POSTHARVEST FUMIGATION RESEARCH AT USDA-ARS

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Abstract. Recent developments in postharvest chamber fumigations are presented, such as methyl bromide and alternative phytosanitary treatments for insect control, strategies to limit or reduce emission of fumigants to the atmosphere, and novel technologies for residue removal.

Introduction.

Agricultural industries are facing, with increasing frequency, environmental and pest-related food safety requirements that are fundamentally difficult to balance. Failure to disinfest foodstuffs in trade and marketing channels can result in insect- and microbial-derived damage which limits economic profitability, curtails market access, and, more importantly, vectors plant and animal illnesses. This report describes critical research elements of the Crop Protection and Quality Research Unit of the USDA-ARS-SJVASC that specifically address this contemporary dilemma, one that will only become more challenging and important as world-wide demand on production and distribution expands over the next decades.

Case-studies.

QPS methyl bromide. Methyl bromide (MB) chamber fumigations were evaluated for postharvest control of light brown apple moth, *Epiphyas postvittana* (Walker), in fresh fruit exports. To simulate external feeding, larvae were contained in gas-permeable cages and distributed throughout loads of peaches, plums, nectarines, apples, raspberries, or grapes. Differential sorption of MB by fresh fruit types and between replicate fumigation trials of the same fruit type resulted in a range of exposures that were verified by gas-chromatographic quantification of headspace concentrations. Concentration x time cross products (CTs) $\geq$ 60 and $\geq$ 72 $mgL^{-1}h$ at 10.0 ± 0.5 and 15.6 ± 0.5 °C ($\bar{x} \pm s$, AVE ± STDEV), respectively, resulted in complete mortality of ~ 6,200 larvae at each temperature. These confirmatory fumigations corroborate mortality data for the first time in relation to measured MB exposures and collectively contain the largest number of *E. postvittana* larvae tested to date. A kinetic model of MB sorption was also developed as a tool to identify how load factors and geometries can be manipulated for different fruit and packaging types to ensure that resulting exposures are consistent with the desired insecticidal efficacy.

Methyl bromide alternatives. Soak tanks and wash lines consistent with commercial cleaning and packing protocols of California were used to demonstrate that adult ACP are completely washed from citrus fruit that is submerged, flooded, or sprayed at high-pressures (~200 psi) and nearly 99% remain trapped by the solution until they drown or drain. Probit 9 level mortality (99.9968%) of adult ACP is observed after ≥ 3.3 min exposure to forced-air at temperatures used in commercial dryers (118-138°F). The cumulative effect of consecutive postharvest cleaning and packing elements is discussed in the context of evaluating ñsystemicò joint probabilities of ACP removal and mortality. The use of washing procedures, including dunking, flooding, and high-pressure spraying as part of cleaning and packing protocols results in ñACP-free fruitò, as there is zero joint probability of ACP remaining on the fruit surface, irrespective of orange cultivar. Moreover, ñHornò phosphine fumigation under 37°F cold-storage is discussed as a final value-added mitigation event to the systems-based approach.

Residue Remediation. Ozone fumigation was explored as a means for degrading organic fungicide residues on fresh produce. Fungicides sorbed onto model abiotic glass surfaces or onto grape berries were fumigated separately in a flow-through chamber. Gaseous ozone at a constant concentration of 150 ± 10 ppmv (μLL^{-1}) selectively oxidized fungicides sorbed to model surfaces. Over 140 min, boscalid and iprodione levels did not change significantly based on a single factor analysis of variance (ANOVA) at the 95% level of confidence (p = 0.05), however, *pseudo* first-order losses resulted in observable rate constants of ozonlysis, $k_{OZONOLYSIS}$ (min^{-1}), of 0.0233 ± 0.0029 ($t_{1/2} \approx$ 29.7 min), 0.0168 ± 0.0028 ($t_{1/2} \approx$ 41.3 min) and 0.0127 ± 0.0010 ($t_{1/2} \approx$ 54.6 min) for fenhexamid, cyprodinil, and pyrimethanil, respectively. The relative degradation of fungicides on berries at gaseous ozone concentrations of 900 ± 12 ppmv (μLL^{-1}) over 2 h was similar to that on glass; decreases in residue concentration were observed for only fenhexamid (~ 64%), cyprodinil (~ 38%), and pyrimethanil (~ 35%) with corresponding $k_{OZONOLYSIS}$ (min^{-1}) of 0.0085 ± 0.0021 ($t_{1/2} \approx$ 81.5 min), 0.0039 ± 0.0008 ($t_{1/2} \approx$ 177.7 min) and 0.0036 ± 0.0007 ($t_{1/2} \approx$ 192.5 min). Heterogeneous rate constants of gaseous ozone reacting with a sorbed fungicide, k_{O3} ($M^{-1}min^{-1}$), were calculated for both surfaces and indicate losses proceed ~15-fold slower on grapes. The kinetics and mechanism of fungicide removal, supported by gas chromatography- and liquid chromatography-mass spectrometry product analyses, is discussed in the context of facilitating compliance with maximum residue level (MRL) tolerances for fresh produce.

References.

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