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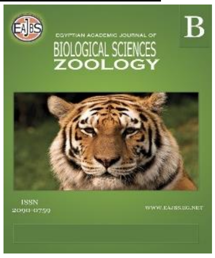

Effect of Microwave Energy on Some Stored Product Mites

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ABSTRACT

Efficacy of microwave energy against larva, protonymph and adult stages of three stored-product mite species: *Acarus siro* L., *Caloglyphus berlesei* (Michael) and *Carpoglyphus lactis* (L.). The results indicated that the mortality increased gradually when exposure time and power increased. The mortality rate for all stages of mites in the untreated treatment is zero. The mortality in *C. lactis* was higher than in other mite species. The mortality experiments were conducted with an exposure time ranging from 120–300 sec. at the powers of 180, 300 and 450 W. *Acarus siro*, *C. berlesei* and *C. lactis* larvae died at a higher rate than protonymph and adults. The protonymph died at a higher rate than adults when exposed to the same microwave energy. Mortality percent for larvae of *A. siro* was 94% using microwave energy at 180 W for 300 sec. The mortality of *A. siro* adults was 94% at 450W for 120 sec., and the mortality of *C. berlesei* adults was 82% at 450W for 240 sec. While the mortality of *C. lactis* larvae was 96% at 450W for 120 sec. These results indicated that the exposure time is more effect on acarid mites than power energy.

INTRODUCTION

Infestation with acarid mites is a well-known problem in stored grains, often influencing the quality and hygienic condition of the grains. The flour mite, *Acarus siro* L., *Caloglyphus berlesei* (Michael) and the dried fruit mite, *Carpoglyphus lactis* (L.) are the most common mites found in stored products, with high reproductive potential and a short life cycle (Hughes, 1976). Large numbers of these mites in stored food and its derivatives not only cause direct economic losses by reducing nutrient content but also cause indirect economic losses by reducing nutrient content in stored products (Boczek, 1991; Krantz, 1955). It can contaminate stored foods with toxicogenic microorganisms' mycotoxins, causing serious health problems (Hubert *et al.*, 2003). Physical and chemical methods are used to control storage mites, the main issue with chemical methods is the remaining residues in the food, posing a health and environmental risk to consumers. As a result, modern control methods with minimal side effects are required.

Thus, the microwave appears to have a potential role as an alternative method of killing pests in cereals and other products that have been stored for a long time. Microwaves are electromagnetic waves with 300–3000 MHZ (Decareau, 1985).

Microwave heating works by converting electromagnetic field energy into thermal energy through the interaction of polar molecules in a substance like water (Das *et al.,* 2013). Friction is created by the rapid movement of these molecules, which results in heat generation in the material. The heat generated within the materials irradiated by the microwave energy source could account for part of the lethal effect, as could direct microwave absorption (Shayesteh and Barthakur, 1996). The amount of energy absorbed by a medium in a microwave field is determined by its physical and dielectric properties, as well as the MW energy source's power output and frequency (Watters, 1975). Living things can be harmed by microwave radiation in a variety of ways (Ondracek *et al.,* 1976). Nelson (1996) found microwave radiation has the ability to suppress all stages of storage pests' development as well as diminish the reproduction rates of surviving pests. Vadivambal *et al.* (2006) showed that microwave radiation is appealing in pest management approaches for storage pests.

Microwave insect disinfestation of cereals and cereal products has been studied extensively by several authors, e.g., (Hamid *et al.,* 1968; Wilkin and Nelson, 1987; Vadivambal *et al.,* 2010; El Zun *et al.,* 2011; Barbosa *et al.,* 2017. Therefore, the aim of this work is to determine the effectiveness of microwave energy for controlling some stored-product mite pests.

MATERIALS AND METHODS

Mites Mass Rearing:

Acarus siro, *Caloglyphus berlesei* and *Carpoglyphus lactis* cultures were started using old contaminated wheat bran samples. Identification of mites was carried out according to (Hughes, 1976). The three mite pests were mass-reared on a mixture of dry baker's yeast and flour with a ratio of (3:1) in top-vented plastic cages (9 cm in diameter and 3 cm height) at 25±1˚C and 80±5%R.H. in dark condition. The tested mites were reared and identified in the laboratories of Plant Protection Research Institute, Agriculture Research Centre, Dokki, Giza, Egypt.

Microwave Energy:

The microwave frequency used in the experiment is 2450 MHz. Microwave oven; Electra, Japan, model EM-280 M, capacity 28L, the cavity dimensions (21.9 X 35 X 35 mm) was used. The oven had three energy settings (low, medium-low, and medium) with respectively 17, 44, and 66% power output (output: 800W).

Larva, Protonymph and Adult Treatments:

Approximately 500 individuals each of larvae, nymphs and adults of each of the three species, *A. siro, C. berlesei* and *C. lactis,* were introduced into glass jars containing 250 g of wheat bran (each about 500 ml). The top vented glass jar with a muslin cloth for ventilation. Each treatment included 5 replicates (50 g/replication).

The glass jars were set in the oven on plate rotation. The experiments were conducted with exposure times at 120, 180, 240 and 300 sec. at the powers of 180, 300 and 450 W for each stage and each species. An untreated group (control) of 500 mites (adults, protonymph, or larvae) was obtained at room temperature, away from the influence of microwaves. Each developmental stage of larvae, protonymphs and adults was replicated five times. A Tullgren funnel was used to separate the mites of each treatment, which was then stored for 24 h under 40 W electric lights. The mites were collected in Petri-dish, surrounded with Vaseline to prevent the mites from escaping and the mites were counted.

Data Analysis:

The mortality reduction of stages in treatment was calculated as the following formula:

$$\text{Mortality\%} = \frac{\text{No. of individuals in control} - \text{No. of individuals in treatment}}{\text{No. of individuals in control}} \times 100$$

Simple correlations and partial regression were used for the effect of microwave energy at various exposure times and power levels, which could be attributed to the percentages of explained variance (EV%) as the combined effect of time and power. Obtained data were analyzed using Procs Corr, Reg, and ANOVA in SAS (Anonymous 2003).

RESULTS AND DISCUSSION

Mortality in *Acarus siro:*

As exposure time or power settings increase, mortality increase for all stages compared with no mortality detection in the untreatment. The lowest mortality percentage of adult, protonymphal and larval stages respectively was 22, 34 and 42% using microwave energy at a power level of 180 W for 120 sec. The highest mortality of adult, protonymphal and larval stages was 100% obtained at 300 W for 300 sec. while mortality reached 100% at 450 W for 180, 240 and 300 sec for adult, protonymphal and larval stages (Table 1).

Table 1: Mortality percentage of adult, protonymph and larva of *Acarus siro* infesting crushed wheat exposed to microwave irradiation at various exposure times and power levels.

Power (W)	Exposure time (sec)	Mortality percentage (%)		
		Adult	Protonymph	Larva
180	120	22	34	42
	180	46	48	50
	240	70	76	86
	300	92	92	94
300	120	40	52	54
	180	56	66	74
	240	88	90	100
	300	100	100	100
450	120	94	98	100
	180	100	100	100
	240	100	100	100
	300	100	100	100

Mortality in *Caloglyphus berlesei*

The mortality of *C. berlesei* adults was 10% using microwave energy at a power level of 180W for 120 sec, the mortality increased to 100% with 450W for 300 sec. On the other hand, the lowest protonymph mortality was 16% at 300 W for 120 sec., while the highest mortality was 100% at 450W for 300 sec. The mortality of the larval stage was 30% at 180 W for 120 sec., then increased to 100% at 300W for 300 sec. and at 450W for 240 and 300 sec. In comparison with the untreated group, mortalities for all stages were zero (Table 2).

Table 2: Mortality percentage of adult, protonymph and larva of *Caloglyphus berlesei* infesting crushed wheat exposed to microwave irradiation at various exposure times and power levels.

Power (W)	Exposure time (sec)	Mortality percentage (%)		
		Adult	Protonymph	Larva
180	120	10	16	30
	180	28	40	52
	240	38	56	72
	300	64	82	92
300	120	16	24	34
	180	40	48	58
	240	80	84	90
	300	96	98	100
450	120	20	32	44
	180	52	80	88
	240	82	94	100
	300	100	100	100

Mortality in *Carpoglyphus lactis*:

The mortality increased with an increase in exposure time or power for larva, protonymph and adult of *C. lactis*. The adults seemed to be the most resistant to the other stages. The lowest mortality percentage for adult, protonymphal and larval stages were respectively 24, 32 and 40% at 180 W for 120 sec. The highest mortality for adults and protonymph was 100% at 300W for 300 sec. and at 450W for 180, 240 and 300 sec., while that of the larval stage was 100% at 450 W for 120, 180, 240 and 300 sec. In comparison to the untreated group, the mortalities for all stages were zero (Table 3).

Table 3: Mortality percentage of adult, protonymph and larva of *Carpoglyphus lactis* infesting crushed wheat exposed to microwave irradiation at various exposure times and power levels.

Power (W)	Exposure time (sec)	Mortality percentage (%)		
		Adult	Protonymph	Larva
180	120	24	32	40
	180	44	50	52
	240	68	78	88
	300	88	94	96
300	120	46	54	62
	180	70	78	84
	240	92	92	100
	300	100	100	100
450	120	96	98	100
	180	100	100	100
	240	100	100	100
	300	100	100	100

Effect of Microwave Energy at Various Exposure Times and Power Levels on Acarid Mites:

Significant positive correlation values were observed for adult, protonymph and larva of *A. siro* at an exposure time and power level ranging from 0.60 to 0.66 with P-values between 0.0357 and 0.0188; Similar results were obtained for *C. berlesei*, which has significant positive correlation values for exposure time ranged from 0.88 to 0.89; and insignificant positive correlation for power energy. For *C. lactis*, which has significant positive correlation values for exposure time ranged and power energy from 0.60 to 0.68 (Table 4). The current result indicated that exposure time is more effective on acarid mites than power energy.

The explained variance (EV%) was respectively 81.89, 81.34 and 75.09% on adult, protonymph and larva of *A. siro*. The combined effect of exposure time and power energy on adult, protonymph and larva of *C. berlesei* was respectively 92.46, 93.58 and 91.63%. While that for *C. lactis* was respectively 83.45, 79.81 and 73.29% which is less than that found for *C. berlesei* (Table 4).

Table 4: Simple correlation coefficients and multiple regression values for the effect of microwave energy at various exposure times and power levels on *Acarus siro*, *Caloglyphus berlesei* and *Carpoglyphus lactis* infesting crushed wheat.

Species	Stage	Factor	Simple correlation		Multiple regression				
			r	p	b	P	F	P	E.V.%
A. siro	Adult	Time	0.64	0.0230	0.25	0.0014	20.35	0.0005	81.89
		Power	0.63	0.0272	0.15	0.0016			
	Nymph	Time	0.61	0.0346	0.20	0.0022	19.62	0.0005	81.34
		Power	0.66	0.0188	0.13	0.0013			
	Larvae	Time	0.61	0.0327	0.19	0.0049	13.56	0.0019	75.09
		Power	0.60	0.0357	0.11	0.0052			
C. berlesei	Adult	Time	0.88	0.0001	0.40	0.0001	55.18	0.0001	92.46
		Power	0.37	0.2315	0.10	0.0027			
	Nymph	Time	0.88	0.0001	0.38	0.0001	65.55	0.0001	93.58
		Power	0.39	0.2083	0.10	0.0012			
	Larvae	Time	0.89	0.0001	0.34	0.0001	49.28	0.0001	91.63
		Power	0.34	0.2750	0.07	0.0061			
C. lactis	Adult	Time	0.60	0.0384	0.22	0.0016	22.70	0.0003	83.45
		Power	0.68	0.0135	0.15	0.0007			
	Nymph	Time	0.61	0.0339	0.20	0.0027	17.79	0.0007	79.81
		Power	0.64	0.0223	0.13	0.0019			
	Larvae	Time	0.60	0.0382	0.18	0.0068	12.35	0.0026	73.29
		Power	0.60	0.0358	0.11	0.0064			

The obtained results are in agreement with those of Bakr (2010) who found larvae of Astigmata are often more sensitive than adults when exposed to the same dose of several control protocols. Also, the same author (2017) found *Tyrophagus putrescentiae* (Schrank) adults are more tolerant of the heating effects of MW energy than larvae when exposed to the same time and power of MW energy radiation. Karabulut and Baykal (2002) and Vadivambal *et al.* (2010) used microwave radiation as extensively an alternative approach to insecticides in numerous studies. Ernieenor and Ho (2010) found that exposing *Dermatophagoides pteronyssinus* (Trouessar) and *D. farina* Hughes adults to 2450 MHZ microwave radiation at high and medium power settings for 300 sec. resulted in virtually 100% death**.**

Conclusion

The results indicated that the mortality increased gradually when exposure time and power were increased. The exposure time is more effect on acarid mites than power energy. The adults of three mites *A. siro*, *C. berlesei* and *C. lactis* are more tolerant of the heating effects of Microwave energy than protonymph and larvae stages when exposed to the same time and power energy. As a result, the mites may be killed by microwave energy without having an impact on the product's final quality attributes. Microwave energy has the benefit of being applicable to packaged goods.

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ARABIC SUMMARY

تأثير طاقة الميكروويف على بعض أكاروسات المنتجات المخزنة

إيمان لطفي عياد، علا محمد رشدي، حسنية عيد الفتاح عفيفي
معهد بحوث وقاية النباتات- مركز البحوث الزراعية – الدقي- جيزة

تمت دراسة فعالية طاقة الميكروويف علي اليرقات والحوريات والطور الكامل لثلاثة أنواع من اكاروسات المواد المخزونة: أكاروس الدقيق و *Caloglyphus berlesei* و أكاروس الفاكهة المجففه. أشارت النتائج إلى أن معدل الوفيات يزداد تدريجياً مع زيادة وقت التعرض والطاقة. معدل الوفيات لجميع مراحل الاكاروس الكنترول هو صفر. كان معدل الموت في أكاروس الفاكهة المجففه أعلى من الأنواع الأخرى من الحلم.