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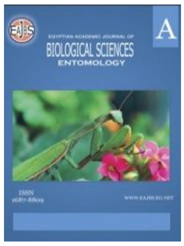

Modified Atmosphere Enriched with Argon Gas as An Alternative Measure for Controlling Four Stored Dates Pests

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ABSTRACT

This work aimed to evaluate the efficacy of modified atmosphere (MA) enriched with Argon gas as an alternative measure for controlling four stored dates pests, two from order: Lepidoptera, *Ephestia cautella* (Walker) & *Plodia interpunctella* (Hübner) and two from order Coleoptera; *Oryzaephilus surinamensis* Linnaeus & *Stegobium paniceum* (L.) and its effect on some enzymes activity of tested insects. Argon gas concentrations of (60, 80 and 100 %) had been tested against the four mentioned insects at different exposure times ranged from 3 to 144 hrs. The results revealed that Lepidopterous were more sensitive to Argon gas than Coleopterous. Also, data indicated that not all tested insects have the same sensitivity to Argon gas. Obtained results indicated that the reduction % of adult emergence increased by increasing exposure duration and or concentration. At the concentration of 100 % Argon, data reported that the larvae of *E. cautella* were the most susceptible and reached a 100% reduction after 12 hrs. While the adults of *O. surinamensis* was the most tolerant insect stage to Argon gas where reached 74.60 % reduction after 72 hrs. Exposure of *P. interpunctella* and *O. surinamensis* to LT 50 of Argon increased the activity of two defensive enzymes within tested insects, Acid phosphatase, &Carboxlesterases. and decreased the activity of LDH enzyme.

INTRODUCTION

In many countries palm is consederd as one of the most important crops, with mor than 2200 species distributed throughout the tropic and subtropic areas (Johnson, 1996); representing an important part of tropical forests (Johnson 1995). The palm trees have a significant effect on the economy of millions of people around the world. Many products can be obtained from these different palm species. There is wide variation in palm products such as, fruits, oil, starch, seeds, honey, crystallized sugar and sap products. Also, palm trees which can be used in food, feed, furniture, energy, clothing and gardens Jones (1995).

The almond moth, *E. cautella* (Walker) (Lepidoptera: Pyralidae) is one of the most major date fruit pests in Egypt. The infestations begin from the field to the storehouse through infested dates which have various generations (Howard *et al.*, 2001). Beside date palm fruits, dried fig, cereal and its' products, cocoa, chocolate, raisin, dried fruit, spices, nuts, peanut and processed foods are reported as hosts of almond moth (Hodges and Farrell, 2004; Rees, 2007).

P. interpunctella (Indianmeal moth) (Lepidoptera: Pyralidae subfam. Phycitinae) is an important insect of stored food products (Doud and PhillipS, 2000; Nansen *et al.*, 2004; Nansen and Phillips, 2004). Because of *P. interpunctella* uses a wide range of products in its diet it has a very strong economic importance (Sauer and Shelton, 2002; Rees, 2004).

The saw-toothed grain beetle, *O. surinamensis* (Coleoptera: Silvanidae), is one of the key stored grain pests in worldwide (Rossiter *et al.*, 2001; Hashem *et al.*, 2012). It is a secondary feeder which infests whole grains with minor cracks or mechanical damage (Pricket *et al.*, 1990). It can feed on different stored product goods such as date fruits, cereals, millets, flours, oilseeds, dried meat and nuts etc., (Barnes, 2002; Bowditch and Madden, 1997). Although the neem seed embryo has some pesticide properties, *O. surinamensis* beetle nourishes and grows well on it (Sarup and Srivastava, 1971).

The drugstore beetle *S. paniceum* (Coleoptera: Ptinidae) is also distributed worldwide, as a strange species (Umeya 2012). It consumes a wide variety of dried plant products and biological specimens in museum collections (Gilberg and Brokerhof 1991). Adults of both *O. surinamensis* and *S. paniceum* lay eggs on dry foods in food storage containers. After feeding of the larvae dead beetles and its' wastes remain inside food, causing huge economic damage (Ashworth 1993).

Chemical insecticides such as Malathion, methyl bromide and phosphine, have been widely used for controlling insects because they are fast-acting and cheap. On the other hand, chemical insecticides have a bad deep impact on humans, animals and useful insects (Muir and White 2001). In addition, using chemicals insectsides fumigants develop resistance. Nowadays, many markets no longer accept products with chemical insecticides residues. As a result, other control methods need to be developed and applied. The modern trend focuses on developing physical methods of insect control. These methods depend on the ecology of stored-product insects. These methods that involve manipulation of the physical environment, like the composition of atmospheric gas (Argon). This paper aime to evaluate the effect of modified atmospheres enriched with Argon gas as an alternative measure for controlling four stored dates pests.

MATERIALS AND METHODS

Experiments were conducted at date pests and diseases Dept., Central Laboratory of Date Palm, Agricultural Research Center, Giza, Egypt and the laboratory of stored product pests' control, Plant Protection Dep. Fac. of Agriculture, Benha University.

Test Insects:

1. Rearing of Insects Culture:

The four insect species were collected from infested date fruits were reared on their standard food diets. Insects culture was kept in an incubator at 27±2°C and 65±5% relative humidity (r.h.). The adult insects have reared on dry date fruits Frihi cultivar. The date fruits were sterilized before use by continuous freezing (-10°C) for at least two months, then kept under laboratory conditions for 12 hrs, before use (Hussain, 2008). The eggs and larvae of Lepidoptrous species; *Ephestia cautella* and *Plodia interpunctell* were separately evaluated while in the case of Coleopterous species; *Oryzaephilus surinamensis* and *Stegobium paniceum* larvae and adults were tested.

Modified Atmosphere:

1. Gases Used.

Argon was provided as pure gas in pressurized steel cylinders. The cylinder was connected to a pressure regulator. The dilution method was used to achieve the required argon concentration. For the atmosphere of nearly pure Ar 100%, the valve of each cylinder was opened for three minutes in order to fill the gastight Dreshel exposure flask with the gas. Modified Atmosphere (MA) of Argon concentrations 60 and 80 % in air were prepared using Gas Distribution device. Determination of the concentrations of Ar was monitored using a gas Analyser model 2(10-600 Gow-Mac-Instruments Company U.S.A.).

2. Preparing the Insect Species Samples for Bioassay Tests of Modified Atmosphere:

A number of 50 *E. cautella* & *P. interpunctella* eggs were kept into small cloth bags (4×8 cm) filled with about 25 g artificial diet and closed with rubber bands. 30 fourth instar larvae were put also with 25g of artificial diet. In the case of *O. surinamensis* and *S. paniceum*, 30 larvae and 20 adults of each species were put into small cloth bags (4×8 cm) filled with about 25 g artificial diet and closed with rubber bands. Cloth bags were taken and introduced into the gastight Dreshel-flasks of 0.55L volume. Various insect stages in the gastight flasks were treated with the MA at mentioned concentration and different exposure periods ranged from 3 to 144 hrs. at 27 ± 2°C. After the exposure periods, the flasks were aerated for 24 hrs.and the insect stages were transferred into Petri dishes and kept at 27 ± 2°C and 65 ± 5% RH and were examined daily to record adult emergence until the emergence of adult stopped for reduction% assessment.

3. Bioassay Tests of Modified Atmospheres:

The efficacy of MA containing various Argon concentrations was investigated against four species of stored date fruits pests at tested temperature (27±2 ˚C and 65 ± 5% R.H.). Experiments were conducted inside 0.55 L gastight flasks at the laboratory. Different insect species stages were used for the bioassay to study their sensitivity to Argon concentrations. The reduction % of adult emergence was calculated according to the formula of Henderson and Tilton (1955).

$$\text{Reduction } \% = \frac{\text{Control} - \text{treated}}{\text{Control}} \times 100$$

4. Biochemical Studies:

A known weight of tested species larvae and adults (1 g) which was tested with LT_{50} and the same weight of untreated ones were kept in the deep freezer until used for certain physiological purposes as follows: each specimen was homogenized in 1ml distilled water by using chilled glass Teflon homogenizer (ST- 2 Mechanic-Preczyina, Poland). Homogenates were centrifuged at 8000 r.p.m. for 15 min at 5 ºC and the supernatant was used for enzyme assay Amin (1998).

5. **Determination of Enzymes Activity:**

The current study was carried out to clarify the effect of Modified Atmosphere enriched with Argon gas on the activities of the following enzymes:

-Carboxlesterases determination, Carboxlesterase activity was_measured according to the method described by Simpson *et.al.* (1964).

-Determination of phosphatases, Acid phosphatases was determined according to the method described by Powell and Smith (1954).

-LDH, the method described here is derived from the formulation recommended by the German Society for clinical chemistry (DGKC, 1972).

6. Statistical Analysis:

Data on the effect of MA concentrations and exposure periods on the tested four insect species were subjected to probit analysis, as described by Finney (1971). LT50 and LT90 values were calculated using the computer program developed by Noack and Reichmuth (1978).Data of analysis insect species enzymes were analyzed using Proc., ANOVA in SAS (SAS Institute 2006).

RESULTS AND DISCUSSION

1. The Effect of MA Contains Argon Gas Application on Four Tested Insects:

Results concerning the evaluation efficacy of concentration 100% of Argon on eggs and larvae stages of *E. cautella* and *P. interpunctella* and on adult and larvae stages *of O. surinamensis* and *S. paniceum* are shown in Table 1. The results revealed that reduction % in emerged adults increased gradually by increasing the exposure period. Complete reduction (100%) was observed in Lepidoptera (*E. cautella* and *P. interpunctella*) after the exposure time of 12 hrs. in the larval stage but in the case of the Egg stage after 18 hr and 24 hrs. resp., Whereas, in the case of Coleoptera (*O.surinamensis* and *S. paniceum*) complete reduction (100%) was noticed only for *O.surinamensis* larval stage after the exposure time of 18 hrs.

Table 1: Effect of MA enriched with Argon 100 % on adult emergence of the four tested insects.

Insect	stage	Reduction %							
		Exposure time (hrs.)							
		3	6	9	12	18	24	48	72
Plodia interpunctella	Egg	18.87	43.4	56.6	77.36	94.34	100	-	-
	Larva	24.07	59.26	72.22	100	100	100	-	-
Ephestia cautella	Egg	25.86	48.27	68.96	80.39	100	-	-	-
	Larva	39.22	68.63	80.39	100	100	-	-	-
Oryzaephilus surinamensis	adult	2.12	6.88	11.64	14.29	20.63	46.03	59.26	74.60
	Larva	33.33	46.30	70.37	92.59	100	-	-	-
Stegobium paniceum	adult	6.99	18.99	23.99	36.96	54.00	75	86	96
	larva	14.81	16.67	33.33	48.15	50	62.96	72.22	88.89

Results concerning the evaluation efficacy of concentration 80% of Argon on Eggs and larvae stages of *E. cautella* and *P. interpunctella* and on adult and larvae stages *of O. surinamensis* and *S. paniceum* are shown in Table 2. The maximum reduction % in adult emergence resulted from treated larvae after 6 days in the case of *P. interpunctella* and 4.5 days in *E. cautella*. Meanwhile, *O. surinamensis* complete reduction % in adult emergence in larvae after 4.5 days while it was 6 days in the adult stage. In the case of *S. paniceum the* complete reduction % in adult emergence resulted from treated adults and larvae after exposure time was 5 and 6 days %, respectively.

Table 2: Effect of MA enriched with Argon 80 % on adult emergence of different tested insects.

Insect	Stage	Reduction %								
		Exposure time (day)								
		0.5	1	2	2.5	3	4	4.5	5	6
Plodia interpunctella	Egg	5.66	11.32	32.08	49.06	58.49	66.04	71.70	75.47	94.34
	Larva	11.11	16.67	38.89	55.56	61.11	72.22	75.93	77.78	100
Ephestia cautella	Egg	8.61	24.13	39.65	53.45	65.51	72.41	81.03	89.65	100
	Larva	14.81	31.48	44.44	55.56	68.52	77.78	100	-	-
Oryzaephilus surinamensis	adult	8.99	17.46	36.51	51.85	60.85	62.43	74.07	86.24	100
	Larva	12.96	27.78	40.74	51.85	62.96	75.93	100	-	-
Stegobium paniceum	adult	32.99	46.99	53.00	57.00	74.00	83.00	87.00	100	
	larva	9.26	14.81	35.19	42.59	44.44	55.56	66.67	72.22	100

Results concerning the evaluation efficacy of concentration 60% of Argon on eggs and larvae stages of *E. cautella* and *P. interpunctella* and on adult and larvae stages of *O. surinamensis* and *S. paniceum* are shown in Table 3. The complete reduction % in adult emergence resulted only from the treated adult of *S. paniceum* after 5 days. Our results stated that grubs were more tolerant of Argon treatment than caterpillars.

Table 3: Effect of MA enriched with Argon 60 % on adult emergence of different tested insects.

Insect	Stage	Reduction %								
		Exposure time (day)								
		0.5	1	2	2.5	3	4	4.5	5	6
Plodia interpunctella	Egg	0.00	0.00	9.44	20.76	30.19	37.74	41.51	47.17	50.94
	Larva	3.70	9.26	16.67	24.07	35.19	44.44	50	55.56	59.26
Ephestia cautella	Egg	3.44	6.89	17.24	32.75	39.65	44.82	51.72	58.62	62.07
	Larva	7.41	16.67	22.22	35.19	42.59	48.15	55.56	62.96	66.67
Oryzaephilus surinamensis	adult	3.17	8.99	14.29	23.81	33.33	40.74	42.86	48.68	56.08
	Larva	7.41	12.96	22.22	33.33	40.74	53.70	61.11	64.81	72.22
Stegobium paniceum	adult	16.99	28.99	35.99	45.99	58	70	79	100	
	larva	0.00	5.56	12.96	24.07	40.74	46.30	50	57.41	64.81

2. Lethal Time LT_{50} and LT_{90} Values Per Hour and Parameters of the Mortality Regression Line for Two Stages of Different Four Insects Exposed to Argon (100%):

LT_{50} and LT_{90} (time required to kill 50 and 90% of the population at a certain concentrations) values of 100 % Argon gas against eggs and larvae stages of *E. cautella* and *P. interpunctella and* on adults and larvae stages of *O. surinamensis* and *S. paniceum* are shown in Table 4. Results showed that argon was more effective for the four species when concentration and exposure periods were increased from 60 to 100 %. LT_{90} for *P. interpunctella* was 21.73 and 15.35 hrs. for egg and larva stages, respectively; also, LT_{90} was 16.99 and 13.29 hrs. for eggs and larvae stages of *E. cautella*, respectively. But argon gas was less effective against *O. surinamensis* and *S. paniceum* where LT_{90} recorded 25.41 and 106.15 hrs. in larva stages, respectively. Whereas, at the adult stage, LT_{90} was 139.54 and 47.20 hrs. respectively. The obtained data revealed that Lepidoptera was more sensitive to Argon gas than Coleoptera. Also, data indicated that not all insects have the same sensitivity to argon gas.

Our data is in agreement with El-Shafei, *et al*. (2019) who revealed that the required exposure duration to get 100 % mortality of the adult mite females decreased by increasing of the Argon concentration from 50 to 100 % and Argon was the most efficient gas at 100%. Also, Valentin (1993) reported that to kill all life stages of *S. paniceum* by using Argon gas need 96 h at 30 C^{o}.

Table 4: Lethal time values per hour and parameters of mortality regression line for two stages of tested insects exposed to MA enriched with Argon (100%).

insect	stage	LT_{50} (hr)	LT_{90} (hr)	Confidence limits (hr)				Slope ± SE	Chi square $\chi2$
				LT_{50}		LT_{90}			
				Lower	Upper	Lower	Upper		
Plodia interpunctella	Egg	6.88	21.73	6.10	7.76	17.01	31.87	2.56±0.3	2.09
	larva	5.25	15.35	4.59	5.97	11.92	23.66	2.75±0.3	0.58
Ephestia cautella	Egg	5.62	16.99	4.93	6.30	13.85	23.10	2.66±0.3	2.19
	larva	3.86	13.29	3.09	4.50	10.23	21.43	2.38±0.3	2.83
Oryzaephilus surinamensis	larva	5.55	25.41	4.51	6.59	16.12	69.48	1.91±0.3	2.94
	adult	34.94	139.54	30.86	40.30	106.38	202.75	2.13±0.18	6.68
Stegobium paniceum	larva	17.16	106.15	14.78	20.15	72.38	192.52	1.61±0.18	6.67
	adult	15.16	47.20	13.65	17.11	36.63	69.52	2.59±0.2	4.27

3. Determination of the Effect of MA Contains Argon Gas on Three Enzymes Activity of Two Tested Insects:

The results obtained in Table (5) indicated that acid phosphatase insignificantly increased in *Oryzaephilus surinamensis* but in the case of *P. interpunctella* significantly increased compared with control after exposure to LT50 MA enriched with Argon gas. On the contrary, LDH content differed insignificantly decrease in the case of *Oryzaephilus* *surinamensis* and significantly decreased in *P. interpunctella* compared with control. Carboxlesterases activity significantly increased in *Oryzaephilus surinamensis* after treatment with argon gas and insignificantly increased in *P. interpunctella*. Similar findings are obtained by (Li *et al*., 2007, 2009) menthioned that the activity of carboxylesterase increased after exposure to CO2-enriched atmosphere in *S. paniceum* and *Lasioderma serricorne*, compared to control. Also, CO2 stress increase the activity of Acid phosphatase with increasing of exposure time (Li *et al*., 2008). Exposuring to CO2-enriched MA (75% CO2, 5% O2 and 20% N2) for 3 h increased significantly the activities of acid phosphatase and carboxylesterase in *Araecerus fasciculatus* (Li *et al*., 2012). Rasha A. Zinhoum and El-Shafei (2019) found that the activity of LDH enzyme insignificant decrease in treated larvae of *Plodia interpunctella* with ozone.

Table 5: Changes in Carboxlesterases, LDH and Acid phosphatase content in two insects treated with MA enriched with Argon gas

Insect	Treatment	Acid phosphatase	LDH	Carboxlesterases
Plodia interpunctella	Control	147.00±3.6^b	3666.67±25.3^a	117.67±3.9^a
	Argon	260.67±3.5^a	3543.33±55.5^a	128.00±6.3^a
	L.S.D.	**13.91**	**169.20**	**20.49**
Oryzaephilus surinamensis	Control	282.00±4.4^a	891.67±5.9^a	141.00±3.1^b
	Argon	290.00±6.7^a	298.33±10.1^b	172.67±6.5^a
	L.S.D.	**22.10**	**143.97**	**19.91**

Conclusion:

The efficacy of MA containing 60, 80 and 100% Argon at 27±2°C against four stored dates pests was varied through the different concentrations and different types of insects. The results revealed that Lepidopterous were more sensitive to Argon gas than Coleopterous. The most efficient MA is that containing100% of Argon. So, it is recommended to use these high levels of MAs, in particular, Argon gas in controlling the four tested date pests.

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REFERENCES

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.

Ashworth, J. R. (1993). The biology of *Lasioderma serricorne*. J. Stored Prod. Res. 29: 291–303.

Barnes, J.K., (2002). Saw toothed grain beetle. Arthropod Museum Notes No.7. University of Arkansas Division of Agriculture Department of Entomology.

Bowditch, T. G., and Madden, J. L. (1997). Infestation of Chocolate-based Products: Insects Responsible and Origins of Contamination. Aust. J. of Entomol., 36(3), 263-267.

Deutsche Gesellschaft für Klinische chemie (1972). Empfehlungender Deutschen Gessellschaft für Klinische chemie (DGCK). J. clin. chem. Biochem., 10:182-193.

Doud, C. W. and Philips, T. W. (2000). Activity of *Plodia interpunctella* (Lepidoptera: Pyralidae) in and around flour mills. J. of Econ. Entomol. 93: 1842-1847.

El-Shafei, W. K. M؛ Rania H. Mahmoud and El-Deeb S. E. (2019). Impact of Controlled

Atmosphere of different three gases for Controlling the stored dates mite, *Tyrophagus putrescentiae* (Schrank) (Acari: Acaridida),. Acad. J. of Entomol., 12 (2): 49-56.

Finney, D. J. (1971). Probit Analysis, Third Edition, Cambridge University Press, Cambridge, UK.

Gilberg, M., and Brokerhof, A. (1991). The control of insect pests in museum collections: the effects of low temperature on *Stegobium paniceum* (Linneaus), the drugstore beetle. J. Am. Inst. Conserv. 30: 197–201.

Hashem, M.Y.; Ahmed, S.S.; El-Mohandes, M.A. and Gharib, M.A. (2012). Susceptibility of different life stages of saw-toothed grain beetle *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae) to modified atmospheres enriched with carbon dioxide. J. of Stored Prod. Res. 48, 46-51.

Henderson, C.F. and Tilton, E.W. (1955). Tests with acaricides against the brow wheat mite, J. Econ. Entomol.48, 157-161.

Hodges, R. and Farrell, G., (2004). Crop Post-Harvest: Science and Technology, Volume 2. Blackwell Publishing Company, Oxford, England.

Howard, F.W.; Moore, D.; Giblin-Davis R.M. and Abad R.G., (2001). Insects on palms. CABI Publishing, Wallingford, UK, 1-332 pp.

Hussain, H.B.H. (2008). Using some safe methods in controlling certain insect Pests of stored dates. Ph.D. Thesis, Fac. Agric., AL-Azhar Univ., 154.

Johnson, D.V (1995). Palm conservation: its antecedents, status and needs. In: “World Palm Symposium”. Fairchild Tropical Botanical Garden (Miami, FL) 20-21 October 1995, UAE, pp. 135.

Johnson, D.V. (1996). Palms: their conservation and sustained utilization. IUCN Publications Services Unit-219, Huntington Road, Cambridge, UK, pp. 190.

Jones, D.L. (1995). Palms throughout the world. Washington: Smithsonian Institution, 1995. 410p.

Li, C.; Li, Z. Z.; Cao, Y., and Wang, J. J. (2012). Effect of controlled atmosphere on the activity and kinetics of three detoxification enzymes in Araecerus fasciculatus (Coleoptera: Anthribidae). J. Plant Prot. 55, 950–957.

Li, C.; Li, Z. Z.; Cao, Y.; Zhou, B., and Zheng, X. W. (2009). Partial characterization of stress-induced carboxylesterase from adults of *Stegobium paniceum* and *Lasioderma serricorne* (Coleoptera: Anobiidae) subjected to CO2-enriched atmosphere. J. Pest. Sci. 82, 7–11.

Li, C.; Li, Z. Z.; Zheng, X. W.; Zhou, B., and Cao, Y. (2008). Effects of carbon dioxide-enriched atmosphere on the activity of phosphatases from mature larvae of *Stegobium paniceum*. Plant Prot. 34, 123–126.

Li, C.; Li, Z. Z.; Zhou, B.; Zheng, X. W., and Cao, Y. (2007). Effect of carbondioxide enriched atmosphere on the activity of acetylcholinesterase in adults of *Stegobium paniceum* and *Lasioderma serricorne* (Coleoptera: Anobiidae). J. Plant Prot. 34, 642–646.

Muir, W. E. and White, N. D. G., (2001). Chemical control methods,” in *GrainPreservation Biosystems*, W. E. Muir, Ed. Winnipeg, MB: University of Manitoba, 2001, pp. 354-371.

Nansen, C. and Philips, T. W. (2004). Attractancy and toxicity of an attracticide for Indian meal moth, *Plodia interpunctella* (Lepidoptera: Pyralidae). J. of Econ. Entomol. 97: 703-710.

Nansen, C.; Philips, T. W.; Parjulee, M. N. and Franqui, R. A. (2004). Comparison of direct and indirect sampling procedures for *Plodia interpunctella* in a maize storage facility. J. of Stored Prod. Res. 40: 151-168.

Noack, S. and Reichmuth, C.H. (1978) . Einrechnerisches Verfahrenzur Bestimmung von beliebigen Dosiswerteneines Wirkst offesausempirischen Dosis Wirkungs-Daten. Mitteilungenaus der Biologischen Bundesanstaltfür Land- und Fortswirtschaft, Berlin-Dahlem, Heft, pp. 185: 1-49.

Powell, M.E.A. and Smith, M.J.H. (1954). The determination of serum acid and alkaline phosphatase activity with 4- aminoantipyrine. J. Clin. Pathol. ,7: 245-248.

Pricket, A.J., Muggleton, J. and Llewellin, J.A., (1990). Insecticide resistance in populations of *Oryzaephilus surinamensis* and *Cryptolestes ferrugineus* from grain stores in England and Wales. Brighton Crop Protection. Conference Pests and Disease 3, 1189-1194.

Rasha A. Zinhoum and El-Shafei, W. K. M (2019). Control of One of The Vital Stored Date Insects, *Plodia interpunctella* (Hübner) (Lepidoptera: Pyralidae), by Using Ozone Gas. Egypt. Acad. J. Biolog. Sci., (F. Toxicology & Pest control) 11(3): 149-156.

Rees, D. (2007). Insects of stored grain. CSIRO Publishing, Canberra, Australia, 80p.

Rees, D. (2004). Insects of Stored Products. Collingwood: CSIRO Publishing.

Rossiter, L.C.; Gunning, R.V. and Rose, H.A., (2001). The use of polyacrylamide gel electrophoresis for the investigation and detection of fenitrothion and chlorpyrifos-methyl resistance in *Oryzaephilus surinamensis* (Coleoptera: Silvanidae). Pest., Bioch., Physiol. 69, 27-34.

Sarup, P.; Srivastava, V.S. (1971). Observation in the damage of neem seed kernel in storage by various pests and efficacy of the damaged kernel as an anti feedent against desert locust. Ind. J. of Entomol. 33, 228-230.

SAS Institute Inc., (2006). The SAS System for Windows 9.1.SAS Institute, Cary, NC, U.S.A.

Sauer, J. A. and Shelton, M. D. (2002). High-temperature controlled atmosphere for postharvest control of Indian meal moth (Lepidoptera: Pyralidae) on preserved flowers. J. of Econ. Entomol. 95: 1074-1078.

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

Umeya, K. (2012). Alien insect pests and naturalized natural enemies in Japan. Zenkoku Noson Kyoiku Kyokai, Tokyo, Japan.

Valentin,N.(1993).Comparative analysis of insect control by nitrogen, argon and carbon dioxi de in museum, archive and herbarium collections. Inter. Biodeterioration & Biodegradation (32), 4, 263-278.

ARABIC SUMMARY

الاجواء المعدلة الغنية بغاز الأرجون كوسيلة بديلة لمكافحة اربعة من آفات التمور المخزونة

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يهدف هذا العمل الى تقييم فاعلية الاجواء المعدلة الغنية بغاز الارجون كطريقة بديلة لمكافحة اربعة من افات التمور المخزونة أثنان من رتبة حرشفية الاجنحة *P. interpunctella* (Hübner) و *E. cautella* (Walker) وأثنان من رتبة غمدية الاجنحة *O. surinamensis* (L.) و *S. paniceum* (L.) وتاثير غاز الارجون على نشاط بعض الانزيمات فى الحشرات المختبرة . تم اختبار تركيزات غاز الارجون (٦٠ , ٨٠ و١٠٠٪) ضد الحشرات الاربعة على فترات تعريض مختلفة تترواحت بين ٣ الى ١٤٤ ساعة. اظهرت النتائج ان رتبة حرشفية الاجنحة أكثر حساسية من رتبة غمدية الاجنحة. كما اوضحت النتائج ايضا انه ليست للاربع حشرات المختبرة نفس الحساسية لغاز الارجون.بينت النتائج المتحصل عليها ان نسبة الخفض فى اعداد الحشرات زادت بزياده فترة التعريض او التركيز.اوضحت النتائج انه عند تركيز ١٠٠ % ارجون كانت يرقات *E. cautella* الاكثر حساسية واعطت نسبة موت ١٠٠٪ بعد ١٢ ساعة في حين أن الحشرة الكاملة لخنفساء السورينام *O. surinamensis* كانت الاكثر مقاومة لغاز الارجون حيث بلغت نسبة الخفض فى اعداد الحشرات ٧٤,٦٠ ٪ بعد ٧٢ ساعة . تعريض *P. interpunctella* و *O. surinamensis* الى LT_{50} من غاز الارجون ادى الى زيادة فى نشاط انزيمين من انزيمات المقاومة داخل الحشرات المختبرة Acid phosphatase و Carboxlesterases ونقص فى نشاط انزيم LDH .