009). Susceptibility of eggs of *Tribolium confusum*, *Ephestia kuehniella* and *Plodia interpunctella* to four essential oil vapors. Phytoparasitica, 37(3): 231-235

Isman, M.B. (2000). Plant essential oils for pest and disease management. In: Crop Prot XIV the International Plant Protection Congress, (19): 603–608.

Kim, S.I.; J.Y. Roh; D.H.Kim; H.S. Lee, and Y.J. Ahn (2003). Insecticidal activities of aromatic plant extracts and essential oils against *Sitophilus oryzae* and *Callosobruchus chinensis*. Journal of Stored Products Research, 39: 293–303.

Kumar, S. (2012). Biopesticides: a need for food and environmental safety. J. Biofertil. Biopestic. 3(4): 1-3.

Kumar, S. (2013). The role of biopesticides in sustainably feeding the nine billion global populations. J. Biofertil. Biopestic, 4(2): 111-114.

Lota, M.; D.R. Serra; F. Tomi and J. Casanova (2000). Chemical variability of peel and leaf essential oils of mandarins from *Citrus reticulata* Blanco. Biochem. Syst.Ecol., 28: 61-78.

Lü, J. H. and Y. Q. He (2010). Fumigant toxicity of *Ailanthus altissima* Swingle, *Atractylodes lancea* (Thunb.) DC. and *Elsholtzia stauntonii* Benth extracts on three major stored grain insects. Ind. Crops Prod. 32 (3): 681–683.

Lu, Y.; J. Zhong; Z. Wang; F. Liu and Z. Wan (2013). Fumigation toxicity of allicin against three stored product pests. Journal of stored products research, 55: 48-54.

Mahdi K.R. and A. Behnam (2018). Fumigant Toxicity and Repellency Effect of Orange Leaves *Citrus sinensis* (L.) Essential Oil on *Rhyzopertha dominica* and *Lasioderma serricorne*, Journal of Essential Oil-Bearing Plants 21(10):1-6.

Mossa, A.T.H.; S.I. Afia; S.M. Mohafrash and B.A. Abou-Awad (2018). Formulation and characterization of garlic (*Allium sativum* L.) essential oil nanoemulsion and its acaricidal activity on eriophyid olive mites (Acari: Eriophyidae). Environmental Science and Pollution Research, 25(11): 10526-10537.

Nerio, L.S.; J. Olivero-Verbel and E. Stashenko (2009). Repellent activity of essential oils from seven aromatic plants grown in Colombia against *Sitophilus*
zeamais Motschulsky (Coleoptera). J. Stored Prod. Res., 45: 212-214.

Nerio, L.S.; J. Olivero-Verbel and E. Stashenko (2010). Repellent activity of essentialoils: A review Bioresour. Technol., 101: 372–378.

Pavela, R. and G. Benelli (2016). Essential oils as ecofriendly biopesticides? Challenges and constraints. Trends Plant Sci., 21:1000–1007.

Rahman, G. K. and N. Motoyama (2000). Repellent effect of garlic against stored product pests. Journal of Pesticide Science, 25: 247-252.

Rajasekharreddy, P. and P.U. Rani (2010). Toxic properties of certain botanical extracts against three major stored product pests. Journal of biopesticides, 3(3): 586-589.

Regnault-Roger, C. and A. Hamraoui (1995). Fumigant toxic activity and reproductive inhibition induced by monoterpenes on *Aeanthoseelides obteetus* (Say)(Coleoptera), a bruchid of kidney bean *(Phaseolus vulgaris* L.). J. Stored Prod. Res. 31: 291-299.

Saleem, M.; D. Hussain; R.S. Rashid; H.M. Saleem; G. Ghouse; and M.R. Abbas (2013). Insecticidal activities of two citrus oils against *Tribolium castaneum* (Herbst). American J. Res. Commun, 1(6): 67-74.

Satyal, P.; J.D. Craft; N.S. Dosoky and W.N. Setzer (2017). The chemical compositions of the volatile oils of garlic (*Allium sativum*) and wild garlic (*Allium vineale*). Foods, 6(8): 63-73.

Shah, S.; M. Hafeez; M.Y. Wu; S. S. Zhang; M. Ilyas; G. Wu and F.L. Yang (2020). Downregulation of chitin synthase A gene by diallyl trisulfide, an active substance from garlic essential oil, inhibits oviposition and alters the morphology of adult *Sitotroga cerealella*, Journal of Pest Science, 93(3): 1097-1106.

Suthisut, D.; P.G. Fields and A. Chandrapatya (2011). Fumigant toxicity of essential oils from three Thai plants (*Zingiberaceae*) and their major compounds against *Sitophilus zeamais*, *Tribolium castaneum* and two parasitoids. J. Stored Prod. Res., 47: 222-230.

Swigar, A.A. and R.M. Silverstein (1981) Monoterpenes. Aldrich Chemical Company Publ., Milwaukee, WI javascript:void.

Tripathi, A.K.; V. Prajaoati; S.P. Khanuja and S. Kumar (2003). Effect of d-Lemonene on three stored products beetles. J. Econom. Entomol., 96: 990-995.

Yang, F.L.; F. Zhu and C.L. Lei (2010). Garlic essential oil and its major component as fumigants for controlling *Tribolium castaneum* (Herbst) in chambers filled with stored grain. Journal of pest science, 83(3): 311-317.

Yildirim, E.; B. Emsen and S. Kordali (2013). Insecticidal effects of monoterpenes on *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae). J. Appl. Bot. Food Qual., 86: 198-204.

تاثيرالنشاط الحيوي للزيوت الأساسية أليوم ساتيفم و سيترس ريتكيول ضد حشرات المنتجات المخزنة ترايبوليم كاستنيوم و ريزوبيرثا دومينكا

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أجريت هذه الدراسة لتقدير تأثير التسمم بالملامسة والتبخير للزيوت الأساسية الثوم (أليوم ساتيفم) و المندرين (سيترس ريتكيولا) ضد اثنين من حشرات المنتجات المخزونة (ترايبوليم كاستنيوم) و (ريزوبيرثا دومينكا) في ظل الظروف المعملية لـ يوم ، إثنان و ثلاثة أيام بعد التعرض. أظهرت النتائج أن الثوم كان أكثر فاعلية من الماندرين ، كانت LC_{50} للثوم بالملامسة بعد ثلاثة أيام 336 .0مجم / مل مقارنة بـ 5.49 مجم / مل للمندرين على حشرة ترايبوليم كاستنيوم ، 0.343 مجم / مل ، 4.130 مجم / مل على ريزوبيرثا دومينكا في نفس فترة الدراسة. علي نفس النحو في التبخير كانت LC_{50} للثوم 0.789 ، 0.386 ميكرو لتر / لتر هواء علي ترايبوليم كاستنيوم و ريزوبيرثا دومينكا على التوالي و 7.778 ، 6.305 ميكرو لتر / لتر هواء للمندرين على ترايبوليم كاستنيوم و ريزوبيرثا دومينكا بعد ثلاثة أيام على التوالي. أظهر تحليل كروموتجرافيا الغاز- مطياف الكتلة (GC-MS) أن المركبات الرئيسية لزيت الثوم الأساسي هي كبريتيد الديليل (9.5 ٪) ، ثنائي كبريتيد ثنائي الأليل (27.9 ٪) ، ثنائي ميثيل رباعي كبريتيد (2.9 ٪) ، أليل ميثيل ثلاثي كبريتيد (17.7 ٪) ، وثلاثي كبريتيد الديليل (16.8٪). في المندرين ، كانت المكونات الرئيسية هي تريكاربونيل [ميثيل 6- فينيل دين هيبتا 2،4-دايين-1- أووت] حديد (52.8٪) ، داي ميثيل هكسان (15.28٪) ، ف- سيمين (5.45٪) ، ليمونين (3.88٪) و γ تربينين (9.47٪). أوضحت النتائج أن الزيوت الأساسية قد تكون بدائل واعدة وآمنة للمبيدات الحشرية الكيميائية التخليقية للسيطرة على حشرات المنتجات المخزنة إما عن طريق المعالجة بالملامسة أوالتبخير ومتوافقة مع الإدارة المتكاملة للآفات.