The Toxicity of Acetaldehyde Vapors to Postharvest Pathogens of Fruits and Vegetables

Yair Aharoni and Glenn J. Stadelbacher

Department of Horticulture, University of Maryland, College Park 20742. Present address of senior author: Division of Fruit & Vegetable Storage, The Volcani Institute of Agricultural Research, Bet Dagan, P.O.B. 6, Israel.

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ABSTRACT

Acetaldehyde vapors at some concentrations, ranging from 0.25% to 20.0% and applied for 0.50 to 120 min at room temperatures, killed all six tested microorganisms. Sublethal concentrations and exposure periods retarded microorganism growth. The most sensitive among tested microorganisms was *Erwinia carotovora*. *Pseudomonas fluorescens*, *Botrytis cinerea*, and *Monilinia fructicola* were less sensitive than was *E. carotovora*, whereas *Rhizopus stolonifer* and *Penicillium expansum* were most resistant.

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Decay in strawberries, inoculated with spores of *Botrytis* and *Rhizopus*, was greatly reduced when stored in atmosphere of 20% CO_2 and 2% O_2 (1). This atmosphere stimulated production of acetaldehyde by the strawberries. Acetaldehyde (Aa) added to the regular storage atmosphere at concentrations of 0.25%, 0.50%, 1.00%, and 2.00% controlled the incidence of storage decay caused by *Botrytis* and *Rhizopus* (1). The results indicated a feasibility for control of postharvest decay of produce in marketing channels and storage.

This paper reports results on lethal doses of Aa vapors and exposure time required to control certain microorganisms that cause postharvest decay of fruits and vegetables.

Cultures of *Botrytis cinerea* (Pers. ex Fr.), *Rhizopus stolonifer* (Ehr. ex Fr.) Lind and *Monilinia fructicola* (Wint.) Honey were grown on pea agar, *Penicillium expansum* (Link. ex Thom.) on potato-dextrose agar, *Erwinia carotovora* (Jones) Holland on nutrient agar, and *Pseudomonas fluorescens* Migula on Starr's medium. The chambers (3 mm deep and 16 mm in diam) of culture slides were filled with melted media, hardened, and inoculated with 3×10^5 to 4×10^5 spores or bacteria cells. Inoculated slides were placed on a wire mesh screen in an 8-liter desiccator. To attain the desired vapor concentrations (expressed as percent of atmosphere by volume), aliquots of liquid Aa were injected into the desiccator. Syringes were chilled on ice prior to injections, since Aa boils at 20.8 C. Vapor equilibrium was established by use of a magnetic stirrer, within 15 sec, as determined by gas chromatography. The experiments were conducted at room temperatures (23-27 C). The treatments are presented in Table 1. Six replicates were employed. The controls were not exposed to Aa. The inoculated agar discs, after exposure to Aa vapors, were transferred to petri dishes containing the same medium. The plates were incubated 16 days at 23-27 C. Where growth occurred, colony diameter was measured. Cultures showing no growth at the end of 16 days were considered killed.

Various treatments of Aa concentrations and exposure times were effective in killing all six microorganisms tested (Table 1). There was a relationship between Aa concentration and exposure time; the lower the concentration the longer the time required to obtain complete kill. Species differed in their response to Aa vapors. *E. carotovora* was the most sensitive, whereas *R. stolonifer* and *P. expansum* were the most resistant. Shaw (1) reported that Aa at concentrations of 0.25%, 0.50%, 1.00%, and 2.00% and exposure time of 20 hr, was fungicidal to *Botrytis* and *Rhizopus*. This investigation, however, indicates that Aa may be either fungicidal or growth-retarding, depending on the organism, Aa concentration, and exposure time (Tables 1, 2).

Growth retardant data (Table 2) indicate that growth proceeds at a fast rate once germination has occurred (66% reduction of *Rhizopus* growth after 2 days when treated with 2% Aa for 30 min versus only 6% reduction after 3 days). The writers believe that the delay in growth from sublethal rates of acetaldehyde may be due to the survival of dormant spores that normally germinate more slowly. These spores would be expected to be more resistant to a fumigant. The fact that all *Erwinia* cells were killed by 14 of 15 treatments whereas complete kill of *Rhizopus* spores occurred in only 5 of 17 treatments (Table 2) would offer some support for this theory. Time-lapse microphotography studies are being initiated to determine if mycelium growth rate is actually reduced or if the so-called growth retardation is due to delayed germination which may or may not be caused by Aa.

The results obtained in this investigation support the previous contentions of Shaw (1) that Aa kills decay-causing microorganisms. This work demonstrates that microorganism control can be accomplished in 30 sec when Aa concentrations are increased to 20% by volume. Although Aa vapors can be phytotoxic, preliminary results with strawberries (2) show that certain levels of Aa vapors may control the pathogen without injuring the product.

TABLE 1. Effect of various acetaldehyde (Aa) vapor concentrations and exposures on survival of six microorganisms[a]

% Aa	Exposure (min)	% Killed[b]					
		Botrytis cinerea	*Penicillium expansum*	*Rhizopus stolonifer*	*Monilinia fructicola*	*Erwinia carotovora*	*Pseudomonas fluorescens*
0.25	60	0	0	0	17	100	0
0.25	90	0	0	0	100	100	100
0.50	60	50	0	0	17	100	34
0.50	90	50	0	0	100	100	100
0.50	120		100	17			
0.75	60	100	0	0	17	100	100
0.75	90	100	0	100	100	100	100
0.75	120		100				
1.00	60	100	0	0	17	100	100
2.00	30	100	17	50	100	100	100
4.00	5	0	0	0	0	0	0
4.00	20	0	17	0	100	100	100
6.00	5	83	100	0	100	100	0
6.00	20	100		100			
8.00	5	100	100	0	100	100	100
10.00	10	100	100	100	100	100	100
15.00	5	100	100	100	100	100	100
20.00	0.50	100	100	100	100	100	100
Control[c]	–[c]	0	0	0	0	0	0

[a] Percent Aa vapor by volume in the atmosphere.
[b] Numbers represent percent of replicates that failed to grow after treatments during 16-day observation periods.
[c] Control, the same as treatments except exposed to atmosphere without Aa.

TABLE 2. Effect of acetaldehyde (Aa) vapors on growth of surviving colonies[a]

% Aa	Exposure (min)	% Reduction of linear growth[b]											
		Botrytis cinerea		*Penicillium expansum*		*Rhizopus stolonifer*		*Monilinia fructicola*		*Erwinia carotovora*		*Pseudomonas fluorescens*	
		Days after treatment[c]											
		3	5	5	8	2	3	3	6	3	6	6	16
0.25	60	10	0	75	12	0	0	54	0			0	0
0.25	90	45	0	78	10	10	0						
0.50	60	76	47	77	14	15	0	87	33			37	7
0.50	90	78	47	81	19	24	0						
0.75	60			89	43	89	29	100	37				
0.75	90			89	43								
1.00	60			87	39								
2.00	30			75	33	66	6						
4.00	5	89	60	30	7	0	0	90	13	70	13	37	0
4.00	20			100	51	76	25						
6.00	5					74	21					41	14
8.00	5					100	80						
10.00	5					100	100						

[a] Growth of colonies was recorded in mm diameter.
[b] Results represent average of one-six colonies, surviving the treatments, as percent reduction when control was considered zero.
[c] First date – period at which greatest differences in growth among surviving colonies were recorded; second date – data to illustrate recovery of surviving microorganisms.

LITERATURE CITED

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