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Effectiveness of Different High Temperatures to Control Stored-product Beetles (different species) on Stored Rice Grain

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ABSTRACT

Heat treatment is being chosen to be an alternative to replace the use of methyl bromide. It involved raising and maintaining the temperature in the warehouse or storage of grain between 50°C to 60°C to control the stored product beetles. The duration may vary from 6 hours to 24 hours based on the types of storage, grains and its quantity. The need for alternatives is vital, considering the statutory limit (until the year 2015) for methyl bromide usage other than for phytosanitary purpose, and the likely widespread occurrence of insect resistance to both methyl bromide and phosphine. To note, these have been used in Malaysia for over half a century. Thus, the objective of this study focusses on testing the effectiveness of lethal temperature and duration in controlling the stored product beetles. High temperatures were used (30°C, 60°C, 70°C and 80°C) to decease the stored product beetles which are Sitophilus oryzae, Tribolium casteneum, and Oryzaephilus surinamensis. By using an oven, milled rice with tested beetles were exposed to the heat treatment. Each day, the heat exposures were given for 15 minutes. The number of dead beetles in 6 days exposure and effect on the eating quality of the cooked rice was observed at the end of the treatment. For Sitophilus oryzae, the duration of exposure requires six days of treatment (15 minutes per day) to kill all 25 adults atr the highest temperature (80°C) while theones with the least resistance; Oryzaephilus surinamensis requires 60 minutes. By using an oven, it is recommended that 60°C to 80°C of temperatures in 15 minutes of exposure be adopted to ensure the effectiveness against all species in heat treatment. The eating quality of cooked rice in terms of the aroma, stickiness, taste, colour and overall acceptability was not affected from the multiple exposure (3 times) to the heat treatment. Findings from this study indicated heat treatment is a potential replacement for insecticides. However, it is recommended to use high temperature in range of 60°C to 80°C in a short time (within 15 minutes) of exposure. Thus, heat treatment can be used for commercial application rice mill producer to control stored product insects during storage phase and milling process.

Keywords: *Heat treatment, Temperature, Rice, Stored product insect, Cooked rice*

1. INTRODUCTION

Rice grains are used as a main food for human. Rice has been considered as an important cereal after wheat due to its large production and also consumed by most of people in the world [1]. Two-thirds of the world population considered rice as one of the important foods as it supplies a great source of energy to human body [2]. In Asia, over 2 billion people gain 80% of their

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energy needs from rice, which comprise of 80% carbohydrates, 7 to 8% protein, 3% fat and 3 % fiber [3]. In Malaysia, rice is also considered as part of essential food especially for small holders as they gain their living earnings from this crop. Over the last decade, Malaysia's paddy and rice production recorded only a modest increase, from 1.36 million MT in 1993 to 1.76 million MT in 2017. Meanwhile, the level of domestic consumption has increased higher as compared to domestic production. To fulfil the market demand, Malaysia should produce large amount of high quality rice.

However, the rice that is stored in warehouse before being delivered to market could be infested by stored-product insects, some of which would feed and reproduce within the rice, leading to damaged kernels and reduced economic value and quality of rice [4]. Generally, genus Sitophilus is considered as primary pest because this species is able to attack intact grains, while genus Tribolium is classified as secondary pests which attack already damaged grains or grain products [5]. Losses caused by insects after harvest may be direct or indirect. A direct loss is the disappearance of the commodity as a result of insect feeding, whereas an indirect loss is the lowering of the quality of the commodity to the extent that it attracts a lower price or is rejected completely [6]. To achieve high quality of rice mill, rice need to be stored in an appropriate storage to avoid insect infestation [7].

Before this, methyl bromide was applied in storage area of rice to eliminate the presence of stored product beetles. However, the use of methyl bromide was banned due to it being hazardous and not environmentally friendly. So, the alternative has been searched to replace the use of methyl bromide. There are few studies that have reported the effect of heat treatment on beetles. Heat treatment has been chosen to be tested in this research because the heat is safe to environment and also humans. The main objective of this research is to determine the effectiveness of heat to control stored product insect in rice.

2. MATERIALS AND METHODS

2.1 Rice collection

For this research, three bags of 5kg of MR269 rice were bought from Kilang Beras Jelapang Selatan, Muar, Johor at RM12.00 per bag. There were 3 replications conducted for each species of insects, T. castaneum, S. oryzae and O. surinamensis and each replication used 1 kg of rice, and therefore a total of 9 kg of rice were used for the treatment.

2.2 Insect Collection

Adults from 3 types of species of major stored product beetles namely the *T. castaneum, S. oryzae* and *O. surinamensis* were used in this research. These 3 species of beetles were found within old rice around residential area at Kampung Sri Mendapat and Lipat Kajang, Jasin Melaka. We also went to Kilang Beras Jelapang Selatan Muar, Johor to collect the beetles. After collecting, each type of beetle was kept in a different small container for different type of species. The containers with small holes on the lid were tightly close to provide some aeration for the beetles before the experiments started. The aeration was needed to prevent the insects from death. Large holes need to be avoided to prevent the beetles from creeping out of the

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container. There was about 100g of rice given to the beetles as their source of food in order to keep them alive.

2.3 Oven Preparation

The oven used under this experiment was located at Entomology Laboratory of UiTM Jasin, Melaka. This oven was 1 m (L) x 1.5 m (W) x 1.3 m (D) and has a range of temperature ranging from 0°C to 100°C. In this experiment, the temperature used to kill the beetles were at 28°C (control: room temperature), 60°C, 70°C and 80°C. These temperatures were considered as suitable temperature used to kill the stored product insects within a short time even when using an oven as the process did not affect the rice quality [7].

2.4 Heat Treatment

There were 25 adults from test beetles (each species per container) added in a container containing 1kg of rice. There were 36 containers needed as there were three species of insects for 3 replications used under this treatment. The containers with the tested beetles and rice, also called as samples were inserted into four ovens and heated with different temperatures for 15 minutes[8]. After 15 minutes, the temperature in the ovens will automatically shut off and the samples were taken out from the ovens and left in a room temperature (27 to 30°C) for 24 hours [9]. After 24 hours, the beetles were sifted out from the grain and the number of live and dead beetles were counted. Any changes regarding the quality of the rice were also noted. This process was continued on the next day until total of 25 adults of the test insects in the samples were dead. Three replications of the test beetles were made on the same day to gain precise data and results.

2.5 Tester by Panel

Before the heat treatment, 300g of the original rice (without infestation) were cooked with 400ml of water. Then, the cooked rice was tasted by 10 expertise panels made of lecturers, laboratory assistant and students to describe the criteria needed for the rice. Table 1 shows the criteria needed to determine the quality of the rice;

After heat treatment, 300g of cooked rice (after insects' infestation) were also cooked and given to the same 10 panels to describe the quality of the cooked rice. This process is done to identify whether the insect infestation and heat treatment done had affected the rice or not.

Table 1: Criteria of determination of cooked rice quality

Criterias	Description
Aroma	The aroma or smell of the cooked rice
Colour	Colour of the cooked rice (i.e. white yellowish, pure white)
Taste	Cooked rice tastes the same as other rice or not (i.e. loss of sweetness, slightly bitter)
Texture	Cooked rice is slightly hard to chew
Stickiness	The rice is sticky to each other
Overall acceptibility	Acceptance by the panels

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2.6 Statistical Analysis

The statistical test using IBM SPSS Statistics v20 software was used to see the relationship between two variables; Days of treatment as independent variable (iv) and Mean of insects' mortality as dependent variable (dv). The effectiveness of heat treatment was presented by the mean of insect's mortality. Probit analysis was used to test the relationship between the mean of insect's mortality and days of treatment and ANOVA was used to determine the significant differences of mortality among the three types of selected insects.

3. RESULT AND DISCUSSION

3.1 Results

3.1.1 Effects of Temperature on Three Different Species of Stored-Product Beetles

All the beetles showed the 100% mortality towards heat treatment. Table 2 showed the mean of insect mortality between 3 types of beetles which are *T. castaneum, O. surinamensis* and *S. oryzae* in different of temperatures exposures in 24 hours. Based on the tables it showed that these three types of beetles have different level of mortality towards heat treatment. *S. oryzae* is one of the insects that was less susceptible towards high temperature as it had undergone the lowest mortality after 15 minutes exposures time. This beetle needed 6 days to decease all 25 adults of beetles followed by *T. castaneum* (5 days) and *O. surinamensis* (3 days). Figure 1 shows that the highest temperature which is 80°C took six days to have a complete mortality on three species. Thus, it is proven that using heat treatment will result in the insect's mortality. There is also a significant difference among these spesies . The highest mortality was achieved by *O. surinamensis* and the other two species has a low mortality rate compared to *O. surinamensis*. Meanwhile, the relationship between days and mortality of insects is also of significance (p=0.000). The mortality of insects became longer when the longer the duration of the beetles was exposed to heat. From the hypothesis testing of p-value method, it can be concluded that using high temperature will result on insect's mortality as the number of insect's death from three species; *T. castaneum, S. oryzae* and *O. surinamensis* were increasing from day to day after exposed to the heat treatment.

Table 2: Mean insect mortality (± SEM) after 15 minutes of heat exposure (Day 1 of treatment).

Temperatures	***TC***	***OS***	***SO***
Room temperature 28°C-30°C	0.0	0.0	0.0
60°C	4±0.3	6±3.3	3±0.2
70°C	4±3.3	8±4.7	3±0.2
80°C	6±0.3	9±3.3	5±0.2

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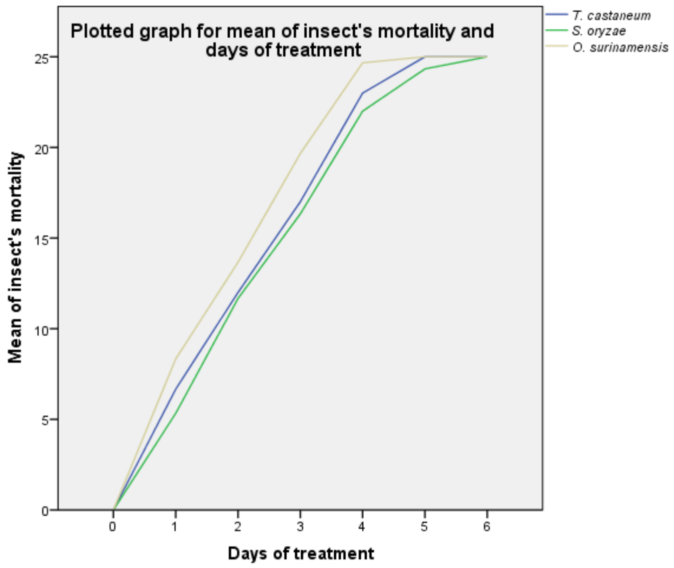

Figure 1. Mean of insect mortality between tested stored product beetles and days of treatment (80°C).

3.1.2 Results for Cooked Rice Eating Quality

Rice eating quality were tested to identify the quality of the cooked rice between pre and post treatment. This procedure distinguished whether the heat treatment did give any effects and reduce the quality of the rice or not. The rice grain prior to the treatment were not exposed to high temperature while rice grain after treatment were exposed to heat treatment. There were 10 panel of expertise among students, lecturers and staff of UiTM chosen to test both before and after treatment of the cooked rice.

Based on the result obtained in Table 3, it showed that there was only slight difference on the cooked rice eating quality between before and after treatment. Some of the criterias showed no difference, $p > 0.5$ (not significant) which means the quality of the cooked rice remained the same even after multiple exposure to the high temperature. Slightly different means of before and after treatment indicated that the quality of the cooked rice after treatment was not really affected by multiple exposure to heat treatment. Based on overall acceptability, most testers agreed that the taste, aroma, texture, stickiness and colour of the rice after treatment showed not much difference compared to before the treatment. Thus, the cooked rice will still be accepted by consumers even after multiple exposure of rice grain to the heat treatment.

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