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MIMICRY OF FORMALDEHYDE AS ALDEHYDE: A POTENTIAL AND NOVEL CHEMICAL COMPOUND TO CONTROL STORAGE PESTS

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ABSTRACT

Tribolium castaneum is one of the most pervasive pests to threaten the storage of rice in Malaysia; thus, control methods are being studied to overcome this problem. The main objective of this study is to measure the efficacy of paint to attract *T. castaneum*. Based on preliminary results regarding olfactory responses, the formaldehyde compound in paint is highlighted as a potential and alternative method to be used as bait to trap the *T. castaneum* that infest rice storage warehouses. This result is likely due to the paint's main element, formaldehyde, which releases a pungent smell and attracts the pests. Chemically, formaldehyde is a simpler form of aldehyde, with the formula CH2O. The idea to use paint in this study was inspired by the reports of warehouse workers who declared that insect pests are attracted to the paint that is stored in warehouses. Interestingly, this preliminary finding results in an interesting conclusion and a novel outcome in the field of stored product research. To this end, researchers recommend a paint or formaldehyde compound to serve as bait capable of attracting *T. castaneum*.

Keywords: *Tribolium castaneum*, formaldehyde, effective, alternative, storage pests.

ABSTRAK

Tribolium castaneum merupakan salah satu spesies serangga perosak yang mengganggu tempat penyimpanan beras di Malaysia; oleh itu kaedah kawalan serangga perosak ini telah di kaji untuk mengatasi masalah ini. Objektif utama kajian ini adalah untuk menguji keberkesanan cat untuk menarik *T. castaneum.* Berdasarkan kepada hasil awal kajian tentang respon bau, kompaun formaldehid di dalam cat berkemungkinan mampu menjadi kaedah alternatif untuk dijadikan umpan untuk menangkap *T. castaneum.* Kompaun formaldehid mengeluarkan bau yang tajam dan telah menarik serangga perosak kepadanya. Secara kimia, formaldehid merupakan satu kumpulan di dalam kompaun aldehid, dengan formula CH_2O. Idea untuk menggunakan cat di dalam kajian ini tercetus apabila pekerja gudang memberitahu bahawa penampakan tarikan serangga perosak terhadap cat yang disimpan di dalam gudang. Hasil awal ini menjadikannya menarik dan hasil yang novel dalam bidang kajian serangga perosak di tempat penyimpanan. Dengan ini, pengkaji mencadangkan cat atau kompaun formaldehid sebagai umpan yang berupaya untuk menarik *T. castaneum*.

Kata kunci: *Tribolium castaneum,* formaldehid, keberkesanan, alternatif, serangga perosak gudang.

INTRODUCTION

Tribolium castaneum (Herbst, 1979) is known as a secondary pest that afflicts the processed foods stored in mills (Campbell et al. 2010). The pest has various unique features; it has a short life cycle, is highly competitive, and is able to adapt to limited resources (Duehl et al. 2011). *Tribolium castaneum* has generated much research interest due to its external life cycle, which makes it easy to study compared to other primary pests such as *Sitophilus oryza* and *Ryzopertha dominica*. Thus, *T. castaneum* provides a strong model for this research.

Stored products such as rice are vulnerable to infestation by numerous insect pests, and many can cause serious nutritional damage and economic loss. Early detection is essential, yet their presence often goes unnoticed until the infestation becomes severe. Many insect species use chemical cues as tools to select targets for feeding, mating, and oviposition. Recent studies of olfactory cues show behavioural responses on the part of *T. castaneum* and demonstrate that *T. castaneum* is attracted to stored foods such as dry cocoa beans **(**Jonfia-Essien et al. 2007) and cotton seed fungi (Faheem et al. 2012).

Until now, insect pest infestations have commonly been controlled using insecticides, fumigation, and chemical compounds (Herbert 2013). However, the application of these chemicals can have a negative long-term effect on the stored rice. Continuous pest control activities of this nature can thus cause harm to human health and the environment. An alternate method of controlling insect pest infestations should be developed in order to maintain and protect a country’s rice production. Moreover, many tenacious pests that attack stored products have shown resistance to more than one form of pesticide (Donahaye et al. 2000).

In this study, the olfactory response of *T. castaneum* toward different compounds was identified; research consisted of establishing food sources and non-food sources as bait to attract the insects.

METHOD AND MATERIALS

A total of 15 traps were prepared and placed in a rice warehouse (Figure 1); the traps emitted five distinct odor compounds, namely formaldehyde (paint), pyrazin (coffee), ethanol (vinegar), euganol (cinnamon), and banana (amyl acetate). Each compound was placed in a transparent container sized 18cm x 18cm x 6cm^3, and sticky transparent plastic wrap was positioned below each plastic container in an attempt to trap insects. Two containers held 500g of either cinnamon or coffee powder. For liquid compounds, 500ml of amyl acetate or vinegar were poured onto white cotton and placed in containers to reduce the evaporation rate during the sampling period. The traps were placed on the floor at 10m apart. The traps were left for 6 hours (from 10:00 am until 4:00 pm), and three repetitions of this sampling method were conducted.

To confirm the white colour of paint do not influence to attract of *T. castaneum*, the placement of 15 colour sticky traps, which consists of five colours namely white, yellow, green, black and red were placed parallelly to the odor compounds trap. The sticky traps also placed in a line transect of 150 m, while duration and the placement were similar to the odor compounds trap (Figure 1).

To record the sampling data from each trap, the sorting and identification of *T. castaneum* was conducted under stereo-microscope per the species keys of Ferrer (1995). Researchers recorded the number of *Tribolium* *castaneum* that were stuck to each sticky trap or present in the containers. ANOVA one-way analysis was conducted to rule out the effects of an abundance of *T. castaneum* on odor compounds and colours. Besides, the ANOVA-two way to measure the correlation between odor compounds and colours.

RESULTS AND DISCUSSIONS

A total of 820 individuals of *T. castaneum* (Table 1) were collected in this experiment. Treatment with the different odor compounds resulted in the highest abundance (29%) of *T. castaneum* in the formaldehyde compound; this result was followed by ethanol and pyrazin with 21% each of trapped *T. castaneum*, amyl-acetate with 18%, and euganol with 11%. However, ANOVA tests showed no significant difference between odor compounds, with a P-value = 0.306 and F= 1.39 (Table 2).

Generally, insects are surrounded by various odor compounds emanating from food sources, humans, the environment, other insects, and assorted chemicals. The use of olfactory cues or senses in the search for food or mates is an essential tool used bycountless insect species (Edee & Philips 2006; Nguyen et al. 2008). For example, the adult *Sitophilus granaries* respond positively to aliphatic alcohol, ketone, and aldehyde when presented with olfactometer traps (Germinara et al. 2008).

More than 200 volatiles have been identified in rice profiles (Bergman et al. 2000; Champagne 2008), each of which has its own function in the rice itself. The likelihood that insect pests will be attracted to the various smells in stored foods is high. Results show that *T. castaneum* are attracted to non-food items and that formaldehyde results in the strongest attraction (Fig. 1).

Formaldehyde is the main element of paint that contributes to its unique smell and is often used in industrial and manufacturing applications. Chemically, it is a simple compound with the formula CH2O. Results of this study indicated that formaldehyde provided the strongest attraction for *T. castaneum* despite its pungent smell and the fact that it is not a food source. This result demonstrates that insect pests have a strong sense of smell and are not solely attracted to food-based materials. Lin et al. (2010) found that 30% of rice's weight is composed of aldehyde. Formaldehyde being a simpler form of the aldehyde compound, it becomes clear why *T. castaneum* were more strongly attracted to formaldehyde than to the other odor compounds. Researchers did not test the rate of formaldehyde evaporation into the environment; still, formaldehyde's pungent smell may be the cause of its attractiveness to *T. castaneum,* even in the form of semi liquid paint.

It is possible for insects to respond to odors other than those originating from stored food sources. Insects' sense of smell is widely and daily used, and their movements are influenced by the quality of resources and the various stimuli that are released by the materials in their environment (Romero et al. 2010). Additionally, researchers have confirmed that *T. castaneum* were not attracted to the white colour of the paint; this conclusion was reached based on additional experiments regarding the species' attraction to color. Basically, colors were not shown significant difference in attracting *T. castaneum* with F-value= 0.89 and P= 0.506. The results of that study demonstrated that only 18% of *T. castaneum* were attracted to the color white (Figure 1). The colour yellow attracted the highest number of *T. castaneum,* followed by green and white. According to Lopez et al. (2009), insects tend to choose their favourite colors according to environmental factors such as habitat and food sources.

However, this argument contradicts our results, which revealed that *T. castaneum* were attracted to the color yellow even if their habitat and food sources were primarily white in color. This may also indicate that *T. castaneum* prefer to use their olfactory sense over their sense of vision when in need of a major daily tool. The analysis also has shown significant difference with T-value= 7.48; P-value= 0.000 dan DF= 44, that showing combination of odor and colour was influenced to attract of *T. castaneum.*

CONCLUSION

In future research, the type of paint, evaporation rates, and the spread of paint odors in the warehouse will be examined to fully understand the attraction preferences of the pest species, *T. castaneum.* Furthermore, the concentration of formaldehyde must be measured in each type of paint, and researchers should investigate the composition of the effective compounds in paint using Gas Chromatography-mass spectrometry (GC-MS) and Liquid chromatography-mass spectrometry (LCMS) in near future study.

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CONFLICT OF INTERESTS

The authors declare that no competing financial interests exist.

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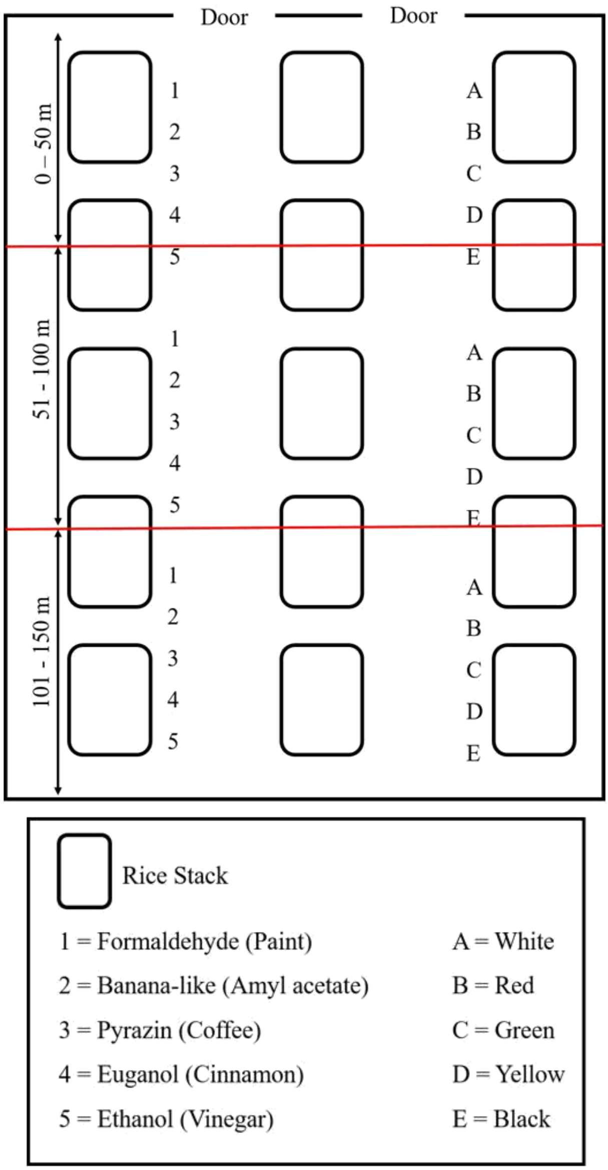

Figure 1 Trap illustration for the placement of odor compounds and colour sticky traps in the warehouse

Table 1 Abundance of *Tribolium castaneum* on different odor

Plot		Type of Compound					Total individual per plot
		Formal dehyde	**Banana**	**Pyrazine**	**Euganol**	**Ethanol**	
1	1	10	12	2	7	7	38
	2	19	10	3	0	12	44
	3	18	6	3	21	44	92
2	1	18	26	23	10	11	88
	2	45	26	9	14	14	108
	3	30	7	8	20	17	82
3	1	39	29	61	11	13	153
	2	38	14	39	1	11	103
	3	21	19	22	7	43	112
Total		**238**	**149**	**170**	**91**	**172**	**820**
Percentage (%)		**29**	**18**	**21**	**11**	**21**	

Table 2. Mean and P-value of odour compound

Odor compound	Mean	F-value	P-value
Formaldehyde	79.3	1.39	0.306
Banana-like	49.7		
Purazin	56.7		
Euganol	30.33		
Ethanol	57.3		