FINAL REPORT

Title: Storage Decay and Postharvest Quality Research

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Objective: This research blends activities in the areas of postharvest pathology and physiology. One objective is to further develop a storage decay control program for winter pears in which diverse, independent decay control practices contribute to dependable reduction of postharvest diseases. A second objective is to develop and evaluate methods and materials for the promotion of pear quality during storage.

Significant Findings:

1. It was previously found that Bosc pears treated with 100 ppm ethylene for 24 hr at 68°F could replace the 2 weeks cold storage necessary for Bosc to develop the capacity to ripen uniformly. New results indicate that ripening can occur with a shortened ethylene treatment of 12 hr + 2 days cold, or 6 hr + 7 days cold (Table 1). However, eating quality was unsatisfactory with less than 24 hr ethylene + 7 days cold, or 12 hr. ethylene + 12 days cold.

2. Early harvested Comice pears treated with MCP at 50, 100, or 200 ppb did not ripen adequately after 5 months cold storage (Table 2). Late harvested Comice ripened to good quality following MCP treatment at 50 or 100 ppb after 5 months storage, but did not ripen adequately following treatment at 200 ppb.

3. Early harvested Bosc pears treated with MCP at 50 or 100 ppb failed to ripen after 6 months cold storage (Table 3). Late harvested Bosc showed unacceptable levels of internal breakdown after 6 month cold storage despite MCP treatments.

4. Tests of postharvest and preharvest fungicides against a range of pathogens causing postharvest decay resulted in effectiveness profiles for each fungicide (Table 4). Scholar and Pristine were effective against all pathogens except *Neofabraea alba*, one of the bull's eye rot fungi. Evaluation of decay control treatments using inoculated fruit are in progress.

5. A potential "biofumigant" biological control agent, *Muscodor albus*, was a powerful suppressant of blue mold and gray mold when inoculated fruit were kept in a sealed container for 24 hours at room temperature before cold storage (Tables 5-7). Treatments were much less effective when placed directly into cold storage, except in the case of Cladosporium rot (Table 6). *Muscodor* does not show much activity in reducing blue mold contamination of wooden bin surfaces.

6. Laser labeling of pears does not appear to provide an entry point for decay-causing microorganisms. Decay did not preferentially develop at labels when pathogen spores were pressure or vacuum infiltrated into fruit.

7. Evaluation of other storage decay projects focused on orchard and postharvest integrated management is in progress.

Results and Discussion:

1. Bosc pears typically require approximately 2 weeks of cold storage before developing the capacity to ripen to a buttery texture. Previously it was demonstrated in this project that 100 ppm ethylene for 24 hr at 68°F could replace the chilling requirement in Bosc. An attempt was made to identify shorter periods of exposure to ethylene that would still allow ripening. Using a standard of ripeness of 6 lb. firmness, ripeness was achieved within 7 days at room temperature following ethylene exposure for 12 hr. followed by 2 days cold (31°F), or for 6 hr. followed by 7 days cold. Although ripening was achieved with as little as 12 hr. + 2 days cold, or 6 hr. + 7 days cold, flavor was lacking until fruit received a minimum of 24 hr ethylene + 7 days cold, or 12 hr. ethylene + 12 days cold.

2. Lowering dosage of MCP does not appear to be a sufficient solution to the previously observed problem of excessive inhibition of ripening of Bosc and Comice pears. Late harvest of Comice followed by MCP treatments led to ripening with good quality at 5 months, which may be useful. However, the predictability of this strategy remains to be established. In current tests to be evaluated in spring 2005, Comice and Bosc pears were exposed to ethylene prior to MCP treatments.

3. Effectiveness profiles of fungicides used in pre- or postharvest treatments for pear decay control show a wide range of diversity among fungicides. Scholar and Pristine had the broadest range of effectiveness among postharvest pathogens, followed by Penbotec. These results indicate the value of knowing the target fungi for designing the most effective treatment strategy. They also show the excellent potential of newer fungicides to give broad-spectrum decay control.

4. *Muscodor albus* is a fungus that, growing on grain, emits volatile compounds that can inhibit other microorganisms. This form of biological control, called “biofumigation”, does not involve direct contact between the biocontrol agent and the pathogen or fruit. When placed in sealed containers with pear postharvest pathogens growing on agar in petri dishes, *Muscodor* inhibited growth of postharvest pathogens, as long as the pathogen did not have more than a 24 hour head start in growth. With inoculated fruit, a 24 hour exposure to *Muscodor* at room temperature was necessary prior to cold storage. This treatment was only moderately effective against gray mold, but highly effective against blue mold. Cladosporium rot was controlled by *Muscodor* at cold temperatures, even without pre-treatment in cold. Tests using *Muscodor* to sterilize wooden bin surfaces has thus far not shown much promise.

5. Laser labeling may find acceptance as an alternative to stickers in labeling individual pear fruit. Since the labeling in accomplished by a certain amount of injury to fruit cells, tests were carried out to determine if labels can become entry points for postharvest pathogens. Pressure and vacuum infiltration methods with various pathogens have thus far shown that laser labels do not provide such entry points for decay pathogens.

Table 1. Ripeness of Bosc pears after various combinations of ethylene treatment and post-ethylene cold storage. Pears were harvested at an average firmness of 16 lbs.

	Days at 31°F after ethylene treatment				
Hours in ethylene	**0**	**2**	**7**	**12**	**15**
	Fruit firmness after 7 day ripening period at 68°F				
0	14.3	13.7 a	8.8 a	3.3 a	3.3 a
6	-	13.9 a	3.6 b	3.3 a	3.0 b
12	-	5.9 b	3.5 b	2.7 b	2.6 bc
24	-	2.9 c	2.6 c	2.5 b	2.3 c

Table 2. MCP effect on Comice Pears.

I. Comice early harvest (12 Sept. 2003, 12.2 lb) followed by 5 months storage.

	Fruit firmness (lbs)					**% of fruit ripe (< 5 lb)**					**% of fruit with internal browning**			
	Days at 20 C					**Days at 20 C**					**Days at 20 C**			
MCP (ppb)	**0**	**5**	**7**	**10**		**0**	**5**	**7**	**10**		**0**	**5**	**7**	**10**
0	10.1 a	2.5 a	2.5 a	1.9 a		0	95	95	95		0	0	35	75
50	11.6 b	7.5 b	8.0 b	7.4 b		0	30	5	25		0	0	0	0
100	11.6 b	11.2 c	10.2 c	9.7 c		0	0	0	5		0	0	0	0
200	12.1 b	11.3 c	10.8 c	11.2 c		0	0	0	0		0	0	0	0
Quality: 0 MCP extensive breakdown; all MCP treatments inadequate ripening, coarse and dry.														

II. Comice late harvest (1 Oct., 2003, 10.8 lb) followed by 5 months storage.

	Fruit firmness (lbs)					**% of fruit ripe (< 5 lb)**					**% of fruit with internal browning**			
	Days at 20 C					**Days at 20 C**					**Days at 20 C**			
MCP (ppb)	**0**	**5**	**7**	**10**		**0**	**5**	**7**	**10**		**0**	**5**	**7**	**10**
0	7.3 a	2.0 a	1.7 a	1.0 a		0	100	94	100		0	45	89	90
50	9.8 c	2.2 a	1.6 a	0.9 a		0	95	100	100		0	0	0	35
100	9.0 b	2.0 a	1.3 a	0.7 a		0	100	100	100		0	0	0	30
200	10.2 c	6.3 b	4.6 b	4.0 b		0	20	55	75		0	0	0	0
Quality: 0 MCP extensive breakdown; MCP 50-100 ppb good flavor, text., juiciness at day 5.														

Table 3. MCP effect on Bosc Pears.

I. Bosc early harvest (12 Sept., 2003, 17.0 lb) followed by 6 months storage.

	Fruit firmness (lbs)				**% of fruit ripe (< 5 lb)**				**% of fruit with internal browning**		
	Days at 20 C				**Days at 20 C**				**Days at 20 C**		
	0	**5**	**8**		**0**	**5**	**8**		**0**	**5**	**8**
0	14.1	4.7 a	-		0	90	-		0	10	100
50	15.7	13.2 b	13.0		0	0	0		0	0	0
100	15.9	13.4 b	13.0		0	10	5		0	0	0
Quality: Inadequate ripening in all MCP treatments.											

II. Bosc late harvest (15 Oct., 2003, 13.7 lb) followed by 6 months storage.

	Fruit firmness (lbs)				**% of fruit ripe (< 5 lb)**				**% of fruit with internal browning**		
	Days at 20 C				**Days at 20 C**				**Days at 20 C**		
	0	**5**	**8**		**0**	**5**	**8**		**0**	**5**	**8**
0	11.1	4.7	4.0		0	71	93		19	7	29
50	12.2	4.2	3.4		0	95	90		0	30	30
100	11.1	3.8	3.0		0	100	100		10	10	30
Quality: Inadequate ripening in all MCP treatments. Breakdown in all treatments.											

Table 4. Inhibition of postharvest decay pathogens by various fungicides tested *in vitro*[1].

	Inhibition *in vitro* at 1000 ppm						
	Postharvest fungicides			**Preharvest fungicides**			
Pathogen[2]	**Mertect**	**Penbotec**	**Scholar**	**Pristine**	**Flint**	**Ziram**	**Topsin**
Penicillium expansum	+	+	+	+	+	-	-
Botrytis cinerea	+	+	+	+	-	+	+
Cladosporium herbarum	-	-	+	+	+	-	+
Alternaria sp.	-	+	+	+	-	+	-
Phialophora malorum	-	+	+	+	+	+	-
Neofabraea alba	-	-	-	-	-	+	-
Neofabraea perennans	-	+	+	+	+	+	-

[1] *In vitro* test: filter paper disks soaked in fungicide solutions were place on agar plates freshly seeded with spores of the pathogen. Zones of inhibition (no fungal growth) around disks were observed 3-10 days later. + = growth inhibited, - = growth not inhibited. Note: single isolate of each fungus tested; may not reflect response of other individuals in a genetically diverse population.

[2] *Penicillium expansum* = blue mold *Botrytis cinerea* = gray mold *Phialophora malorum* = side rot
Cladosporium herbarum = Cladosporium rot (symptoms indistinguishable from side rot)
Alternaria sp. = Alternaria rot (symptoms indistinguishable from side rot)
Neofabraea alba = bull's eye rot *Neofabraea perennans* = bull's eye rot

Table 5. Effect of *Muscodor albus* "biofumigant" on decay in Bosc pears exposed at room temperature for 24 or 48 hours prior to 2 months storage at 31°F.

	Botrytis cinerea **(gray mold)**		***Penicillium expansum*** **(blue mold)**	
	Lesion diameter (mm)	**% wounds infected**	**Lesion diameter (mm)**	**% wounds infected**
48 hr. without *Muscodor*	45.9 a	100.0 a	15.7 a	100.0 a
24 hr. without *Muscodor*	32.6 b	97.8 b	9.4 b	88.9 a
48 hr. + *Muscodor*	12.8 c	51.1 c	3.4 c	33.3 b
24 hr. + *Muscodor*	5.6 d	31.1 d	0.0 d	0.0 c

P value	<0.001	<0.001	<0.001	<0.001

Table 6. Effect of *Muscodor albus* "biofumigant" on decay in Bosc pears maintained 2 months at 31°F in LifeSpan modified atmosphere packaging.

	***Botrytis cinerea* (gray mold)**		***Penicillium expansum* (blue mold)**		***Cladosporium herbarum***	
	Lesion diameter (mm)	**% wounds infected**	**Lesion diameter (mm)**	**% wounds infected**	**Lesion diameter (mm)**	**% wounds infected**
Standard liner without *Muscodor*	31.9 a	100 a	14.1 a	100 a	10.3 a	100.0 a
LifeSpan without *Muscodor*	21.1 b	100 a	12.5 b	100 a	2.2 b	30.0 b
LifeSpan + *Muscodor*	14.2 c	90 b	8.8 c	75 b	0.0 c	0.0 c
P value	<0.001	0.002	<0.001	<0.001	<0.001	<0.001

Table 7. Survival of pear postharvest pathogens on agar in petri dishes exposed to *Muscodor albus* at 68 and 31°F.

	Growth of colonies					
	Penicillium expansum		***Botrytis cinerea***		***Cladosporium herbarum***	
	Musc.	**No *Musc.***	***Musc.***	**No *Musc.***	***Musc.***	**No *Musc.***
24 h exposure at 68°F	no	yes	no	yes	no	yes
48 h exposure at 68°F	no	yes	no	yes	no	yes
24 h growth, then 24 h exposure at 68°F	no	yes	no	yes	no	yes
48 h growth, then 24 h exposure at 68°F	yes	yes	yes	yes	no	yes
72 h growth, then 24 h exposure at 68°F	yes	yes	yes	yes	yes	yes
24 h growth, then 1 wk exposure at 31°F	no	yes	no	yes	no	yes
48 h growth, then 1 wk	yes	yes	yes	yes	no	yes

exposure at 31°F						
72 h growth, then 1 wk exposure at 31°F	yes	yes	yes	yes	yes	yes