Progress Report and Proposal - Pear Research Review, 2000

TITLE Effect of Paper Wraps on Postharvest Decay and Disorders of Anjou Pear Fruit

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JUSTIFICATION

Washington pears are wrapped in tissue paper at packing to protect fruit from damage during shipping. In addition, wraps are commonly impregnated with either oil, copper, or ethoxyquin, alone or in combination, to prevent superficial scald and the spread of decay, especially gray mold (caused by *Botrytis cinerea* Pers.: Fr), in packed fruit. The effectiveness of paper treatments in preventing spread of decay has not been formally assessed. Oil wraps were used to prevent storage scald prior to the introduction of ethoxyquin treatments, either as wraps, line sprays, or drenches. In recent years however, oil wraps have been implicated with the occurrence of other fruit skin disorders, especially calyx-end browning (CEB [= DSD]).

OBJECTIVES

- Determine the effectiveness of paper wraps used in pear packing in preventing the spread of gray mold in packed boxes of Anjou pear fruit.
- Assess the effects of various wraps on fruit skin disorders.

PROGRESS

Procedures

Decay. All fruit in six single replicate boxes (US No.1, size 100) of commercially harvested Anjou pears were wrapped in one of 7 papers or left unwrapped. The fruit was from a single grower run at each of two warehouses in 1997 and three warehouses in 1998. The wraps included those treated with 6% oil, 3% oil + copper, 6% oil + copper, Supercop (6% oil + copper + ethoxyquin), plain(dry), powdered, and copper alone in the 1997 trial. In 1998, the powdered paper was eliminated and a low oil Supercop (3% oil + copper + ethoxyquin) was added. All of the boxes were lined with perforated poly liners. Two wounded, inoculated fruit, each wrapped in the same paper as the other fruit in the respective boxes, were placed in each of two locations in each box to create infection foci. After packing, boxes from each warehouse were placed in commercial CA storage at 30 - 31°F for approximately 31 weeks at the respective warehouses. In 1997, fruit were kept in standard CA conditions (1.5% - 3.5 % O_2, < 1.0% CO_2) for 140 days after which they were held in regular air storage. In 1998, the fruit from two warehouses remained in standard CA storage until about one week before assessment, while the third warehouse slowly raised the oxygen and carbon dioxide levels in the last 12 weeks of storage.

Nesting was assessed by determining the number of fruit with lesions adjacent to those that had been inoculated.

Storage disorders. Fruit from each treatment were assessed for the incidence of each of several disorders including superficial scald, calyx-end browning, and dark skin-burn within 24 hrs after they were removed from refrigeration and again 7 days later. In 1997, the proportion of fruit with each disorder was determined in a single box of fruit from warehouse 1 and two boxes from warehouse 2. In addition, scald on fruit from warehouse 2 was rated for severity (S) on a 0-3 scale (0 = no scald and 3 = severe scald) and a severity index (SI) was calculated where SI = the sum of the proportion of fruit in each severity class multiplied by S. In 1998, every box of fruit (48 boxes) in each of three warehouses was assessed for incidence of calyx-end browning, dark skin-burn, and scald. Scald severity was also rated and SI calculated.

Results and Discussion

Decay. Paper wraps significantly reduced the incidence of gray mold nesting in packed boxes of Anjou pears compared to unwrapped controls in both years. Aerial mycelia were observed on the surface of paper wraps covering some inoculated fruit in all treatments, but these mycelia did not always produce secondary infections on adjacent fruit. In 1997, decay incidence was reduced from 4.5% of fruit with symptoms in unwrapped fruit to <2.0% in those wrapped with oiled papers and 2.3% in those wrapped with powdered paper (Table 1). Neither paper wraps impregnated with copper alone or plain paper had a significant effect on nesting. In 1998, however, all of the papers tested, including plain and copper alone, significantly reduced gray mold nesting from 6.0% of fruit with symptoms in unwrapped fruit to <3.4% by all other wraps (Table 2).

Storage disorders. *Calyx-end browning.* Symptoms appeared as light brown areas with irregular margins primarily at the calyx-end of fruit and often extended mid-way up the cheeks of fruit. Symptoms were present on fruit at the time they were removed from storage and the area affected did not increase over time. Interestingly, when PLU stickers were present in symptomatic areas, fruit skin appeared green and healthy under the stickers, and browning was not apparent.

Although oil containing papers were effective at reducing gray mold nesting, oil may cause or lead to conditions under which CEB occurs. In both years, symptoms were most prevalent in fruit wrapped with papers containing 6% oil alone (Tables 1 and 2). Incidence decreased with the addition of copper to the oil. Calyx-end browning was essentially eliminated with the addition of ethoxyquin. Less than 1.5% of fruit developed CEB symptoms in either unwrapped fruit or those in dry paper.

Superficial scald. Scald symptoms began to develop about 1.5 days after fruit were removed from storage and placed at room temperature. In contrast with CEB symptoms, scald increased in severity, both in area affected and darkness of marking, up to about 6 days after removal from storage. Margins of affected areas were irregular and scald extended to areas under PLU stickers.

In both years, significantly less scald was apparent in fruit wrapped with oil treated papers than in fruit wrapped with dry papers (Tables 2 and 3). Addition of copper to oiled paper

appeared to further reduce scald. Superficial scald was lowest in fruit wrapped with Supercop papers and no significant difference was apparent between formulations in 1998 (Table 2).

Other disorders. In 1997, dark-skin burn was present in fruit from warehouse 2. Symptoms of this disorder were blackened blotches (about 2-3 cm diam.) with irregular margins that appeared to occur randomly over the fruit surface and were apparent upon removal from cold storage. Dark skin-burn was not observed in fruit from warehouse 1. Copper impregnated paper wraps, both with and without oil, appeared to alleviate this symptom (Table 3). Highest incidence of dark skin-burn was observed in fruit wrapped in powdered paper (75.6% of fruit affected). Paper with oil alone and plain paper had no effect on dark skin-burn incidence compared to the unwrapped control.

In 1998, relatively little dark skin-burn was observed. However, a high incidence of speckling was apparent in fruit only from warehouse 2. Speckling was apparent upon removal of fruit from cold storage. Initial symptoms appeared as distinct brown spots (1 mm diam.) that often had coalesced into larger patches. Symptoms were not confined to any obvious region of the fruit surface. Highest incidence of speckling (42.2% of fruit affected) occurred in unwrapped fruit (Table 2). All papers reduced the incidence of speckling over that in unwrapped fruit, but Supercop papers had the greatest effect on reduction of speckling ($\leq$ 2.2% of fruit affected).

It was also noted in 1998, that small burns occurred on fruit wrapped in papers containing copper that were wet from juice or condensation. These burns were usually associated with Mucor rot and may be mistaken for incipient decay lesions.

Conclusions

Paper treatments affected decay and storage disorders differentially. The interaction of copper and oil was apparent in both years. Oiled paper was effective against gray mold nesting and scald. In 1997, copper in the paper had no appreciable effect on gray mold nesting, but appeared to have some effect on scald when it was combined with oil. In 1998, copper alone did reduce gray mold nesting relative to that which occurred in unwrapped fruit. Calyx-end browning incidence was greatest in oil treated paper, in both years, and copper appeared to ameliorate that effect. In addition, although oil was not associated with dark skin-burn, copper appeared to be very effective at eliminating that disorder. Scald control was improved by the addition of ethoxyquin to the paper wrap in both years, and may allow the use of oiled paper for decay and scald control. Supercop paper was also effective at reducing the incidence of speckling.

The cause of the storage disorders examined in this study are not known. However, their incidence and/or severity were greatly affected by the type of paper wrap used (oil, copper, or ethoxyquin treated). The differential effects of the materials used in the wraps suggest different causes for the various disorders. A serious look at the causal factors of these disorders and the mode of action in which the paper treatments affect them is warranted.

PROPOSAL

Purpose

This test is to determine if fruit storage in controlled atmosphere is requisite for the development of calyx-end browning (CEB) in fruit wrapped oiled paper.

Procedures

Three single replicate boxes of fruit from each of three lots of commercially run fruit will be packed with one of three paper wraps. Wraps will consist of: Plain (dry), Oil (6%), and Oil (3%) + copper + ethoxyquin. After packing, fruit will be placed in either in standard CA storage (1.5% O_2 and <1% CO_2) or regular atmosphere storage and held for about 6mo.

Fruit will be assessed for CEB, scald, and other disorders upon removal from storage.

ANTICIPATED BENEFITS

Packers will be able to make informed decisions on which of the paper wraps available on the market are most cost effective for protecting fruit from spread of decay and occurrence of skin disorders.

PUBLICATIONS:

Sanderson, P. G. and Bennett, D. L. 1999. Effect of Paper Wraps on Postharvest Decay and Disorders of Anjou Pear Fruit. Proc. Wash. State Hortic. Assoc. 94:.

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Table 1. Effect of paper fruit wraps on nesting of *Botrytis cinerea* and calyx-end browning in packed Anjou pear fruit after 31 weeks of storage at 31 F in a commercial storage.[x]

Treatment	Decay (%)	Calyx-end browning (%)
No wrap	4.5 a[y]	0.0 c
Oil (6%)	1.8 b	58.6 a
Oil (3%) + copper	1.5 b	17.2 b
Oil (6%) + copper	2.0 b	5.3 bc
Supercop (oil (6%) + copper + ethoxyquin)	1.7 b	0.7 c
Plain (dry)	3.1 ab	0.4 c
Powdered	2.3 b	0.0 c
Copper	2.9 ab	0.0 c
	($P = 0.001$)[z]	($P < 0.001$)

[x] Fruit were held in CA for about 140 days after which they were kept in regular air storage.
[y] Means followed with a common letter are not significantly different according to Tukey's test ($P = 0.05$).
[z] Significance of F statistic from analysis of variance. Percentages were transformed to arcsin $\sqrt{\text{prop.}}$ values before analysis.

Table 2. Effect of paper fruit wraps on nesting of *Botrytis cinerea* and calyx-end browning in packed Anjou pear fruit after 31 weeks of storage at 30 F in a commercial storage.

Treatment	Decay (%)	Calyx-end browning (%)	Superficial scald (SI)[w]	Skin Speckling[x] (%)
No wrap	6.0 a	1.4 cd	79.5 ab	42.2 e
Oil (6%)	1.1 c	37.1 a	35.6 c	21.5 de
Oil (3%) + copper	1.6 bc	5.4 b	29.2 c	10.7 cd
Oil (6%) + copper	1.4 bc	2.3 c	28.6 c	14.2 d
Supercop (oil (3%) + copper + ethoxyquin)	3.4 b	0.0 d	19.2 d	2.2 ab
Supercop (oil (6%) + copper + ethoxyquin)	2.6 bc	0.1 d	17.3 d	0.0 a
Plain (dry)	1.8 bc	0.0 d	87.7 a	9.3 cd
Copper	2.7 bc	0.0 d	77.6 b	4.7 bc
	($P < 0.001$)[z]	($P < 0.001$)	($P < 0.001$)	($P < 0.001$)

[w] SI = ∑proportion of fruit in each severity class × S. Rating was on a 0-3 rating scale with 0 = no scald and 3 = severe scald.

[x] Warehouse 2 only.

[y] Means followed with a common letter are not significantly different according to Tukey's test ($P = 0.05$).

[z] Significance of F statistic from analysis of variance. Percentages were transformed to arcsin $\sqrt{\text{prop.}}$ values before analysis.

Table 3. Effect of paper fruit wraps on superficial scald and dark skin burn on Anjou pear fruit after 31 weeks of storage at 31 F in a commercial storage.[w]

	Warehouse 1		Warehouse 2	
Treatment	Superficial scald (%)	Burn (%)	Superficial scald (SI)[x]	Burn (%)
No wrap	96.5	0.0	96.7 a[y]	26.3 bc
Oil (6%)	18.5	0.0	46.7 b	25.8 bc
Oil (3%) + copper	14.5	0.0	30.0 c	1.7 d
Oil (6%) + copper	33.0	0.0	33.3 c	0.0 d
Supercop (oil (6%) + copper + ethoxyquin)	4.2	0.0	16.7 d	0.0 d
Plain (dry)	97.9	0.0	96.7 a	44.5 b
Powdered	98.9	0.0	96.7 a	75.6 a
Copper	67.7	0.0	90.0 a	5.9 cd
			($P < 0.001$)[z]	($P < 0.001$)

[w] Fruit were held in CA for about 140 days after which they were kept in regular air storage.
[x] SI = ∑proportion of fruit in each severity class × S. Rating was on a 0-3 rating scale with 0 = no scald and 3 = severe scald.
[y] Means in each column followed with a common letter are not significantly different according to Tukey's test ($P = 0.05$).
[z] Significance of F statistic from analysis of variance. Percentages were transformed to $\arcsin\sqrt{\text{prop.}}$ values before analysis.