Removal of Sooty Blotch and Flyspeck from Apple Fruit with a Chlorine Dip

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ABSTRACT

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Sooty blotch, caused by *Gloeodes pomigena*, and flyspeck, caused by *Zygophiala jamaicensis*, were removed from apple fruit with a postharvest chlorine dip. A 5- to 7-min dip in 500 ppm of chlorine in the dump tank of a commercial packing line, followed by brushing and a fresh water rinse, reduced the incidence of sooty blotch from 100 to 0% and flyspeck from 100 to 27%. Apples stored for 3 mo after removal of sooty blotch and flyspeck lost only 3.6–4.7% weight. Neither chlorine treatment nor waxing or brushing affected weight loss. Pesticide residues were reduced by the treatment. No phytotoxicity was observed on Red Delicious apple fruit exposed to 4,100 ppm of chlorine for 15 min, a level and treatment period far in excess of that required for effectively reducing disease incidence.

In an effort to develop an Integrated Pest Management (IPM) approach to apple insect and disease control, development of sooty blotch, caused by *Gloeodes pomigena* (Schwein.) Colby, and flyspeck, caused *Zygophiala jamaicensis* E. Mason (teleomorph = *Schizothyrium pomi* (Mont. & Fr.) Arx), was observed weekly in 1986 and 1987. These diseases were not adequately controlled by applying registered fungicides after disease development began on the fruit. Because control of these diseases is essential for production of marketable fruit, alternatives were evaluated. A postharvest chlorine dip proved promising in initial tests and was evaluated further.

Chlorine has been used extensively as a postharvest germicide. Eckert and Sommer (1) reviewed the literature on the use of chlorine for control of postharvest diseases of fruits and vegetables.

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Segal (3) found that pH, temperature, and exposure time greatly influenced efficacy. Spotts and Peters (4) found that chlorine reduced conidial germination of all decay fungi causing rot of pears. Vanderplank (5) used chlorine as a postharvest treatment to remove sooty blotch from orange fruit.

This study was initiated to determine if chlorine could be used to remove sooty blotch and flyspeck from apple fruit after harvest without phytotoxicity.

MATERIALS AND METHODS

The apple cultivars Red Delicious, Golden Delicious, Granny Smith, Rome Beauty, Gala, Jonathan, Stayman, and Empire growing at the Georgia Mountain Experiment Station were not sprayed for sooty blotch and flyspeck control in 1988 and 1989 to produce heavily infected fruit for this research. All cultivars were heavily infected with sooty blotch and flyspeck.

Sodium hypochlorite and calcium hypochlorite were used as sources of chlorine, and levels tested were 0, 130, 260, 390, 520, 650, 780, 940, 1,270, and 1,670 mg a.i./ml. This test was repeated five times. Concentrations were measured with an Orion ionalyzer Model 407A meter and a combination chloride electrode Model 96-17-00 (Orion Research Inc., Cambridge, MA).

Initially, apples were treated by submersion in a 370-L vat containing each test concentration of chlorine. The lowest chlorine concentration was placed in the vat initially. After treatment of fruit at that chlorine concentration, chlorine was added to bring the concentration up to the next level to be tested. Fruit were exposed for 5–7 min to simulate the time it takes fruit to move from the dump tank to the line in a commercial packing operation. Four replicates of 100 fruit each were tested at each concentration, including a treatment in water alone. Fruit treated in a vat were rinsed but not brushed or waxed after treatment.

After effective chlorine concentrations were determined in the vat test, fruit were exposed to chlorine concentrations in a 3,785-L dump tank of a commercial packing line. Fruit were exposed for 5–7 min to either 0, 50, 100, 300, 400, or 500 ppm of chlorine, then passed over a series of wet brushes while being rinsed with nonchlorinated water.

The effectiveness of the chlorine treatments was measured by determining the incidence of sooty blotch and flyspeck among treatments after 24–48 hr. Data were analyzed with a regression analysis.

Weight loss of fruit in storage after chlorine treatment was determined. Eight replications of 100 fruit each of varieties Red Delicious and Golden Delicious were treated with 500 ppm of chlorine in a commercial packing line to remove sooty blotch and flyspeck. A treatment with nonchlorinated water was included. Four replicates of 100 fruit from each treatment, including the water,

Table 1. Effect of 500-ppm chlorine dip for 5 min on captan, Imidan (phosmet), and maneb residues remaining on apple fruit

Treatment	Residues (ppm)		
	Captan	Imidan	Maneb
Water dip	0.42[a]	0.3	5.84
		0.16	
Chlorine dip	0.0	0.2	1.63
		0.00	

[a]Values are average of 21 residue analyses. Ten fruit were submitted to the laboratory.

Table 2. Effect of chlorine treatment and fruit waxing on weight loss of Red Delicious and Golden Delicious apples after 12 wk of storage at 1–3 C

Variety	Treatment		Initiation of storage		After 12-wk storage		
	Wax	Chlorine	Weight (g)	SD	Weight (g)	SD	Weight change (g)
Golden Delicious	−	+	105.9[a]	10.4	101.2	10.3	4.7
	+	+	102.1	11.1	97.8	10.8	4.3
	−	−	97.4	7.6	92.6	7.5	4.8
	+	−	102.4	10.8	98.3	10.4	4.1
Red Delicious	−	+	154.9	16.5	150.7	16.0	4.2
	+	+	142.1	27.2	138.5	24.4	3.6
	−	−	156.1	15.7	152.0	15.3	4.1
	+	−	164.9	14.1	156.5	14.2	8.4

[a]Data were analyzed with the General Linear Models procedure.

were coated with wax (Pennwalt Decco Apple Luster, Pennwalt Corp., Philadelphia, PA). Fruit were individually weighed immediately after treatment and at 2-wk intervals for 3 mo. All fruit were stored on trays in boxes at 1–3 C for the duration of the test. Data were analyzed with the general linear models procedure.

Phytotoxic levels of chlorine on apples were determined by exposing eight replicates of 100 fruit each of Red Delicious apples to chlorine concentrations of either 1,120, 2,400, 3,300, or 4,100 mg a.i./ml for 15 min. Pennwalt Decco 311 buffer (Pennwalt Corp.) was added to half of the replicates at volumes equivalent to those of sodium hypochlorite used. The buffer was added because it is suggested by Pennwalt, the company that has registered the chlorine treatment at 500 ppm. After exposure, fruit were placed in either a paper bag, plastic bag, or rinsed and placed in a plastic bag. All fruit were wet when bagged. Fruit were stored at 1–3 C for 30 days before evaluating the effect of treatment on fruit finish.

Pesticide residues were measured in a University of Georgia EPA-approved laboratory using the Official Methods of Analysis of the Association of Official Analytical Chemists (2).

RESULTS

In the initial experiments with high levels of chlorine, sooty blotch control was 100% at concentrations of 940, 1,270, and 1,670 mg a.i./ml. Flyspeck incidence was significantly reduced but not eliminated. When this experiment was repeated with lower chlorine concentrations of 290 and 520 mg a.i./ml chlorine, the incidence of sooty blotch was reduced from an initial 100 to 85 and 80%, respectively. Flyspeck incidence was reduced from 100 to 92 and 88% after the same respective concentrations. Fruit tested in both experiments showed no evidence of phytotoxicity. This test was repeated five times with similar results. The data for sooty blotch is expressed by the formula $Y = 109.6 - 0.068X$ ($R^2 = 0.81$, $P = 0.0001$). For flyspeck, the formula is $Y = 101.5 - 0.03X$ ($R^2 = 0.6$, $P = 0.0001$).

When treated in the dump tank of a commercial line and subsequently brushed, flyspeck was reduced from 100 to 58% at 290 mg a.i./ml. This was equivalent to results obtained with 500 mg a.i./ml without brushing. At 500 mg a.i./ml with brushing, flyspeck was reduced from 100 to 27%. In the same experiment, sooty blotch was reduced from 100 to 60% at 200 mg a.i./ml. Less removal occurred at 500 mg a.i./ml in the initial experiment without brushing. Sooty blotch was eliminated when a treatment of 500 mg a.i./ml was followed by brushing. This test was repeated in 1989 with similar results. The formula for sooty blotch is $Y = 76.3 - 0.2X$, where Y is incidence and X is chlorine concentration ($R^2 = 0.63$, $P = 0.001$). For flyspeck, the formula is $Y = 80.6 - 0.09X$, where Y = incidence and X = chlorine concentration ($R^2 = 0.34$, $P = 0.0027$).

Neither cultivar nor chlorine source affected the removal of sooty blotch and flyspeck. Pesticide residues were reduced by the chlorine treatment (Table 1). Captan residues were reduced to less than detectable levels, Imidan (phosmet) by 33% or more, and maneb levels by 73% compared with washed fruit, which was brushed.

In the storage tests, weight loss averaged about 4.5% for Golden Delicious and 3.6% for Red Delicious fruit over the 12-wk period (Table 2). The chlorine and wax treatments did not affect weight loss.

When Red Delicious fruit were treated with chlorine levels from 1,120 to 4,100 ppm with and without buffer to determine phytotoxic levels, fruit finish was not affected by any of the treatments.

DISCUSSION

Chlorine was found to be an effective technique for removal of sooty blotch and for reducing the incidence of flyspeck on a wide range of apple varieties. No phytotoxicity was observed, even at levels eight times the effective concentration and twice the time of exposure needed for efficacy. Chlorine treatment also reduced residues of captan, phosmet, and maneb. The latter is an important consideration as consumers are becoming more aware of pesticide residues on fruits. Apples can be stored up to 3 mo after treatment with minimal and acceptable weight loss.

Sooty blotch and flyspeck are not effectively controlled in the orchard using current IPM tactics for apple production. Data are not available for forecasting these diseases, and chemicals with sufficient curative action are not registered for use on apples.

The removal of these fungi by a postharvest treatment with chlorine may allow growers to compensate for the lack of sooty blotch and flyspeck control in the orchard and to use IPM techniques, including sanitation, scouting for bitter rot, and applying white rot control measures as dictated by fruit soluble solids and weather. Use of IPM procedures can reduce the number of fungicide sprays each summer by up to eight compared with spray guide suggestions, depending on weather conditions and development of other diseases (*unpublished*).

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