J. Plant Prot. and Path., Mansoura Univ., Vol.9 (9): 595- 600, 2018

Biology and Control of Indian Meal Moth, *Plodia interpunctella* (Hubner) (Lepidoptera: Pyralidae) Infesting Stored Date, Almond and Peanut Fruits

El-Shafei, W. K. M.[1]; Rasha A. Zinhoum[2] and H. B. H. Hussain[2]
[1]Central lab.for Date Palm, Agric. Res. Centre (ARC), Giza, Egypt.
[2]Plant Prot. Res. Inst., Agric. Res. Center (ARC), Dokki, Giza, Egypt.

ABSTRACT

This study aimed to evaluate different diets effects on the biological parameters of *plodia interpunctella* (Hubner). Three hosts namely; date, almond and peanut. Results showed that the hatchability percentage, weight per larva, pupation percentage and adult emergence percentage were the highest on almonds diet. Incubation period, generation time and life cycle were shortest in almonds. Also data indicated that almonds were the most preferred host. The efficacy of three microwave powers was investigated against two *plodia interpunctella* stages. The result cleared that the increase in microwave power and exposure times caused an increase in eggs and larvae reduction rate % and accordingly the microwave power more effective in larvae than egg stage. Also, results showed that there is no harmful effect on the chemical fruits characteristics under microwave treatment.

INTRODUCTION

Date palm (*Phoenix dactylifera* L.) is one of the oldest and important cultivated crops in the world. The Middle East is the primary date growing region in the world. In Egypt, palm plantations represented by more than 15 million trees producing the largest quantity in Arab world, where the annual production reached 1.700.000 tons of fresh, semi - dry and dry fruits each year; nearly 21.5% from this amount is dry date varieties , Egyptian Ministry of Agriculture (2015). Peanut (*Arachis hypogaea* L.) is an important food and export crop in Egypt. Peanut is one of the leading agricultural crops of the world for the production of edible plant oil and protein Adegoke *et al*., (2004).

Pests are one of the most severe threats for food products, but often ignored by many manufactures, which leads to a world-wide loss equivalent to thousands of millions of euros per year Haff and Slaughter (2004).

Generally, postharvest food losses are estimated to range from 8 to 10% in industrialized countries Ciepielewska and Kordan, (2001); Brader *et al*., (2002). The Indian meal moth is a cosmopolitan pest that not only attacks a wide range of stored cereal products LeCato, (1976); Madrid and Sinha, (1982) and Mbata, (1990); but also other food products including dried vegetables Na and Ryoo, (2000), groundnuts Mbata, (1987), dried fruits and almonds Cox and Bell, (1991), raisins and prunes Johnson *et al*.,(1995). The larvae are general feeders, which may feed on grain products, seeds, dried fruit, dog food, and spices. It causes quantitative and qualitative economic damage in stored products.

Many chemical insecticides and fumigates are used as protectants against insect infestation in stored grains and fruits. But their indiscriminate use and residual toxicity affect the non-target animals and human beings

Fumigation with phosphine is widely used to control stored product pests, has high toxicity and most effective without deleterious effects on the viability of dormant grain. However, the continuous and indiscriminate use of phosphine has resulted in the evolution of resistant populations of targeted pests, Lorini *et al.,* (2007).

Recently, worldwide attention is focus on screening and developing less hazardous and cheap materials as alternative pest control method Graham (1997). Microwaves are a nonionizing form of energy that interact with polar molecules and charged particles of penetrated medium to generate heat. Use of microwave heating has the advantage of saving time and energy, improving both nutritional quality and acceptability of some foods by consumers Nijhuis *et al*., (1998) and Sumnu, (2001).

Microwaves are electromagnetic waves which lie between infrared radiation and radio waves in the electromagnetic spectrum. Their frequency ranges from 300 MHz to 300 GHz which corresponds to the wave length 1-1000 mm Suhajda (2006). The principle behind killing of insects using microwaves is the dielectric heating of insects which depend on its electrical properties Novotny *et al*., (2013) and Suhajda (2006).

The objectives of this paper investigation were to study the life cycle, generation, host preference of *Plodia interpunctella* on stored date, almond and peanut fruits in addition to study potential use of microwave as a new control method against *P. interpunctella* at three microwave power levels and different exposure times.

MATERIALS AND METHODS

1. Tested insect and host fruits

The Indian meal moth, *plodia interpunctella* Hubner was reared in plastic jars of one liter volume on artificial diet consisting of wheat ground, sugar ground , dry yeast and glycerol pure (250:25:25:37.5 g by weight, resp.) under 27±2Cº and c 65±5 %R.H. The emerged adults were collected daily by vacuum pump and placed in glass cages with screen bottom to obtain eggs. The eggs also were collected daily old in petri dish and transferred inside plastic tubes to obtain new hatched larvae. Three host fruits were used in this study, namely, Almonds, dates and peanuts. The different hosts of fruits were sterilized before use by freezing (-10 Cº) for 2 weeks to destroy any insect infestation.

2. Biological aspects studies

The incubation period of eggs was determined by 100 newly deposited eggs (0.0 – 12 hrs old) in four plastic tubes (4.5 cm long and 3 cm diam) as replicates , 25 eggs/each replicate. Eggs were noticed daily to record date of hatching. To study the effect of different host diets on the development rates of *plodia interpunctella* stages. Larval and pupal stages, 30 newly hatched larvae (0.0 – 12 hrs. old) were singly transferred inside plastic tube as a aforementioned and provided with small parts of almond, date and peanut which were changed at requirement. The tubes were incubated under experiment conditions and inspected daily to record larval, pupal and adult stages duration as well as the duration of life cycle, longevity and generation. Four replicates of each host were used.

3. Host preference of almond , data and peanut by *p. interpunctella* Larvae

One hundred and fifty of whole almond, data and peanut fruits were put in glass jars (250 ml), 50 newly hatched larvae were introduced each glass jar and well closed and kept under the experiment condition. Till F1-progeny, after four weeks, the glass jars were examined daily to record larval-pupal duration and adult emergence. Ten pairs of newly emerged adults put in small tubes as ten replicates, pre-oviposition, oviposition, post-oviposition duration; number of eggs laid and fertility were studied.

The weight loss (%) was calculated according to the equation of Ferial El-Sayed, *et. al*., (2005)

WL = (initial fresh weight –final fresh weight) / initial fresh weight X 100

Growth index was calculated according to Howe, 1971 as follow:

Growth index = (log F) / D X 100

Where: F= total number of adult emergence
D= the mean of development period

4. Exposure of eggs and larvae of *p. interpunctella* to various microwave powers:

The oven was operated at various microwave power of 10, 20 and 30 % of 1000 watt 2450 MHz energy levels, against eggs and larvae of *P. interpunctella* on different diet and its effect on fruit component. Thirty gram of various host (almonds, dates and peanut) were artificial infested with 50 eggs (1 day old) and 30 larvae (fourth larval instar). Each stage was placed separately inside glass jars (250 ml) and exposed to 10 and 20 % microwave power for 20,40,60,80,100 and 120 seconds and 2.5,10,20,30,40,60 and 80 seconds at 30% microwave power. Non-exposed replicates were used as control. Mortality of larvae and eggs were calculated as reduction % of progeny according to Abbott(1925),the previous design was replicated three times for treatment and control.

5. Chemical analysis

Crude protein, by Total soluble protein levels were measured by using BIO-RAD protein assay dye reagent by the method of Bradford (1976). Total carbohydrates were determined by the method described by Singh and Sinha (1977). Total lipids were estimated according to Knight *et al.* (1972).

6. Statistical analysis

Data were analyzed using the SPSS computing program using ANOVA, as described by Snedecor and Cochran (1956). Data on the effect of exposure periods on the tested insects were subjected to probit analysis, as described by Finney (1971). LT_{50} and LT_{95} values were calculated using the computer program developed by Noack and Reichmuth (1978).

RESULTS AND DISCUSSION

1- Biological aspects studies

Fecundity, hatchability percentages, larval weight and pupation percentages of *Plodia interpunctella* reared on almonds, dates and peanuts are shown in Table (1).The fecundity expressed as mean number of eggs per *p. interpunctella* female was affected significantly by the tested hosts. The mean fecundity was 40.1 eggs/female reared on peanut followed descending by almonds which equal 43.5 eggs/female with no significantly differences between the hosts, while, the highest fecundity was 60.9 eggs/female reared on dates. In case of hatchability percentages, there was no significant difference among tested hosts; it was 81.14 ± 2.01, 74.87 ± 3.1 and 74.23% ± 2.63% percentages when reared on almonds, dates and peanuts, respectively. Statistical analysis revealed that there were significantly difference in mature larval weight values, it recorded 30.03, 26.07 and 23.71 mg/per larva reared on almonds, dates and peanuts, respectively. In addition, our results showed that the percentage of pupation were 81.33 ± 1.33, 66.67 ± 3.50 and 45.33 ± 2.43% on almonds, dates and peanuts, respectively.

Table 1. Fecundity, hatchability percantages, larva weight and pupation percentages of *P. interpunctella* reared on different diets.

Diet	No. of eggs per female	Fertility Rate	Hatchability %	Larval weight (mg)	Larval Mortality %	Pupation	Pupal Mortality %
Almonds	$43.5±3.33^{b}$	$36.72±3.20^{ab}$	$81.14±2.01^{a}$	$30.03±0.63^{a}$	$18.67±1.33^{b}$	$81.33±1.33^{a}$	$28.89±4.45^{a}$
Dates	$60.9±4.89^{a}$	$46.70±4.01^{a}$	$74.87±3.15^{a}$	$26.07±0.36^{b}$	$33.33±3.53^{b}$	$66.67±3.50^{a}$	$31.11±2.22^{a}$
Peanuts	$40.1±3.84^{b}$	$31.00±3.43^{b}$	$74.23±2.63^{a}$	$23.71±0.41^{c}$	$54.67±0.42^{a}$	$45.33±2.43^{b}$	$46.67±3.91^{a}$
L.S.D.	13.49	11.91	8.74	1.69	16.65	16.63	16.60

It can be seen from Table (2) that there were significant differences among the incubation period of eggs, larval periods and life cycle of *P. interpunctella* when reared on the different hosts. The shortest egg, larval and pupal stages period belonged to almonds. The egg stage period significantly varied from 3.8 on almonds to 4.7 days on dates and peanuts, with no significant differences between them. The larval stage period significantly exhibited 34.40±0.23 days on almonds, 45.32 ± 0.31 and 49.21±0.22 days on date and peanuts. The complete developmental period from the egg laying to the adult emergence (Life cycle) recorded 54.30±1.70 days on almond, then, significantly increased to 64.70±1.75 and 67.30±2.75 on date and peanut with no significant differences between them, indicating that life cycle of *P. interpunctella* was most rapid on almond compared with the other hosts. In addition, there was no significant difference between dates and peanuts in all developmental parameters.

Table 2. Duration of egg, larva, pupa stages and life cycle of *P. interpunctella* reared on different diets.

Diets	Incubation period(days)	Larval stage (days)	Pupal stage (days)	Life cycle (days)
Almonds	$3.8±0.22^{b}$	$34.40±0.23^{b}$	$6.9±0.23^{a}$	$54.30±1.70^{b}$
Dates	$4.7±0.26^{a}$	45.32±0.31a	$7.6±0.31^{a}$	$64.70±1.75^{a}$
Peanuts	$4.8±0.25^{a}$	$49.21±0.22^{a}$	$7.5±0.22^{a}$	$67.30±2.75^{a}$
L.S.D.	0.82	5.83	0.74	6.15

Results presented in Table (3) show emergence percentages, pre- ovi, post-oviposition in days, longevity (days) and generation duration (days). Data revealed that there is some variation among the tested hosts for percentages of *P. interpunctella* progeny. The least emerged adult percentages was recorded on peanuts, (35.56%), then, increased to record 51.11and 71.11 % on date and almonds with significantly differences between them. No significant differences between pre-oviposition, oviposition and post-oviposition period in all hosts. The results showed significant differences in duration of generation of *P. interpunctella* on almond was 62.80±2.37 days, then, significant increased to 72.24±2.32 and 73.65±3.51 days on dates and peanuts, respectively with no significantly differences between them.

In general the effect of different diets on the biology of *P. interpunctella* was studied by several authors which their results go in harmony with the findings as Cline and Highland (1985), they reported that the mean developmental time and adult progeny production of the Indian meal moth are largely influenced by the type of diet on which the moth feeds during the larval stage. In addition, Phillips and Strand (1994) indicated that oviposition behavior in *P. interpunctella* is influenced by food odor. Perez-Mendoza and Aguilera-Pena (2004) found that *P. interpunctella* females began to oviposit within 12–48 hours after mating with the maximum oviposition rate occurring during the first 24 h after mating. Mohandass *et al.* (2007) stated that fecundity, developmental time and other biological parameters of *P. interpunctella* are extremely variable, depending on the specific food source that was used in a particular research study. Na and Ryoo (2000) indicated that the development of stored product insects is influenced by the physical, chemical and biochemical factors in their diets.

Table 3. Emerged adult, longevity and generation of *plodia interpunctella* reared on on different diets.

Diet	Development from egg laying to adult emergence (days)	Adults emergence %	Pre-oviposition Period(days)	Ovi-position Period (days)	Post-oviposition Period (days)	Longevity (days)	Duration generation (days)
Almonds	54.03±1.71^{b}	71.11±4.45a	0.27±0.02a	2.90±0.28^{a}	5.60±0.37^{a}	9.00±0.37a	62.80±2.37^{b}
Dates	64.40±1.73a	51.11±3.85b	0.30±0.04a	2.80±0.25^{a}	4.74±0.30^{a}	7.80±0.33^{b}	72.24±2.32^{a}
Peanuts	67.10±2.75a	35.56±2.22c	0.20±0.05a	1.80±0.20^{a}	4.55±0.51^{a}	6.60±0.48^{c}	73.65±3.51^{a}

2- Host preference of almond , date and peanut by *p. interpunctella* Larvae

Data obtained in Table (4) indicated that the oviposition preference of *P. interpunctella* on different food hosts. The obtained results indicated that, almond was the most preferred hosts for oviposition period, in which the mean number of eggs laid was 302±10.76 eggs/female followed descendingly by date, it was 272±34.74 eggs/female with significantly differences between them, while, peanut host was the least preferred one for oviposition period 56.67±12.85 eggs/female with significant differences between almond and date. For the mean developmental period from eggs lying until adult emergence on different hosts, the longest period was recorded on date, in which the mean developmental period was 55±1.73 days followed descending insignificant by peanut and almond, it were 51±4.05 and 50±0.58 eggs. Regarding progeny, data revealed that there were highly differences among the hosts. The least progeny was recorded on peanut, it was 3.00±0.58 insects, meanwhile, the greatest of progeny was recorded on almond, it was 10.67±0.67 insects. From these results, it is observed that the lowest value of progeny was occurred on peanuts, indicating that preference of *P. interpunctella* was low on peanut as compared with other hosts. It was insignificant different in weight loss between peanuts and date, almonds recorded the maximum weight loss (33.18%).

Similar results were found by Johnson *et al*., (1992), they recorded that the mean fecundity of 258, 275, and 280/female when the young larvae *P. interpunctella* were reared on walnuts, almonds, and wheat bran, respectively. Scriber and Slansky (1981) revealed that growth, development and reproduction of insects are strongly dependent on the quality and quantity of food ingested. Ayvaz and Karaborklu (2008) reported that the lower protein and carbohydrate contents of wheat bran may reduce egg production and delayed development of *Ephestia kuehniella*. Fecundity of *P. interpunctella* differed greatly from one study to another and is dependent upon several factors, such as type of food, size of the female, provision of drinking water, and physiological state of the female moths Mbata, (1985).Also, the type of commodity or food material greatly influences the time required for *P. interpunctella* to complete the life cycle Johnson *et al.,* (1995).

Table 4. Preference of *plodia interpunctella* adult for almonds, dates and peanut hosts.

Larval diet	Mean egg no. /female	Development period (days)	Progeny	Susceptibility index S.I	Weight loss% of diets
Almonds	302±10.76^{a}	50±0.58^{a}	10.67±0.67^{a}	2.05±0.05^{a}	33.18±3.84^{a}
Date	272±34.74^{b}	55±1.73^{a}	5.67±0.67^{b}	1.37±1.37^{b}	18.06±0.50^{b}
peanuts	56.67±12.85^{c}	51±4.05^{a}	3.00±0.58^{c}	0.85±0.15^{b}	10.54±0.66^{b}
L.S.D.	12.43	8.86	2.22	4.34	7.84

3. The efficacy of microwave powers with different exposure periods against two *P. interpunctella* stages.

Effectiveness of 100,200 and 300 watt microwave powers against egg and the 4th instar larvae of *P. interpunctella* at the different exposure are presented in Table (5). The results revealed that reduction percentages in emerged adult increased gradually by increasing the exposure period to microwave power. The maximum reduction in the adult emergence resulted from treated egg and the 4th instar larvae by 100 watt were 96.30 and 97.46 %, respectively, at 120 sec. At 200 watt it was showed approximately complete reduction in the adult emergence, which being 99.07 and 100% at the same time. Meanwhile caused a complete reduction in adult emergence in larvae at 300 watt after 40 sec, while it was 87.04 % reduction in egg stage after 80 sec. The results noticed that 200 and 300 watt were approximately adequate to killing *P. interpunctella* egg and the 4th instar larvae.

Lethal time of microwave power for the egg and the 4th instar larvae of *P. interpunctella* were given in Table (6). It was obvious that microwave power was more effective in larvae than egg stages .LT_{95} values at 100W, 200W and 300W were 147.38, 121.01and 98.76seconds for eggs and 145.19, 118.74 and23.22 seconds for the larvae.

According to our results, the efficacy of the higher microwave power level was more effective than the lower one. The results are in harmony with the findings of other authors. Al-Azab and Abo-El-Saad (2007) who applied microwave energy against different stages of *E. cautella*. They found that the treated infested date by microwave for 20 seconds caused highly effective to kill all stages of this insect pest. Azizoglu *et al.*(2011) reported that an increase in microwave power and exposure times caused an increase in egg mortality and accordingly the hatched larvae decreased. Baysal *et al.* (1998) found that heating for 90 seconds of sun-dried figs, *Ficus carica* in a 900 W microwave oven at 2450 MHz is sufficient to kill most stages of *Ephestia cautella*. Darwish *et al.* (2014) reported that the mortality of tested *E. cautella* stages increased by increasing the exposure time in each microwave powers. Abdullah Ahmady *et al*., (2016) reported that complete mortality of *Tribolium confusum* adults was obtained at 25 sec in 400 W, whereas 98.8% mortality was obtained the same exposure time for *C. maculatus* adults.

Table 5. Effects of microwave powers on mortality of two stages of *P. interpunctella* after exposing them to various periods.

Microwave Power (w)	Exposure time (sec.)	Reduction rate % Eggs	Reduction rate % 4th instar
100	20	15.74	16.10
	40	24.07	25.42
	60	50	52.54
	80	77.78	79.66
	100	86.11	90.70
	120	96.30	97.46
200	20	24.07	26.27
	40	48.15	48.30
	60	70.37	72.03
	80	88.99	90.68
	100	92.59	98.87
	120	99.07	100
300	2	6.7	25.78
	5	14.81	69.49
	10	22.22	80.51
	20	30.56	94.07
	30	43.52	99.15
	40	66.67	100
	60	74.07	-
	80	87.04	-

Table 6. Lethal time values per second and parameters of mortality regression line for two stages of *P. interpunctella*, exposed to three microwave powers.

Microwave Power (w)	Stage	LT50 (s)	LT95 (s)	Confidence limits LT50 Lower	LT50 Upper	LT95 Lower	LT95 Upper	Slope ± SD	R
100	Egg	47.91	147.38	37.65	60.97	115.8	187.54	3.57±0.28	0.905
	Larvae	46.63	145.19	36.42	62.00	118.7	185.70	3.34±0.06	0.901
200	Egg	36.50	121.01	27.63	48.22	91.61	159.85	3.17±0.31	0.971
	Larvae	35.44	118.74	25.57	45.88	87.10	149.60	3.11±0.06	0.940
300	Egg	25.17	98.76	16.05	39.47	90.56	120.76	1.56±0.10	0.928
	Larvae	3.02	23.22	1.78	5.15	13.66	39.49	1.85±0.97	0.979

4. Determination of certain chemical components of stored fruits under microwave treatment.

As shown in Table 7 stored fruit chemical contents under microwave controlling treatment of *P. interpunctella*, insignificant differences were found in the chemical stored fruit content as total proteins content mg/g f.w., total carbohydrates content mg/g f.w. and total lipids content mg/g f.w.,. Almond chemical contents Which was exposed to the maximum microwave power 300 were 338.00,167.83 and 434.67 mg/g f.w. for total proteins , total Carbohydrates and total lipids contents comparing with their control which were 337.33,186.33 and 456.33 mg/g f.w.also,date fruits chemical contents exposed to the maximum microwave power 300 were 39.73,710.67 and 3.90 mg/g f.w. for total proteins , total Carbohydrates and total Lipids contents comparing with their control which were41.53 ,745.33 and3.90 mg/g f.w. Peanuts fruits chemical contents exposed to the maximum microwave power 300 were 155.33 ,76.40 and 502.00 mg/g f.w. for total proteins , total Carbohydrates and total Lipids contents comparing with their control which were 157.00 ,71.10 and 393.67 mg/g f.w. .

These results proved that, there is no harmful effect on the chemical fruit characteristics under microwave treatment. The findings were supported by Al-Azab and Abo-El-Saad (2007) who reported that date treatment using microwave radiation had no adverse effect on protein content and pattern, using SDS-polyacrylamide electrophoresis and sugar profile as well. Baysal *et al.* (1998) Investigated the effect of microwave energy on physical, microbiological and sensory properties of the. Figs *Ficus carica* .It was found that heating for 90 seconds in a 900 W microwave oven at 2450 MHz is improving textural, sensory and microbiological properties of figs. Darwish *et al.*(2014) reported that microwave powers seemed to have no effect on tested physical characteristics and tested chemical contents of dates treated by microwave at various times under tested MP.

Table 7. Effect of microwave on chemical components of treated stored fruits.

Treatments	Microwave power	T. protein content (mg/g.f.w.) Mean±S.E.	T. Carbohydrates content (mg/g.f.w.) Mean±S.E.	T. Lipids content (mg/g.f.w) Mean±S.E.
Almonds	Control	337.33±13.63[a]	186.33±4.67[a]	456.33±12.27[a]
	300	338.00±8.51[a]	167.83±6.34[a]	434.67±8.96[a]
	L.S.D.	32.85	20.53	29.06
Date	Control	41.53±1.29[a]	745.33±18.29[a]	3.90±0.15[a]
	300	39.73±0.43[a]	710.67±7.89[a]	3.90±0.10[a]
	L.S.D	2.39	45.34	0.322
peanuts	Control	157.00±4.62[a]	71.10±2.71[a]	493.67±10.60[a]
	300	155.33±1.33[a]	76.40±1.70[a]	502.00±5.14[a]
	L.S.D.	8.62	6.54	27.13

REFERENCES

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

Abdullah, A. ; Magdi, A.A.M. and Ahmed, A. Z. (2016): Effect of microwave radiation on *Tribolium confusum* Jaquelin du Val (Coleoptera: Tenebrionidae) and *Callosobruchus maculatus* (F.) (Coleoptera:Chrysomelidae: Bruchidae). J. Entomology and Zoology Studies 4(4): 1257-1263.

Adegoke, G. O.; Falade, K. O. and Babalola ,O. C. (2004): Control of lipid oxidation and fungal spoilage of roasted peanut (Arachis hypogaea) using the spice A framomum danielli. Food. Agric . Env., 2: 128-131.

AL-Azab, A.M. and Abo-El-Saad, M.M. (2007): Acceleration of ALP Hydrolysis to Produce PH3 as Alternative of Methyl Bromide for Controlling *Ephestia cautella* (Walker) (Lepidoptera: Pyralidae). The Fourth Symposium on Date Palm in Saudi Arabia, King Faisal University, Al-Hassa, 5-8 May.

Ayvaz, A. and Karaborklu, S. (2008): Effect of cold storage and different diets on *Ephestia kuehniella* Zeller (Lep:Pyralidae). J. Pest Sci. 81:57–62.

Azizoglu,U.;Yilmaz, S. ; Karaborklu , S. and Ayvaz, A. (2011): Ovicidal activity of microwave and UV radiations on Mediterranean flour moth *Ephestia kuehniella* Zeller, (Lepidoptera: Pyralidae). Türk. entomol. derg., 35: 437-446.

Baysal, T.; Ural, A.; Cakr, M. and Ozen, C. N. (1998): Microwave application for the control of dried fig moth. Acta Horticulture. 480, 215-219.

Brader, B; Lee, R. ; Plarre, R. ; Burkholder, W. ; Kitto, G.B. ; Kao, C. H .; Polston, L. ; Dorneanu, E. ; Szabo, J. ; Mead, B. ; Rouse, B. ; Sullins, D. & Denning, R. (2002): A comparison of screening methods for insect contamination in wheat. J. Stord. Prod. Res. Vol. 38, 75-86.

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

Ciepielewska, D. & Kordan B. (2001): Natural peptide substances as a factor reducing the incidence of storage pests-short report. Polish Journal of Food and Nutrition Sciences. Vol. 3, No.3, 47-50, ISSN 1230-0322.

Cline, L.D. and Highland, H.A., (1985): Survival, reproduction, and development of seven species of stored-product insects on the various food components of lightweight, high-density, prototype military rations. Journal of Economic Entomology 78, 779–782.

Cox, P.D. and Bell, C.H. (1991): Biology and ecology of moth pests of stored food. In: Gorham, J.R. (Ed.), Ecology and Management of Food-Industry Pests. FDA Technical Bulletin 4, Association of Official Analytical Chemistry, Arlington, VA, pp. 181–193.

Darwish, A. A. ; El-Lakwah, F.A.M. ; El-Hosary, Rasha A. ; EL-Banna , A. A. and El-Shafei, W.K.M. (2014) :Effect of microwave on *Ephestia cautella* (Walker) (Lepidoptera: Pyralidae) as alternative to methyl bromide. Biol. Chem. Environ. Sci., 2014, 9(4), 247-263.

Ferial, EL-Sayed, M. A.; Ali, M. A. M. and EL-Beshilawy, H. M. I. (2005): Effect of storage and controlled temperatures on infestation potenial, food consumption, damage and weight loss of cowpea and faba been seeds infested with *Callosobruchus maculatus* (F.). Egypt. J. Agric. Res., 83 (2): 609-625.

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

Graham, D. (1997) : Use of ozone for food processing. Food Technology, 51: 72-73.

Haff, R.P. and Slaughter, D.C. (2004): Real- time X-ray inspection of wheat for infestation by the granary weevil, *Sitophilus granarius* (L.).Transactions of the ASAE47, 531-537.

Howe, R.W. (1971): A parameter for expressing the survival of an environment for insect development. J. Stored Prod. Res. 7, 63–64.

Johnson, J.A. ; Wofford, P.L. and Gill, R.F., (1995): Developmental thresholds and degree-day accumulations of Indian meal moth (Lepidoptera: Pyralidae) on dried fruits and nuts. Journal of Economic Entomology 88, 734–742.

Johnson, J.A., Wofford, P.L. and Whitehand, L.C. (1992): Effect of diet and temperature on development rates, survival, and reproduction of the Indian meal moth (Lepidoptera: Pyralidae). Journal of Economic Entomology 85, 561–566.

Knight, J. A.; Anderson, S. and Rawle, J. M.(1972): Chemical basis of the sulfophospho-vanillin reaction for estimating total serum lipids. Clin. Chem. 18: 199-202.

LeCato, G.L. (1976) : Yield, development, and weight of *Cadra cautella* (Walker) and *Plodia interpunctella* (H.ubner) on twenty-one diets derived from natural products. Journal of Stored Products Research 12, 43–47.

Lorini, I. ;Collins, P.J. ; Daglish, G.J.; Nayak, M.K. and Pavic, H. (2007) : Detection and characterization of strong resistance to phosphine in Brazilian *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae).. Pest. Manag. Sci. 63:358-364.

Madrid, F.J. and Sinha, R.N., (1982): Feeding damage of three stored-product moths (Lepidoptera: Pyralidae) on wheat. J. Economic Entomology 75, 1017–1020.

Mbata, G.N., (1985): Some physical and biological factors affecting oviposition by *Plodia interpunctella* (Hubner) (Lepidoptera: Phycitidae).Insect Science and its Application 6, 597–604.

Mbata, G.N., (1987): Studies on the susceptibility of groundnut varieties to infestation by *Plodia interpunctella* (Hubner) (Lepidoptera: Pyralidae). J. Stored Prod. Res. 23, 57–63.

Mbata, G.N., (1990): Suitability of maize varieties for the oviposition and development of *Plodia interpunctella* (Hubner) (Lepidoptera: Pyralidae). Tropical Pest Management 36, 122–127.

Ministry of Agriculture and Land Reclamation (2015): Economic Affairs Sector. Head of the Sector, Giza, Egypt.

Mohandass, S. ; Arthur, F.H. ; Zhu, K.Y. and Throne, J.E. (2007) Biology and management of *Plodia interpunctella* (Lepidoptera: Pyralidae) in stored products. J. Stored Prod. Res. 43, 302–311.

Na, J. H. and Ryoo, M. I. (2000) : The influence of temperature on development of *Plodia interpunctella* (Lepidoptera: Pyralidae) on dried vegetable commodities. J. Stored Prod. Res. 36(2): 125–129.

Nijhuis, H.H. ; Torringa, H.M. ; Muresan, S. ; Yuksel, D. ; Leguijt, C. and Kloek, W. (1998): Approaches to improving the quality of dried fruit and vegetables. Trends in Food Scence and .Technology. Vol. 9, 13-20.

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.

Novotny, M.; Jan, S. ; Karel, S. and Vladimir, T. (2013) : Sterilization of biotic pests by microwave radiation. Procedia Engineering.; 57:1094-1099.

Perez-Mendoza and Aguilera-Pena, M. (2004) : Development, reproduction, and control of the Indian meal moth, *Plodia interpunctella* (H.ubner) (Lepidoptera: Pyralidae), in stored seed garlic in Mexico. J. Stored Prod. Res. 40, 409–421.

Phillips, T.W. and Strand, M.R., (1994): Larval secretions and food odors affect orientation in female *Plodia interpunctella*. Entomologia Experimentalis et Applicata 71, 185–192.

Scriber, J. M. and Slansky, J. R. F. (1981). The nutritional ecology of immature insects. Annual review of entomology, 26(1), 183-211.

Singh, N. B. and Sinha, R. N. (1977) : Carbohydrates, lipids and protein in the developmental stages of *Sitophillus oryzea* and *Sitophillus granarius*. Ann. Entomol. Soc. Am. 107-111.

Snedecor, G.W. and Cochran, W.G. (1956) : Statistical methods applied to experiments in agriculture and biology. 5th ed. Ames, Iowa: Iowa State University Press.

Suhajda, K.(2006): Rehabilitation of moist masonry structures-Use of rod antenna during microwave pre-drying of injection holes. PhD Thesis. Thesis. Brno.

Sumnu, G. (2001) : A review on microwave baking of foods. International Journal of Food Science and Technology. Vol . 36 , 117 – 127 .

بيولوجى ومكافحة فراشة الدقيق الهندية التي تصيب ثمار البلح ، اللوز و الفول السوداني المخزونة

وائل كمال محمد الشافعى[1] ، رشا أحمد زينهم[2] و حسن بكرى حسن حسين[2]
[1]المعمل المركزى للنخيل - مركز البحوث الزراعية - جيزة - مصر
[2]معهد بحوث وقاية النباتات - مركز البحوث الزراعية-الدقى - جيزة - مصر

أجريت هذة الدراسة بهدف تقييم تأثير تربية فراشة جريش الذرة الهندية على ثلاثة أنواع مختلفة من التغذية على النظم البيولوجية لها . واستخدم ثلاثة أنواع مختلفة لتغذية الحشرة شملت البلح ، اللوز ، الفول السودانى . وقد اوضحت النتائج ان النسبة المئوية للفقس ، وزن اليرقات ، النسبة المئوية لخروج الفراشات كانت أعلى والفترة اللازمة لنمو الجنين ، فترة الجيل ، دورة الحياة كانت أقصر فى حالة اللوز ، وأيضا وجد ان أفضل أنواع التغذية المفضلة للفراشة هو اللوز ، كما تم التحقق من مدى فعالية استخدام ثلاث قوى مختلفة من الميكرويف فى مكافحة طورى البيض واليرقات ، وأوضحت النتائج أن كل من نسبة الخفض و نسبة الموت لطورى الحشرة تزيد بزيادة زمن التعريض وقوى الميكروويف أكثر كفاءة فى مكافحة اليرقات ، ووجد انه لايوجد تأثير ضار على النظم الكيميائية للأغذية الثلاث المختبرة تحت المعاملة بالميكرويف .