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EXPLOITATION OF MICROWAVE SYSTEM FOR CONTROL OF INSECT INFESTATION IN RICE GRAIN

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ABSTRACT

Microwave heating has a potential to disinfest insect in rice grain. This method can be an alternative and a safe method to replace the current use of fumigant types of chemicals. Microwave leaves no chemical residue to hazard human health and safe for environment. A microwave system were developed using domestic microwave oven embedded with an Arduino microcontroller plus a switching circuit to study the effect of microwave energy applied to the infested rice grain. The microwave frequency used in the study was a standard 2.45MHz magnetron. The microcontroller was programmed to maintain the temperature at 50º – 65ºC and duration is set at 2 – 3 minutes per cycle of exposure. The experiments were carried out to monitor the effect of microwave on spawning process and the mortality rate of adult insect. In this study, two types of rice samples were selected and examined as microwave treated and non-treated (control) stored at room temperature to monitor the activity of insect periodically. It was found that the microwave treated samples shows the reduction in the insect growth rate in comparison to the non-treated rice sample. The preliminary analysis was performed to identify the effectiveness of microwave usage for rice treatment in order to provide an alternative method for food preservation electronically. Finally, it was found that the microwave technology has its own advantages which may certainly be used for control of insect infestation as in this study for rice samples specifically.

Keywords: food treatment, insect, infestation, microwave, rice;

INTRODUCTION

Most of agricultural commodities need to undergo several process operations before reaching the consumer. Through the processes such as harvesting, threshing, winnowing, bagging, transportation and storage, there will be acceptable losses to the end product. The losses are caused either by environmental factors such as temperature, moisture, storage structure, insects, rodents, birds and fungi. The major losses during production, storage and marketing of food grain are being attributed to infestation by insect pests, microbiological contamination, and physiological changes [1]. Insect infestations start before the harvesting by spawning process. They attack the commodities at time before harvesting and more severe as the eggs hatch during storage level waiting for next or another process. This leads to the losses on quality of the products [2]. Therefore, stored-product insects from the field to the consumer must be eliminated to prevent economic losses [3].

The losses during storage are classified as quantity losses and quality losses. Quantity losses caused by the insect consume the crop. However, quality losses are reflected as reduced economic value of the crop as damage contributed by the insects. Infestation causes decreased nutritional value, reduced seed germination, and lower economic value and also causes changes in chemical compositions such as increase in moisture, free fatty acid levels, non-protein nitrogen content, and decrease in pH and protein [4]. They reduce the product quality directly by consumed the crop leaving the crop in hollow husk and frass [5]. The increasing time level of infestation also caused the quality of rice grain [6]. It is estimated thousands of insects species destroys approximately one-third of the world's food production, loss to the value more than 100 billion dollar [7].

Rice, (*Oryza sativa L*.) is the most important staple food crop in the world and it is a major commodity for international and domestic trade. However, rice seeds are affected adversely by many insect pests and fungi, causes damage to rice grain and reduced the quality of seeds for the purpose of germination [8].

Infestation in Rice grain causes decreased nutritional value, reduced seed germination and lower economic value and also causes changes in chemical compositions such as increase in moisture, free fatty acid levels, non-protein nitrogen content, and decrease in pH and protein contents in food grain [4]. The absence of pre- or post-harvest paddy may cause barrier for international and domestic trades. *Rhyzopertha dominica (F.),* the lesser grain borer, attacks a wide range of stored cereals and breeds extensively in a warm climate such as that of Malaysia [9]. The lesser grain borer is a serious pest that destroys stored grain and cereal products. The adults and larvae bore into grain seeds and eat the kernel, leaving a hollow husk [10].

There are several methods that are used in an effort to control these insect pests in rice paddies and in the harvested rice [11]. Conventional chemicals, grain protectants, and fumigants are extensively used around the world to control insect pests in stored commodities because of low cost, fast processing, and easy application. Greater regulation and restriction of *methyl bromide* use will likely increase the cost of the fumigant, as well as reduce its availability [12].

In Malaysia, a mixture of *pirimiphosmethyl* (12.0 mg of the active ingredient), *permethrin* (1 mg), and *piperonyl butoxide* (5.0 mg) is used as one liter per ton of paddy to achieve complete prevention of infestation (100% insect control) throughout the grain storage period. Another method used in Malaysia is sealed storage with *carbon dioxide* (CO2) gas [13].

Thus, a safe method is needed to develop in controlling infestation in rice grain. Microwave heating with good penetrability can kill the adult pest and eliminate insect eggs in the grain kernels. The use of microwaves for disinfestation is based on the dielectric heating effect produce in grain, which is a relatively poor conductor of electricity. An attractive feature of the insect control using the microwave energy is that the insects are heated at a faster rate than the product they infest because of high moisture content of insects. Thus, a safe method is needed to develop in controlling infestation in rice grain. Microwave heating with good penetrability can kill the adult pest and eliminate insect eggs in the grain kernels. The microwave system is considered safe and alternative to the fumigation method, which will be focused in this study.

MATERIAL AND METHOD

Rice Samples

Figure 1: Raw sample with adult insect.

Rice samples were obtained from FAIZA Sdn. Bhd. This sample infected by several types of rice weevils such *Prosthepanus Truncates* and *Rhyzopertha Dominica*. It includes adult pest and eggs group between the grains.
Equipments list

1) Domestic Microwave oven (Samsung M1600N)
   A microwave with 2.45 Mhz frequency commonly used in kitchen.
2) PC with LabView software to display temperature detected.
3) DAQ card to convert temperature signal before the signal sent to computer.
4) Microscope (Nikon Eclipse DXM1200F) with Digital camera (Nikon E600) used to monitor insect activity on sample.

EXPERIMENT METHOD

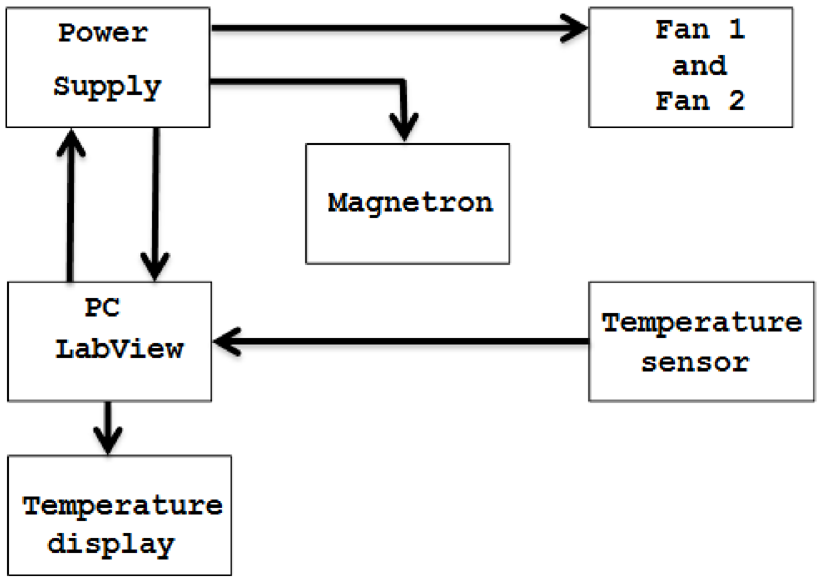

Figure 2: Block diagram of experimental setup

The operating supply is A.C 230V 50 Hz to operate the 2.450 MHz magnetron in the microwave oven. The power supply is controlled by a microcontroller with Arduino development board and a relay circuit to activate the A.C. power supply. At the bottom of sample tray a temperature sensor is located to record temperature samples. The rice is poured onto the sensor to completely cover the sensor surface. When the temperature reaches the desired temperature, the microcontroller activates the relay circuit to cut-off the supply to the oven. As the temperature drop below the desired temperature the relay reconnects the oven power supply. This setting performed continuously until the duration is accomplished for the process.

RESULT AND DISCUSSION

The result is presented by monitoring the behaviour of live insect and effect of microwave heating exposure. Several images are produced to prove the findings in the study.
Figure 3 shows a flow study with two same samples to observe the live insect in weeks of experiment.

Flow of Experiment: Observation

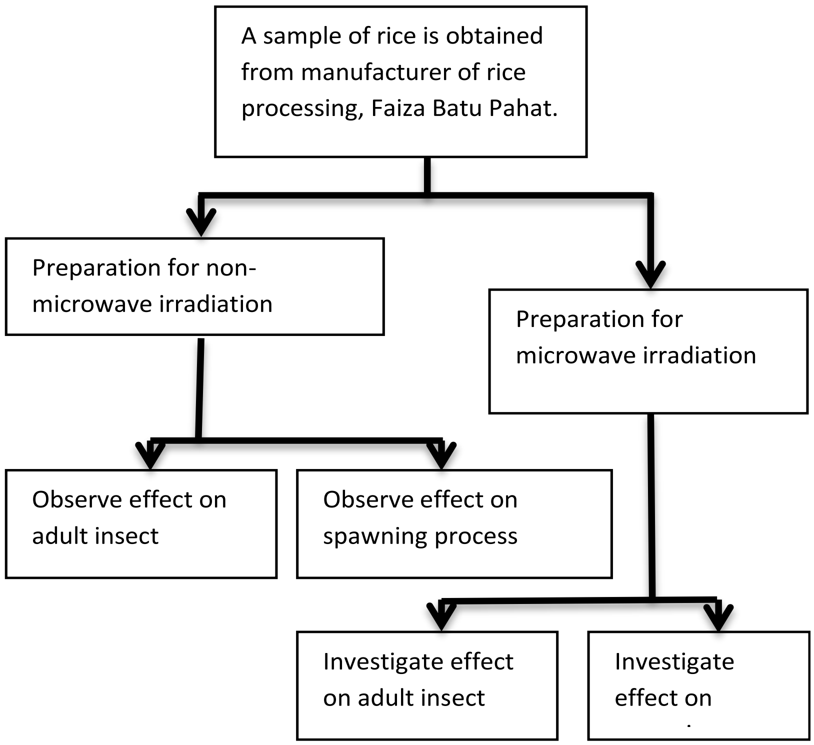

Figure 3: Flow of Study

Test on rice sample with spawning process

Figure 4 shows the rice image under the microscope. White spotted surrounding the grains are the eggs of insect. This includes the dust of rice by the activity of insect bores the grain. This sample is divided into two trays. One of the trays will be exposed with the microwave and the second one without microwave (control). Both trays were kept under room temperature. The samples are then being observed periodically. After 2 weeks, both samples are analysed under the microscope and the results are shown in figure 5(a) and 5(b).

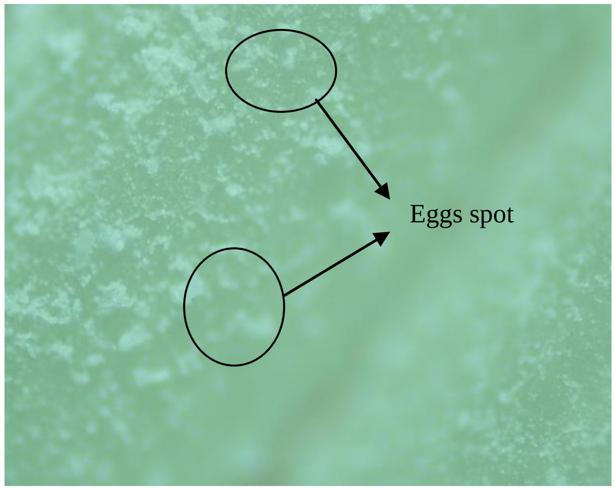

Figure 4: Raw sample of rice grain (*under microscope*)

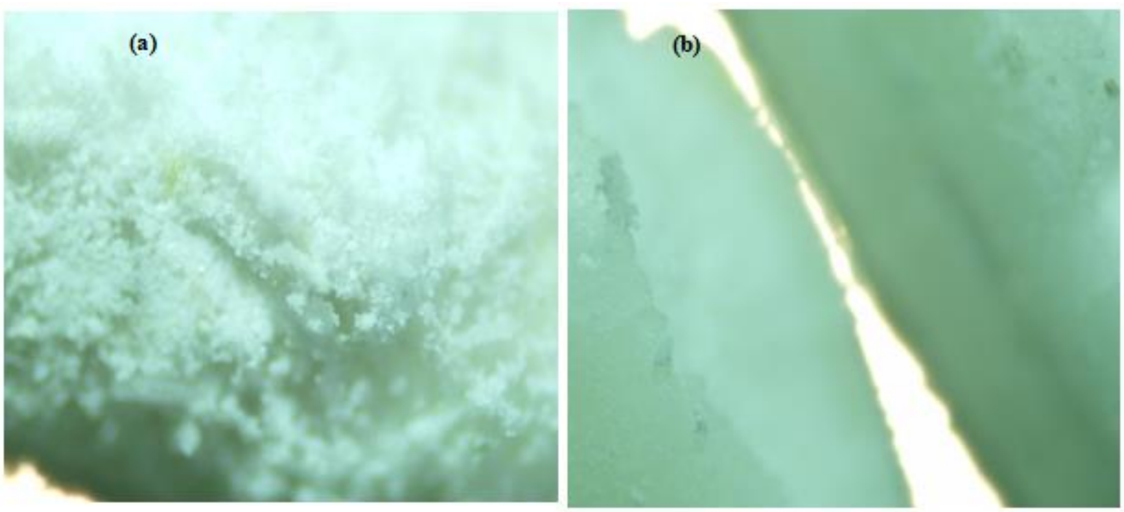

Figure 5: Image recorded after two weeks, (a) without microwave treatment, (b) With microwave

Figure 5(a) shows the development of insect activity caused the almost every single grain covering by the eggs of insect. By comparing to the figure 5(b), it can be seen that the used of microwave makes the surface of rice grain free from insect eggs.

Test on rice sample with adult insect

In order to conduct this test, every single rice grain with an adult insect inside is accumulated in a tray. In figure 6(a) shows a single grain with an insect inside it. In blurring transparent view we can see through the insect with our naked eye. The similar procedure is done where this sample is splitted into two trays. One with microwave and the other without microwave. The samples are monitored periodically.

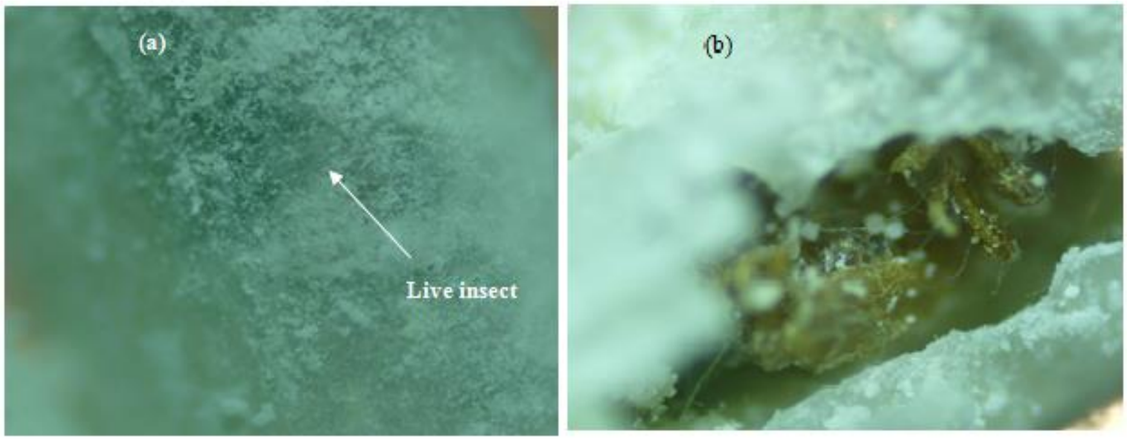

Figure 6: Rice grain with insect inside. (a) before microwave treatment, (b) after treatment.

In figure 6(b), a dead insect can be seen after the broken grain analysed under microscope compared to the rice without microwave treatment a live insect come out from broken grain. In fact, after two weeks, several number of live insect recorded as in table 1.

Table1: Adults detected in two weeks

Duration	No Treatment	Microwave
1 week	3 adults	No detected
2 weeks	6 adults	1 detected

In table 1, in one week there were three live insect were detected in the sample with no microwave treatment. The number of insect was doubled after two weeks in this tray. However, when microwave heating is applied to the rice for first one no live insect was detected but one insect after two weeks of monitoring period.

CONCLUSION

It is proven from this study that microwave energy with specific characteristics can be applied for disinfestation of rice insect. Microwave technique can be a promising alternative to the used of fumigants for stored rice disinfestation process. Based on this result, this method is considered to be potentially safe and competitive alternative to other method in protecting rice from infestation.

Although the microwaves have the potential for disinfesting the rice insect, the adverse effect on rice quality also must be look into. This method must be truly optimized to conserve the quality of rice. Too long the exposure leads to fragile rice grain, which could be the disadvantages of microwave system.

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