Studies on Low-Toxic Sugar Ester Based Pesticides against *Rhyzopertha Dominica*

A dissertation submitted in fulfillment of the requirement for the degree of Master of Philosophy

by

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ABSTRACT

Rhyzopertha dominica is a destructive, cosmopolitan pest of major concern to post-harvest storage of grains and other products. Failing in control of primary insect pest such as *R. dominica* assist the attack of cereal commodities by secondary pests and thus greater damages and losses. Conventional treatments rely heavily on rapid eradication of pest insects using synthetic organic chemicals. However, serious trade-off was only learnt after the broad-spectrum toxicity threatens our eco-system as well as health and the emerging of insect resistance. Insecticide research during the past decades have shift focus to seek for safer alternatives, preferably from natural sources with low toxicity, to ensure the biosecurity of stored grains world-wide. Inert dusts such as diatomaceous earths (DE), the fossil sediments of marine algae mainly composed of silica dioxides, have been used as grain protectants. This biosilica with delicate microstructures has demonstrated control on several insect species including *R. dominica* without the development of resistance. The inhibition mechanism of these effects was believed to be the absorption of cuticle wax by the micro- and nano-pores on DE which leads to dehydration then death of target insects. However, application of DE on stored grains has not been widely adopted. This is mainly due to its negative influences on grain appearance and processing as a result of relatively large effective amounts required. Research in this field has been worked on ways to address this challenge and increase their market acceptance. One promising approach is to combine DE with other safe additives, such as sugar esters. Synthetic sugar ester is a group of low-toxic insecticides produced from natural sources. Previous studies have demonstrated this compound was capable in killing insects without causing any adverse effects to other organisms. Owing to the surfactant nature, these compounds were believed to desiccate target insects via interrupting the cuticular wax layer. In this research, sugar esters were for the first time assayed against *R. dominica*. The synergistic effect from combining with DE has also been evaluated. A series of esters of fatty acids with polyols have been synthesized via direct esterification using an environment-friendly solvent-less method. These crude composites, namely sorbitol octanoate, sorbitol decanoate, sorbitol laurate, xylitol octanoate, xylitol decanoate and xylitol laurate were then purified using a two steps process. Qualitative analysis of the products was conducted using Fourier Transform Infrared (FTIR) and Nuclear Magnetic Resonance (NMR) spectroscopy methods. FTIR provided rapid and reliable identification for the characteristic functional group of sugar esters showing absorption bands. NMR spectra agree with the FTIR results, which have confirmed the formation of expected compounds. The insecticidal activity of these compounds was investigated where sorbitol octanoate was found to be the most effective at the concentration of 4000 ppm. No strong correlation of Hydrophilic-lipophilic balance values (HLB, calculated based on NMR spectra) associated with sugar ester's killing effect was observed as suggested by other research groups. It was also realized that purification was essential in order to enhance insect mortality. Further study has revealed that the mechanism of this compound on killing the insects is by contact rather than ingestion. Combination of sorbitol octanoate with DE was also studied. Data analysis showed that while there was an improvement in the quantity of DE required, the effect is not quiet synergistic where combined is less effective than expected. Lethal dosage of DE that were required to kill over 90% of insect population have been reduced from 700 ppm to 100 ppm when combined with 4000 ppm of sugar ester. Bulk density tests indicated that this formulation can increase grain hectoliter mass by 2-fold and reduced the angle of repose from 34 ˚ to 31 ˚ as opposed to 36 ˚ by 100ppm DE alone. Addition of sugar ester has effectively reduced the friction between DE treated grains which was proven to be a favourable strategy. Adherence of DE on *R. dominica*'s exoskeleton were investigated by both optical microscope and scanning electron microscope (SEM). Both techniques have shown a significant reduction of DE attachment on insect body when combined with sugar esters. Our finding supports the theory that inhibition mechanism may be due to penetration of the lipophile section of sugar ester in the cuticular layer.

DECLARATION

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree. I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968. I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time

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LIST OF PUBLICATIONS

Journal

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2. **Chen, H. S.**, Johnson, L., Collins, P. and Losic, D. (2015) Evaluation of sugar esters for stored grain protection in combination with diatomaceous earth (In preparation)

Conference Presentation

1. T. Kumeria, B. Manpreet, A. Tariq, **H. S. Chen**, K. Mahaveer, W. R. Yang and D. Losic (2012) Diatomite Silica - Graphene Oxide Based Nanohybrid Structures. In OzCarbon 2012. Adelaide
2. **H. S. Chen**, Johnson, J. T. Jennings, P. J. Collins and D. Losic (2014) Morphological study of the lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae) using FIB/SEM. in ICONN.ACMM 2014. Adelaide

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