

## Temperature modifications as a strategy to control *Tribolium castaneum* infestation

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### Abstract

Pest infestation in storage centers and warehouses is of crucial concern to the food safety. The red flour beetle *Tribolium castaneum* is one of the most destructive pests. Management of this pest is usually done by the harmful and non-ecofriendly synthetic pesticides. In order to avoid their hazardous effect, scientists are resorting to alternative management strategies. In the present work, the survival rate of the pest when exposed to extreme temperatures were studied. The results obtained we can infer that the mortality rate of *T. castaneum* adults and eggs were exposed to -20°C and 60°C. Heat treatment by increasing the temperatures to 50–60 °C in the target food processing and use of freezing temperatures to store the processed food could be used as a measure to avoid the infestation of the products by *T. castaneum*.

**Keywords:** *T. castaneum*, food safety, temperature, storage pest

### Introduction

Food safety issues hinder global food security and thus exacerbate poverty in the most vulnerable populations. The quick urbanization has forced cities to give utmost priority to food safety and sustainable food systems planning. The infestation of stored food products by a number of insect pest is of chief concern to food security. *Tribolium castaneum*, *T. confusum*, *Sitophilus oryzae*, *S. granaries*, *Rhyzopertha dominica*, *Plodia interpunctella*, *Oryzaeplilus surinamensis*, *Lasioderma serricornis* are the major pests causing substantial damage and monetary loss to a range of stored products in warehouses. Among these storage pests, *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae), a secondary storage pest, is the most widespread and destructive.



**Fig 1:** *Tribolium castaneum*, The Red Flour Beetle

It is a polyphagous pest commonly found in internal food storage houses that infests different stored-grain and grain products, nuts and dried fruits (Liu and Ho, 1999, Weston and Rattlingourd, 2000; Mishra *et al.*, 2012a) <sup>[1, 2, 3]</sup>. The damage is less due to feeding, but more due to

contamination of the stored product with its various life stages. They also produce many strong substances during their activities that can seriously affect the quality of grain and result in reduced marketability and consumption by humans.

Synthetic insecticides have been broadly used for the management of this pest used due to their quick mode of action, easy application and storage. Though the application of chemical pesticides weakened the threat from pest by their quick knock down effect, these pesticides has least concern to the nutritional contents of the stored products. Hence it is better to resort to alternate management strategies. Manipulation of the storage temperature and their exposure period play an important role in the growth of *T. castaneum*. The optimum temperature for most of stored grain pests is the range of 25-30 C°. Temperature modulations below and beyond this optimum level may weaken the activity of the insect. In the present work, efforts were made to analyze the effect of high and low temperatures on the mortality of the *T. castaneum*.

### Materials and methods

#### Collection and maintenance of *Tribolium castaneum* (Herbst)

The pest, *T. castaneum* was procured from the nearby FCI warehouse from the infested wheat and has been continuously cultured on the same food source until the end of the experiments. The stock culture was maintained in the laboratory in dark atmosphere at 28 ± 20°C and 70 - 80% relative humidity.

#### Effect of high and low temperatures on the mortality of *T. castaneum*

In order to study the effect of increasing temperatures on the mortality of *T. castaneum*, 10 newly emerged adults paced in bottles containing 20g feed and 50 eggs placed in petridish, kept in 5 replicates, was exposed to various temperatures such as 40 °C, 50 °C, 60°C at different exposure periods such as 1hour, 2 hour and 3 hours. Also, to assess the effect of cold temperatures on the viability of the insect, a similar

experiment was set up with the samples exposed to 20 °C, 4 °C and -20 °C for exposure periods such as 15 mins, 30mins, 45 mins and 60 mins. The experiments were replicated 5 times. The percentage mortality (adult and egg) was calculated using the Abbot’s Formula. Statistical Analysis was performed in SPSS software (v25.0).

**Results**

The increase in temperature resulted in increased mortality of the adults and eggs of *Tribolium castaneum*. When exposed to a temperature of 40°C for 1 hour, 2hours and 3 hours the percentage mortality of adult *T.castaneum* was 0±0%, 12±4.47% and 12±8.36% respectively, while the ovicidal effect at 40°C was found to be 0±0%, 4±4.55% and 12±4.47% respectively. At 50°C, the percentage mortality in adults was found to be 52±4.47%, 58±4.47% and 64±5.48% and the percentage ovicidal effect was 48±4.47%, 58±4.47% and 64±5.48% for exposure periods of 1 hour, 2 hours and 3 hours respectively. When the temperature was raised upto 60°C, the percentage mortality in adults were found to be 80±0.00%, 90±7.06% and 100±7.07% while that of the eggs was 80±0.00%, 92±8.37% and 96±5.48% for the three different exposure hours (Table 1, 2).

The effect on adults and eggs of *T. castaneum* when stored at temperatures 20°C, 4°C and - 20°C was also studied. No mortality was observed in the adults and eggs of *T.castaneum* when exposed to the temperatures 20°C and 4°C. While at -20°C, the percentage mortality in adults were found to be 0±0%, 0±0%, 78±4.47% and 100±0.00% and that of the eggs was 6±5.48%, 32±8.37%, 56±5.48% and 78±4.47% for the exposure periods of 15 minutes, 30 minutes, 45 minutes and 60 minutes respectively. (Table 3, 4)

**Table 1:** Percentage Mortality of the Adult *T.castaneum* beetles when exposed to Elevated Temperatures for different exposure times. All values are mean ±S.D of five replicates and significant at p≤0.05 level of significance

Temperature	Dosage time (Hours)	%Mortality
40 °C	1 hour	0±0 <sup>a</sup>
	2 hours	12±4.47 <sup>b</sup>
	3 hours	12±8.36 <sup>c</sup>
50 °C	1 hour	52±4.47 <sup>a</sup>
	2 hours	58±4.47 <sup>b</sup>
	3 hours	64±5.48 <sup>c</sup>
60 °C	1 hour	80±0.00
	2 hours	90±7.07
	3 hours	100±7.07

**Table 2:** Ovicidal Effects when eggs are exposed to increased temperatures for different exposure times. All values are mean ±S.D of five replicates and significant at p≤0.05 level of significance

Temperature	Dosage time	%Mortality
40 °C	1 hour	0±0 <sup>a</sup>
	2 hours	4±4.548 <sup>b</sup>
	3 hours	12±4.47 <sup>c</sup>
50 °C	1 hour	48±4.47 <sup>a</sup>
	2 hours	58±4.47 <sup>b</sup>
	3 hours	64±5.48 <sup>c</sup>
60 °C	1 hour	80±0.00 <sup>a</sup>
	2 hours	92±8.37 <sup>b</sup>
	3 hours	96±5.48 <sup>c</sup>

**Table 3:** Percentage Mortality of the Adult *T.castaneum* beetles when exposed to Low Temperatures for different exposure times. All values are mean ±S.D of five replicates and significant at p≤0.05 level of significance

Temperature	Dosage time	%Mortality
20°C	15 mins	0±0 <sup>a</sup>
	30 mins	0±0 <sup>a</sup>
	45 mins	0±0 <sup>b</sup>
	60 mins	0±0 <sup>c</sup>
4 °C	15 mins	0±0 <sup>a</sup>
	30 mins	0±0 <sup>a</sup>
	45 mins	0±0 <sup>b</sup>
	60 mins	0±0 <sup>c</sup>
-20 °C	15 mins	0±0 <sup>a</sup>
	30 mins	0±0 <sup>a</sup>
	45 mins	78±4.47 <sup>b</sup>
	60 mins	100±0.00 <sup>c</sup>

**Table 4:** Ovicidal Effects when eggs are exposed to -20 °C for different exposure times. All values are mean ±S.D of five replicates and significant at p≤0.05 level of significance

Dosage time	Mortality
15 mins	6±5.48 <sup>a</sup>
30 mins	32±8.37 <sup>b</sup>
45 mins	56±5.48 <sup>c</sup>
60 mins	78±4.47 <sup>d</sup>

**Discussion**

Insect are not resilient to temperature modulations as they are poikilothermic (Colinet & Hoffman, 2012) [5]. The response of the insects to cold and high temperatures could be affected by their exposure periods, their rate of acclimation and many other factors (Li *et al.*, 2015) [6]. The objective of the present study was to assess the use of different temperature ranges in increasing the mortality of the red flour beetle.

Heating rate may have an important effect on the mortality of target insects during heat treatment. In this study, the mortality of *T. castaneum* eggs, and adults significantly increased after they experienced elevated temperatures for different periods. The increase in exposure periods also had a direct effect on their mortality. This finding is in accordance with research of Lü and Liu (2017) [7]. In general, the target temperatures for common standard heat treatments used in management strategies are in the range of 50–60 °C.

The effect of freezing and cold temperatures has a role on the development of *T.castaneum*. Burges and Burrel (1964) [8] has emphasized on the adoption of cooling technologies in grains as a way to reduce the population of insect pests present in stored grains. The present work states that the mortality of insect was found when the feed and the insects (adult and egg) were exposed to -20°C. These results in consistent with the works of Qadar (2020) who concluded that this species is very sensitive to chilling (-22) temperature.

In conclusion, the effectual way of controlling the population of *T.castaneum* in the stored food products could be by the application of Heat treatment during food processing stages and storage of the processed foods in freezing temperatures.

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