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Orijinal araştırma (Original article)

Ovicidal activity of microwave and UV radiations on mediterranean flour moth *Ephestia kuehniella* Zeller, 1879 (Lepidoptera: Pyralidae)[1]

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Summary

Insecticidal activity of microwave and ultraviolet radiation (UV) on *E. kuehniella*, 1879 (Lepidoptera: Pyralidae) eggs were investigated. Eggs (≤24 h) were exposed to microwave and UV radiation at different time periods. Microwave radiation was applied at the powers of 150, 360, 430, and 600 W for different exposure times (10-300 s). It was evident that increasing power and exposure times caused increasing mortality on the eggs and accordingly larval emergence decreased. Complete mortality was achieved at the power of 150 W and the longest exposure time (300 s). The same result was achieved at the highest dose (600 W) and the shortest exposure time (10s). When the eggs were treated with the highest power of microwave radiation used, the lethal times were estimated as, 2.61 (LT_{50}) and 7.34 s (LT_{99}). Similarly short (254 nm) and long-wave UV (365 nm) radiations also decreased the larval emergence from *E. kuehniella* eggs depending on increasing time periods. The highest period of UV treatment (300 s) caused 92.20% and 28.89% egg mortality at 254 and 365 nm, respectively. The lethal times, LT_{50} and LT_{99} for short wave UV radiation were estimated to be 155.68 and 418.068 s, respectively.

Key words: Microwave radiation**,** UV radiation, mortality, lethal time

Anahtar sözcükler: Mikrodalga radyasyonu, UV radyasyonu, ölüm oranı, letal zaman

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Introduction

Cereal grains are the major source of food for humans and include rich vitamins, minerals, carbohydrates, fats, oils, and proteins. It is essential that the availability of cereal grains is consolidated by the development of effective storage practices to minimize losses in stores (Schöller et al., 1997). Stored product pests cause serious losses both in quantity and quality of crops.

Mediterranean flour moth, *Ephestia kuehniella* Zeller, 1879 (Lepidoptera: Pyralidae) is one of the most important stored product pest in flour mills and storehouses, and cause serious economic losses. Moth larvae produce webbing, which blocks machinery and pipes; presence of larvae and webbing in the end product is unacceptable to consumers (Hansen & Jensen, 2002). Generally, control of stored product pests is provided with insecticides such as malathion, chlorpyrifos-methyl, phosphine, and methyl bromide (Arthur, 1996). Chemical insecticides have showed numerous environmental problems such as depletion of atmospheric ozone (Hansen & Jensen, 2002; Fields & White, 2002), development of resistance in insects (Sinha & Watters, 1985), mammalian toxicity, disruption of the food chain, proliferation of more harmful insects and sensitive species (Regnault-Roger, 1997). Consequently environmental concerns led to the development of alternative control tactics (Ayvaz & Karabörklü, 2008). Among the alternative control tactics, radiation technique is one of the most promising methods. Much research has been conducted into the use of radiation to control stored-product pests (Brower, 1975; Brower & Tilton, 1985; Sharma & Dwidedi, 1997; Faruki et al., 2005; Ayvaz & Tuncbilek, 2006; Ayvaz et al., 2007, 2008; Azizoglu et al., 2010). The advantages of irradiation as a pest control measure include the absence of undesirable residues in the foods treated, no resistance development by pest insects and few significant changes in the physicochemical properties or the nutritive value of the treated products (Lapidot, 1991; Ahmed, 2001; Zhao et al., 2007).

Microwave and ultraviolet (UV) radiations are non-ionizing radiations and they show numerous effects on insects. Microwave radiation, with good penetrability, can kill pests existing inside or outside grain kernels (Halverson et al., 1999). Much research has been conducted into the use of microwave radiation to control stored-product pests (Warchalewski et al., 2000; Çetinkaya et al., 2006; Vadivambal et al., 2008; Valizadegan et al., 2009; Lu et al., 2010). The UV radiation is effectively used as insecf attractant and germicide, and in surface disinfection studies of insect eggs (Buce, 1975; Guerra et al., 1968; Faruki et al., 2007). A number of studies were conducted to determine the effectiveness of UV radiation on stored product pests (Calderon & Navarro, 1971; Calderon et al., 1985; Faruki & Khan, 1993; Sharma & Dwivedi, 1997; Faruki, 2005; Faruki et al., 2005, 2007).The aim of the study is to develop an alternative and safer pest control tactic to reduce the use of environmentally hazardous chemical pesticides. In the current study the ovicidal efficacy of microwave and UV radiations was tested to control an important stored product pest, *E. kuehniella* Zeller.

Material and Methods

Insect culture

Ephestia kuehniella larvae were reared on a mixture of wheat flour, wheat bran and glycerol. Insect culture was maintained at constant temperature (27±1ºC), 14L: 10D photoperiod and 60±5% relative humidity (r.h.) (Ayvaz et al., 2009, 2010).

Microwave and UV radiation treatments

Adults emerged from culture medium were placed into glass jars (1 L) and their eggs were collected in a day. Thirty eggs were glued to paper cards (1,5x4 cm) and transferred to Petri plates. The eggs were exposed to microwave radiation at the power of 150-600 W for time periods ranging from 10 to 300 s (2450MHz, 900W, Vestel MD 23). In order to test the effect of short/long wave UV radiation the same exposure periods were applied (Mineralight Lamp, 254/365 nm, 215–250 V, 56/60 Hz, 0.12 A). All treatments were replicated tree times for each radiation source.

Statistical analysis

Data from the experiments were subjected to analysis of variance (ANOVA) using SPSS (2001) for Windows. Percentage data were transformed using arcsine √x before ANOVA (Steel & Torrie, 1980). Means were separated at the 5% significance level by the least significant difference (LSD) test. The data were subjected to probit analysis using the same statistical program to estimate LT_{50} and LT_{99} values of the microwave and UV radiations against *E. kuehniella*.

Results

E. kuehniella eggs were exposed to microwave radiation at the power of 150-600 W for time periods ranging from 10 to 300s, and embryonic development was observed. It was seen that depending on the increasing doses and time periods, development was negatively affected and mortality was increased. Depending on the increasing exposure period, mortality rate significantly increased at the power of 150 W (F= 27.55; df= 7; P ≤ 0.0001). It was seen that 50% of the eggs were killed at 150 W after 120s treatment, and when the exposure time increased to 180s, the mortality rate was observed to be 97.78% at the same power. To obtain complete mortality 300s exposure time was needed (Fig. 1).

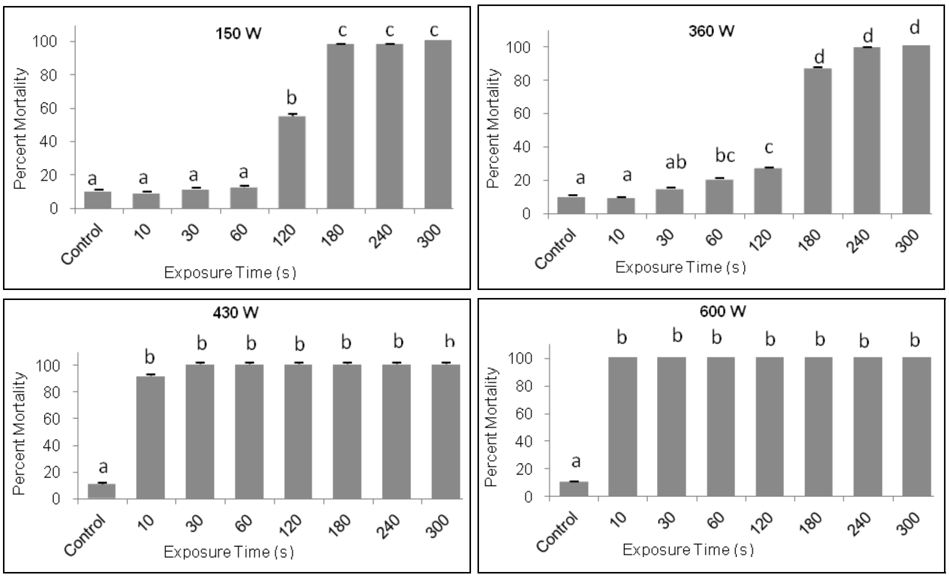

Figure 1. Effect of microwave radiation on *Ephestia kuehniella* (Zeller, 1879) eggs.

Significant egg mortality was also obtained at 360 W depending on the increasing exposure periods (F= 60.21; df= 7; P ≤ 0.0001). Complete mortality was also obtained at the longest exposure time for this radiation dose. *E. kuehniella* eggs showed similar response to microwave radiations at the powers of 150 and 360 W after 180 s and above treatments (Fig. 1).

Drastic mortality rate (91.11%) was found after 10 s exposure at the power of 430 W, and longer exposure periods caused complete mortality at the same power (F= 75.99; df = 7; P ≤ 0.0001). A 10 s exposure time was enough to kill the eggs completely at a power of 600 W (F= 80.02; df = 7; P ≤ 0.0001).

Exposure to 254 and 365 nm UV radiation accelerated the egg mortality depending on increasing exposure periods (10-300 s) (For 254 nm, F= 97.94; df= 7; P ≤ 0.0001 and for 365 nm, F= 3.18; df= 7; P ≤ 0.026) (Fig. 2). Exposure time dependent increases in mortality rates of *E. kuehniella* eggs were evident after short-wave (254 nm) UV radiation, for example 6.67 % mortality rates at the untreated eggs (control) reached to 92.22 % after 300 s exposure. On the other hand mortality rates of the eggs at long-wave UV source did not change significantly up to the 180s exposure. Only 28.89 % mortality was obtained at the longest exposure period with this long-wave UV source (Fig. 2).

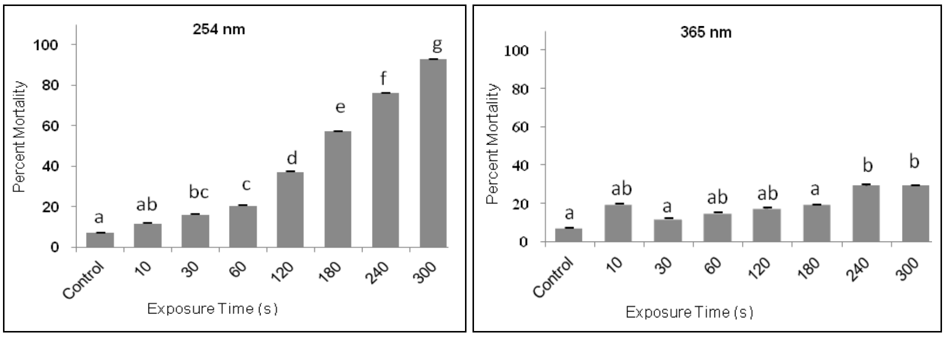

Figure 2. Effect of UV radiation on *Ephestia kuehniella* (Zeller, 1879) eggs.

The time periods required to kill 50 and 99% of the population depending on the microwave radiation doses were calculated and summarized in Table 1. Although the LT_{50} value of microwave radiation at the power of 150W was found to be 103.34s, this lethal time (LT_{50}) decreased to 2.61s at the highest power (600W) tested. To kill the population completely 7.34s was enough at the power of 600W.

LT_{50} and LT_{99} values for long wave UV radiation were 531.36 and 1557.175, respectively. For the short wave UV radiation these values were estimated fairly lower than that of long-wave UV radiation (155.68 s for LT_{50} and 418.068 s for LT_{99}) (Table 1.).

Table 1. LT_{50} and LT_{99} values after exposure to different radiation sources

Microwave Radiation					
Power	LT_{50} (s)	LT_{99} (s)	Chi-Square	DF	P
150 W	103.34	245.97	226.917	22	0.0001
360 W	118.99	288.78	160.662	22	0.0001
430 W	4.87	13.72	23.686	22	0.364
600 W	2.61	7.34	17.420	22	0.740
UV source	UV radiation				
254 nm	155.68	418.068	90.631	22	0.0000
365 nm	531.36	1557.17	24.837	22	0.305

Discussion

It was seen that depending on the increasing dose and duration of the radiation, embryonic development of *E. kuehniella* eggs were negatively affected and consequently mortality was increased. Similarly Vadivambal et al. (2008) reported that when *Tribolium castaneum* (Herbst) 1797 (Coleoptera: Tenebrionidae) eggs (0-48h old) and other stages were exposed to varying microwave radiation at different time periods mortality rates increased significantly. We observed that complete mortality was achieved at a power of

150 and 360 W after 300 s exposure. It was also seen that 30 s or more exposure killed all the eggs at a power of 430 W. Likewise complete mortality was reported by Vadivambal et al. (2008) for *T. castaneum* eggs after exposure to 28 s microwave radiation (400 W).

Several studies showed that egg stages of insects were more susceptible to radiation when compared to other stages (Tilton & Brower, 1983; Shayesteh & Barthakur, 1996; Watters, 1976; Zhao et al., 2007). It was asserted that the effect of radiation on insects is related with cell components. Embryonic cells divide and grow more rapidly than other cells at later stages, and this makes them more susceptible to damage from radiation treatment. Susceptibility of embryonic cells was also reported by Ahmed (2001). Ghanem & Sharma (2007) reported that UV radiation damages the egg chorion and eventually cause to leakage of egg fluid. It was also reported that physiological processes of insects are negatively affected by microwave radiation (Webber et al., 1980). Microwave radiation causes DNA damage in the cell as other radiation resources (Lu et al., 2010). It was seen that LT_{50} and LT_{99} values gradually decreased while the doses of microwave radiation increased. LT_{50} and LT_{99} values at the highest power of (600 W) microwave radiation were 2.61 and 7.34s, respectively.

It was clear that both in microwave and UV radiations, increasing exposure time caused significant increase in the mortality rate of *E. kuehniella* eggs. Guerra et al. (1968) exposed the *Heliothis virescens* (Fabricius), 1777 and *Heliothis zea* (Boddie), 1850 (Lepidoptera: Noctuidae) eggs (18-24h old) to 254nm (2537A°) short-wave UV radiation and showed that increasing treatment time increased the mortality rate significantly. The similar results were obtained from the eggs (24-72 h old) of *T. castaneum* (Herbst),*Tribolium confusum* Jacquelin du Val, 1863 (Coleoptera: Tenebrionidae) and *Cadra cautella* (Walker), 1863 (Lepidoptera: Pyralidae) when they are exposed to short-wave UV radiation (Faruki et al., 2007). Our results showed that the mortality effect of short-wave UV treatment were more impressive (more than threefold) than that of long wave UV treatment. When the wavelengths of UV were shortened, lethal effect on insects increased significantly (Cohen et al., 1975; Beard, 1972).

Our results showed that the mortality rate of eggs exposed to short wave of UV radiation for 300s were 92.22 %. However, eggs of some other stored product pests were reported to be more resistant at the higher exposure period and percentage of larval mortality of *T. castaneum*, *T. confusum* and *C. cautella* eggs (24 h old) were reported as 25.53, 67.97 and 38.52 % at the 480s exposure time, respectively (Faruki et al., 2007). It was seen that the lethal time (LT_{50} and LT_{99}) were lower at short-wave UV radiation compared to long-wave.

This study showed that microwave and UV radiations (short-wave) have high insecticidal activity on *E. kuehniella* eggs. So microwave and UV radiations may be promising control strategies as an alternative to chemical control. It is also important for developing a more reliable and healthy method for controlling stored product pests.

Özet

Mikrodalga ve UV radyasyonlarının Akdeniz un güvesi *Ephestia kuehniella* Zeller, 1879 (Lepidoptera: Pyralidae) üzerindeki ovisidal aktivitesi

Bu çalışmada mikrodalga ve ultraviyole (UV) radyasyonlarının *Ephestia kuehniella* Zeller, 1879 yumurtaları üzerindeki öldürücü etkisi araştırılmıştır. Yumurtalar (<24 h) farklı sürelerde mikrodalga ve UV radyasyonuna maruz bırakılmıştır. Mikrodalga radyasyonu 150, 360, 430 ve 600 W güçte, 10-300 s arasında değişen sürelerde uygulanmıştır. Güç ve zaman artışına bağlı olarak yumurta ölümü belirgin bir şekilde artmış ve buna bağlı olarak larva çıkışında da azalma gözlenmiştir. Yumurtalar 150 W güçteki mikrodalga kaynağına 300 s süreyle maruz bırakıldığında %100 oranında ölüm gözlenmiştir. Aynı ölüm oranı uygulanan en yüksek güce (600 W) sahip kaynak ile 10s'de elde edilmiştir. Yumurtalar 600 W'lık kaynağa maruz bırakıldığında LT_{50} ve LT_{99} değerleri sırasıyla 2.61 ve 7.34 s olarak bulunmuştur. Benzer şekilde kısa dalga (254 nm) ve uzun dalga (365 nm) UV radyasyonları da artan uygulama süresine bağlı olarak *E. kuehniella* yumurtalarından larva çıkışını azaltmıştır. UV radyasyonu 254 ve 365 nm'de en uzun sürede (300 s) uygulandığında yumurta ölümü sırasıyla % 92.20 ve 28.89 olarak belirlenmiştir. Kısa dalga UV uygulamasında LT_{50} ve LT_{99} değerleri sırasıyla 155.680 ve 418.068 s olarak hesaplanmıştır.

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