Title Understanding the mode of action of elevated carbon dioxide for postharvest insect control

Author Tunyalee Martin, Christine Peng and Elizabeth Mitcham

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Abstract

One alternative to methyl bromide fumigation for the control of postharvest insect pests is the use of controlled atmospheres (CA). Typically insecticidal CA have oxygen (O_2) levels below 2% compared to air which contains 21%, or elevated carbon dioxide (CO_2) levels, up from 0.03% in air to 5-60%. Some atmospheres have a combination of both reduced O_2 and elevated CO_2.

The effects of reduced O_2 and elevated CO_2 on physiological changes in animals have been well studied. However, the cause of mortality, the mode of action, is still unknown. Therefore, the goal of my research was to select several theories on the mode of action presented in the literature and develop hypotheses to test. If we can understand the physiological responses of insects to CA and relate them to mortality, researchers could more quickly determine effective treatments.

I chose to develop experiments that tested the hypotheses of (1) reduced ATP levels indicating a decrease in energy supply, (2) decreased cell viability potentially indicating increased cell membrane permeability and (3) changes in the time to certain developmental parameters such as eclosion, oviposition, and life span indicating changes in the aging process. Additionally, using a mealybug species that is tolerant to CA and another that is more susceptible, I observed changes in metabolic heat rates, a measure of metabolism, to determine if differences between the two mealybug species explained differences in susceptibility.

I concluded that there was no relationship between ATP levels and mortality. However, a relationship between arginine phosphate and mortality was observed. We also observed responses suggesting differences in the mode of action of reduced O_2 and elevated CO_2. Controlled atmospheres caused no effects to cell viability of the insect fat body. Experiments observing differences between a susceptible and tolerant mealybug species suggest that metabolism may play a role in survival of CA. Tolerant mealybugs initially had higher metabolic rates in air and their metabolic heat rates remained higher during exposure to CA compared to susceptible mealybugs. Using past literature and the present experiments, a general idea of the mode of action is presented.