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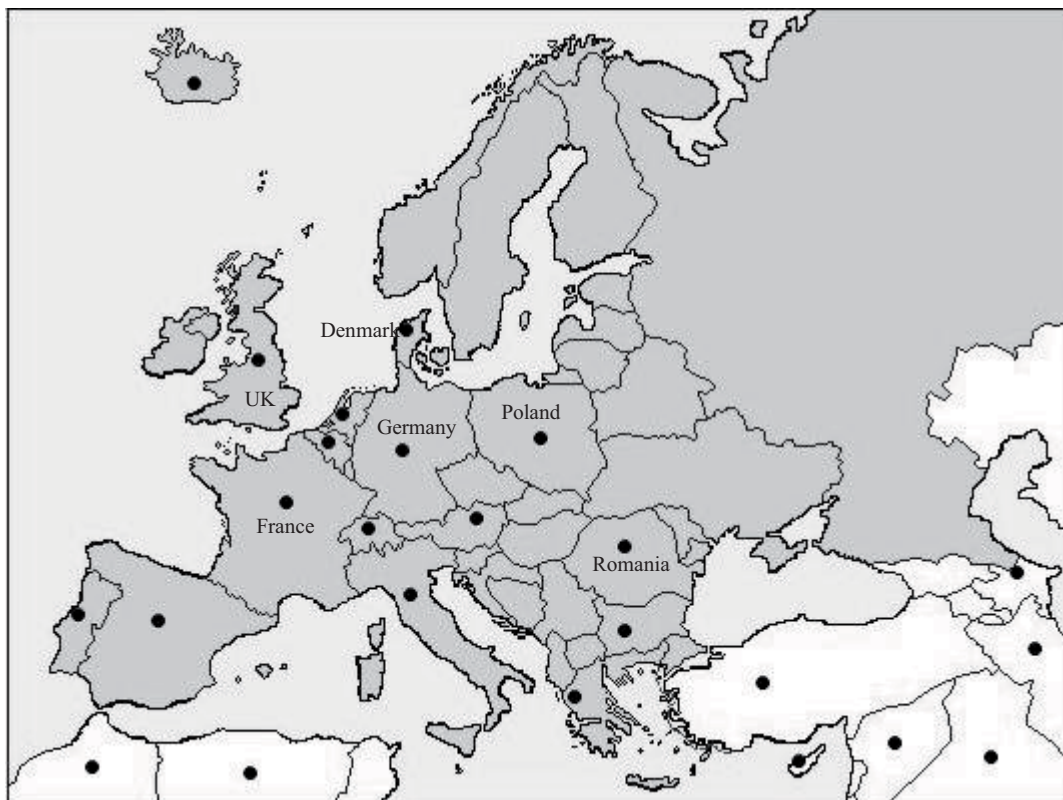
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## I. Introduction

### 1.1. Background

*Oryzaephilus surinamensis* (L.) is a secondary stored-grain insect pest, which was found for the first time in Suriname, South America. The first incident of *O. surinamensis* in Germany was reported in 1953 (Reinhardt *et al.*, 2003). In a survey done in grain stores of ecological farming in Baden-Württemberg-Germany, it was showed that *O. surinamensis* is one of the most important secondary pests because it has the infestation frequency at level 25 % (Niedermayer and Steidle, 2006). According to Beckel *et al.* (2007), over the past decades, the incident of this insect has significantly increased in the storages facilities. It was estimated due to the increase production of the broken grains as a consequence of the increase use of mechanical equipment in post harvest handling.



**Figure 1:** The European distribution of *Oryzaephilus surinamensis*  
([http://www.cabi.org/isc/DatasheetDetailsReports.aspx?&iSectionId=EU\\*0&iDatasheetID=37988&sSystem=Product&iPageID=481](http://www.cabi.org/isc/DatasheetDetailsReports.aspx?&iSectionId=EU*0&iDatasheetID=37988&sSystem=Product&iPageID=481)), 11.04.2011

The rapid spread of the insect is transpired through the exported and imported grain products among the countries worldwide, especially in the warm regions. However, since the insect is living in storage facilities, the incident of this insect is also found in the temperate regions such as Germany. The spread of this insect in European countries globally can be seen in Figure 1. Therefore, it seems that the insect could spread worldwide without limitation of geographical location.

Arthur (2001) stated that *O. surinamensis* becomes a cosmopolitan insect pest of stored grains because it has high speed reproduction rate. In agreement with this, Lessard *et al.* (2005) confirmed that the calculated progeny per pair of parental generation of this insect could reach more than 2000 individuals after 3 months at temperature 30 °C in grain at moisture 13.7 %. It is estimated that at such high population, the insects will consume large amount of grains and produce the dust and other contamination materials. About 1.89 % weight loss was indicated under a low population level of *O. surinamensis* (Hurlock, 1967), thus, the higher weight loss could be expected at the higher number of the initial population. Moreover, the insects have built serious infestation problems that reached the economic threshold, especially because of their high adaptation ability, high mobility, and ability to attack the packaged food (Beckel *et al.*, 2007).

There are a number of methods, which were used for controlling this insect pest, for instance chemical and biological methods. The chemical method (i.e. by using the insecticides) is the common method to be used because of its low cost. However, it suffers from some serious drawbacks. One of these drawbacks is that *O. surinamensis* could build resistance against the insecticides. Conyers *et al.* (1998) investigated that *O. surinamensis*, strain 7012/1malRR Whitminster, was resistant to organophosphorus (malathion, fenitrothion, pirimiphos-methyl, chlorpyrifos, and methacrifos). Beckel *et al.* (2007) also reported that the ability to hide in many places in the storage facilities become another drawback for the insecticides application in controlling this insect.

Searle *et al.* (1984) studied the biological method in controlling adult *O. surinamensis*. The application of fungus *Beauveria bassiana* (Bals.) Vuill. was found effective at dosage of  $10^3$  spores per *ml*, temperature 25 °C and 100 % humidity. However, they could not confirm the safety of using this fungus for human

health. Haas-Costa *et al.* (2010) confirmed that the infestation of *B. bassiana* in commercial chicken food has positive effect on improving weight of *Gallus domesticus L.* (male chicken) However, there is no information about the concentration of spores used that would be a very important factor to cause the malfunction on the bird health. In addition, so far, the application of this method is not commonly used.

Besides the two methods discussed above, the use of thermal effect is considered as an effective method in controlling the pests with some advantages such as no chemical contamination and no risk of pest resistance. The thermal effect can be generated by using hot water, hot air, and steam. Lurie (1998) suggested that the use of such methods is possible to disinfest fruits, vegetables, and flowers.

At the present, the use of those thermal methods to control *O. surinamensis* in the grain products is not implemented yet. Therefore, the possibility of using microwave (MW) energy to generate heat on grain products is expected to have the advantages of using the thermal method in controlling *O. surinamensis*. It is revealed that the MW energy could be an alternative of thermal method since it increases rapidly the temperature in the wet product, thus reduces the application time.

This idea is not new since there are several attempts that have been made to investigate the potential use of MW energy in controlling the insect pests at secure temperature for the products (Hamid *et al.*, 1968; Zhao *et al.*, 2007; Vadivambal, 2009; and Singh *et al.*, 2011). However, at the moment, the MW technology in controlling insect pests is not commercially implemented yet. The primary consideration is the high cost, which is needed to transmit this technology into practice. Therefore, further researches on MW technology are needed to reach the reasonable usage of MW in the area of food protection by improving the MW performance. Especially, since the MW energy produces the irregular temperature distribution, the study on temperature distribution should be conducted to improve the heating uniformity in the product and later it is expected to enhance the product quality. The improvement of MW performance is still a challenge for the grain disinfestations in the industrial application at a reasonable cost.

## 1. 2. Objectives

This study was aimed to address the following objectives that are integrated in the field of agricultural engineering, entomology science, and food protection, those are:

1. To study the heating uniformity on wheat grains after MW heating based on its surface temperature
2. To determine the potential of MW heating for controlling *O. surinamensis*.
3. To investigate the germination rate of grain after the MW heating.
4. To analyze the quality of flour produced from the grain treated by using the MW heating.