



SUSCEPTIBILITY OF LIFE STAGES OF *TRIBOLIUM CASTANEUM* (HERBST) TO MICROWAVE RADIATION

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ABSTRACT

Physical methods of stored grain pest management such as microwave radiation can be utilized as a preventive and curative method of pest control. The susceptibility of various lifestages of *Tribolium castaneum* (Herbst) to microwave radiation was studied by irradiating infested wheat flour at 3 cm flour bed thickness. All the life stages of *T. castaneum* were irradiated at five different power levels viz., 136 W, 264 W, 440 W, 616 W and 800 W for 20 s. Eggs were more susceptible to microwave irradiation, whereas the susceptibility of grubs, pupae and adults were comparable. Mortality of all the life stages of *T. castaneum* increased with the increase in microwave irradiation power. Mortality of egg, grubs, pupae and adults were highest at an irradiation dose of 800 W i.e., 100, 96, 80 and 80%, respectively. Standardization of power, depth of flour bed thickness and duration of irradiation will enable the utilization of household microwave oven for the disinfestation of food grains.

Key words: *Tribolium castaneum*, microwave, irradiation, susceptibility, eggs, grubs, pupae, adult, mortality, red flour beetle, power, wheat flour

Red flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae), is a cosmopolitan stored grain pest causing severe economic loss to cereal-based products, especially wheat flour. The beetle spoils the wheat flour with chemical excretions, body fragments, and dead insects and renders an off odour to the flour (Rees, 2004). Chemical control is the widely adopted practice for managing red flour beetle. Fumigation is an economical and effective management option. However, the residual effect of chemicals, pest resurgence, resistance development in insects, and adverse environmental impact are the undesirable attributes of chemical control (Abdullahi et al., 2019). Resistance development is a major concern in the storage ecosystem due to the continuous selection pressure imposed by insecticides (Boyer et al., 2012). The frequency of phosphine resistance in Kerala populations of red flour beetle recorded was 71.40 to 93.40% at low concentration and 67.79 to 85.39% at high concentration (Sonai Rajan, 2015). Anusree et al. (2019) reported 10.95fold resistance to malathion in *T. castaneum* collected from different Food Corporation of India (FCI) godowns of Kerala. Such studies extend the constant demand for novel, eco-friendly, and economic strategies for storage pest management. Microwave irradiation is an effective, eco-friendly physical management strategy against storage pests.

The dielectric heating generated during microwave irradiation kills the insect and affects the reproductive capacity of surviving insects (Vadivambal et al., 2007; Patil et al., 2020). The current study assessed the efficacy of microwave radiation for the management of *T. castaneum* and studied the susceptibility of each life stage of *T. castaneum* to microwave irradiation.

MATERIALS AND METHODS

The study was conducted during 2021 at the Pesticide Residue Testing Laboratory, Department of Agricultural Entomology, and at the Agri-Business Incubator, College of Agriculture, Vellanikkara, Kerala Agricultural University, Thrissur. The culture of *T. castaneum* was maintained in the laboratory on whole wheat flour with 5 per cent brewer's yeast at 30°C and 70 per cent relative humidity (Pathrose et al., 2005). Adults were sieved out after five days and transferred to fresh rearing jars to obtain uniformly aged insects for conducting various experiments. Each developmental stage of *T. castaneum*, i.e., eggs (two-day-old), grubs (20± 2 day old), pupae and adults (17± 2 day old) of *T. castaneum* were released separately into beakers containing wheat flour at 3 cm bed thickness. Several studies support the use of household microwave oven for the management of storage pest (Ahmady et al., 2016). In our study we used a household microwave

oven (2450 MHz, Morphy Richards 20 MS) at five different power levels (136, 264, 440, 616 and 800 W) for 20 sec. These power levels were chosen as the chosen microwave oven model had these five power levels. Five replications were kept for each treatment. The hatchability of eggs was observed after two weeks by sieving through B.S.S 60 sieve. This data was used to calculate the mortality of eggs. Pupation of grubs was observed five days after treatment, based on which grub mortality was calculated. Similarly, pupal mortality was calculated based on adult emergence from irradiated pupae after five days of treatment. The mortality of adults in each treatment was observed at two days after irradiation. The data obtained were analysed in completely randomized design (two factors- stage of insect and power of irradiation) using an R based statistical package GRAPES, after arcsine transformation (Gopinath et al., 2020).

RESULTS AND DISCUSSION

Analysing the effect of microwave irradiation on various stages, eggs of *T. castaneum* were the most vulnerable stage with significantly high mortality of 51.33%, followed by the larva, adult and pupa (Fig. 1). The mortality of larva (43.33%), adult (40.67%) and pupa (38.00%) did not differ statistically among each other. The susceptibility of different life stages of insects to microwave radiation varies with different species of stored grain pests. Watters (1976) reported that eggs of *T. confusum* were more susceptible to microwave heating followed by pupae, adults and larvae. Shayesteh and Barthakur (1996) also concluded that eggs (12-24 h old) of *T. confusum* was highly susceptible to microwave radiation. Vadivambal et al. (2007) reported that the larvae of *T. castaneum* were more susceptible than pupae and adults to microwave radiation, while the pupae were more tolerant to heat

than the other developmental stages. But the study by Vadivambal et al. (2008) in barley damaged by *T. castaneum* revealed that eggs are more susceptible and adults are least susceptible to microwave radiation. The studies conducted on *Callosobruchus maculatus* revealed that eggs were the most vulnerable and pupae were the least susceptible stage to irradiation (Shouhgy and Elzun, 2014; Tiwari et al., 2021). In the case of lepidopteran storage pest, fig moth *Ephestia cautella* also, eggs were the most susceptible stage followed by female pupae, larvae and male pupae (Khalaf et al., 2015). Azizoglu et al. (2011) stated that proliferation and development of embryonic cells are slower at the egg stage compared to later developmental stages. This made the eggs to be the most vulnerable stage towards radiation treatment.

The second factor, the power of microwave radiation, caused dose-dependent mortality of *T. castaneum* (Fig. 2). As the microwave power increased from 136 to 800 W, mortality increased significantly from 14.00 to 89.00%, and the mortality in control was zero. Furthermore, several studies on disinfestation of stored product with microwave radiation also supports the positive influence of the power of irradiation on mortality of *T. castaneum* (Vadivambal et al., 2007; Vadivambal et al., 2008; Meenatchi et al., 2015). The interaction effect of life stages and the power of microwave radiation is depicted in Table 1. Egg mortality was complete at the highest irradiation dose of 800 W, when exposed for 20 s. Mortality of grub (96%), pupa (80%) and adult (80%) was also higher at the highest microwave power of 800 W, which was statistically comparable. At 800 W irradiation power 96% mortality of grubs was observed. Mortality of pupae and adults at 800 W were comparable with egg, grub and pupal mortality at 616 W and grub mortality at 440 W. Grub and adult mortality at 136 W and grub

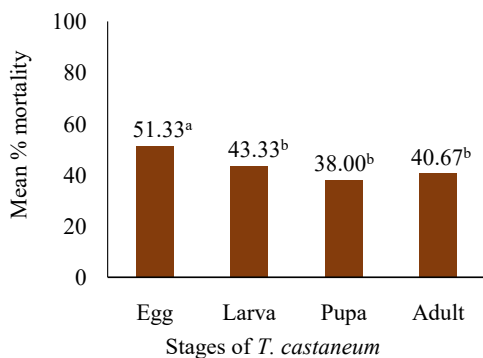


Fig. 1. Susceptibility of life stages of *T. castaneum* to microwave irradiation

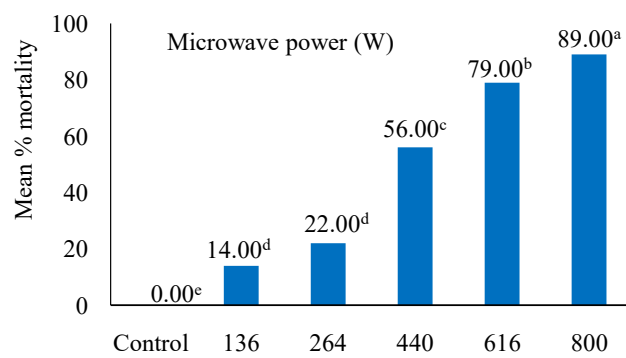


Fig. 2. Effect of microwave power on mortality of *T. castaneum*

Table 1. Effect of life stages/ power of microwave irradiation on mortality of *T. castaneum*

Stage	Power (W)					
	Control	136	264	440	616	800
Egg	0.00 ^h (0.23)	20.00 ^{efg} (0.46)	32.00 ^e (0.59)	76.00 ^{cd} (1.06)	80.00 ^{bc} (1.11)	100.00 ^a (1.34)
Grub	0.00 ^h (0.23)	4.00 ^{gh} (0.27)	0.00 ^h (0.23)	80.00 ^{bc} (1.11)	80.00 ^{bc} (1.11)	96.00 ^{ab} (1.30)
Pupa	0.00 ^h (0.23)	32.00 ^e (0.60)	24.00 ^{ef} (0.50)	12.00 ^{fgh} (0.37)	80.00 ^{bc} (1.11)	80.00 ^{bc} (1.11)
Adult	0.00 ^h (0.23)	0.00 ^h (0.23)	32.00 ^e (0.59)	56.00 ^d (0.86)	76.00 ^{cd} (1.06)	80.00 ^{bc} (1.12)

*Figures in parentheses are sine transformed values; Values with same letters not significantly different (LSD, p=0.05)

mortality at 264 W was comparable to each other and with the control. Vadivambal et al. (2008) reported 100% mortality of *T. castaneum* eggs in barley samples of moisture level 14%, arranged at 1 cm thickness after irradiating at 400 W for 28 s. They recorded cent per cent mortality of grubs, pupae and adults at 500 W, irradiated for 28 s. Higher moisture content leads to a higher temperature level in the irradiated material because of dielectric heating (Qu et al., 2017) and results in higher mortality of insects compared to samples at lower moisture content. Also, microwave irradiation at thin layers results in higher mortality than thick layers (Mohapatra et al., 2014). The low moisture content of 10.66% and a higher bed thickness of 3 cm may have resulted in relatively lower mortality of all stages in the current study compared to the previous studies. The results obtained in the study revealed that microwave irradiation could cause 100% mortality of the eggs of *T. castaneum*. Increasing the duration of irradiation (more than 20s) or reducing the thickness of flour can achieve complete mortality of all life stages of *T. castaneum*.

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