Injury of Stone Fruits by Preharvest Captan Sprays Followed by Postharvest Treatments

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ABSTRACT

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A preharvest spray of 50% captan [N-(trichloromethylthio)-4-cyclohexene-1,2-dicarboximide] (2.4 g/liter) was applied on Le Grand nectarines; Blenheim and Tilton apricots; Suncrest, Fay Elberta, Carnival, and Halloween peaches. Captan-sprayed and unsprayed fruits (peaches and nectarines) were brushed and treated with benomyl plus Botran® in wax or with benomyl alone in wax (apricots). Fruit were commercially packed and stored at 0.5 and/or 20 C. Suncrest peaches developed surface streaking ranging from brown to black after 4 days of storage and Le Grand nectarines developed irregular or circular surface discoloration after 7 days. Blenheim apricots field-sprayed with captan 20 days before harvest and treated postharvest with benomyl in wax developed diffused brown surface discoloration after 3 days at 0.5 C and more distinct lesions after 3 days at 20 C. Only the fruit treated with captan and Botran® and/or benomyl in wax after harvest developed surface discoloration. Laboratory studies on Tilton apricots show that similar discoloration developed only when fruit with a captan residue was brushed; more severe symptoms occurred when brushed fruits were treated with a wax solution or when wax containing captan was applied after brushing. Fay Elberta, Carnival, and Halloween peach fruit did not develop any discoloration regardless of pre- or postharvest treatments.

Additional key words: phytotoxicity, brushing, injury.

Captan, a widely used fungicide (6), is recommended for the control of brown rot of stone fruits [caused by *Monilinia fructicola* (Wint.) Honey and *M. laxa* (Aderh. and Ruhl.) Honey] in California by applications during bloom and prior to harvest. Captan has a tolerance of 50 μg/g on peaches, nectarines, and apricots, with no time limitation on its use for these fruit crops (4). Daines et al. (3) and Miller (7) observed injury from captan sprays on the foliage of apples and peaches. Injury to peach foliage and fruit can occur if captan is used within 60 days before or 90 days after the application of oil (2).

Following harvest, fresh-market stone fruits often receive a postharvest benomyl and/or Botran 75W® (2,6-dichloro-4-nitroaniline) in wax treatment to reduce decay during shipment and storage. Injury to Suncrest peach fruit has been observed during and after storage when a preharvest spray of captan was followed by commercial postharvest treatment. In 1972, Blenheim apricots that received a captan spray 20 days before harvest and a subsequent commercial postharvest treatment developed surface discoloration during storage.

The objective of our study was to determine if preharvest sprays of captan followed by commercial postharvest treatment results in the development of fruit surface discoloration and, if so, to determine the factors that contribute to the phenomenon.

MATERIALS AND METHODS

Chemicals and methods of application.—Captan (Orthocide 50W®, Chevron Chemical Company, Richmond, California) was used in all experiments unless stated otherwise. All commercial postharvest treatments consisted of 300 μg/ml benomyl and 900 μg/ml Botran 75W® in Decco WT-52 peach-grade wax diluted 1:8 with water and applied with a Decco peach defuzzer and waxer (Decco Division, Pennwalt Corp., Monrovia, California) for peaches and nectarines, or 300 μg/ml benomyl in WT-52 peach-grade wax diluted 1:8 with water and applied to apricots with a Decco apricot treater.

The WT-52 wax is a food-grade wax containing water, carnuba and paraffin waxes, liquid hydrocarbons, fatty acid soaps, sodium lauryl sulfate, and orthophenylphenol as a preservative.

Preharvest captan treatments.—Blenheim apricots that had received a captan spray 20 days before harvest were given the commercial postharvest treatment or packed without treatment. Blenheim apricots that had not received a preharvest spray of captan were sprayed with captan (2.4 g/liter) the day of harvest. Harvested fruits were packed after the postharvest treatment and were stored at either 0.5 C or 20 C.

Suncrest peaches were sprayed with captan (2.4 g or 1.2

g/liter) the day of harvest and along with untreated fruits were given the commercial postharvest treatment. The fruits were then packed and stored at 0.5 C.

To determine if fruits of other peach and nectarine cultivars develop injury during storage, Fay Elberta peaches and Le Grand nectarines were sprayed with captan (2.4 g/liter) the day of harvest. Carnival and Halloween peaches were sprayed with captan (2.4 g/liter) 18 or 4 days before harvest. After the commercial postharvest treatment, the fruits were packed and stored at 0.5 C.

Residue analyses.—Captan residues were determined from 2- to 5-kg fruit samples by repeated extraction with pesticide-quality (spectro-grade) benzene using a Waring Blendor. Samples were evaporated to dryness in a flash evaporator at 55 C. The residues were resuspended in 100 ml of benzene and analyzed for captan by using a gas chromatographic procedure (5).

Phytotoxicity of captan formulation components.—Components of the captan formulation were tested for phytotoxicity. Technical-grade (90% active ingredient) captan (1.3 g/liter), captan (2.4 g/liter), and captan filler (1.2 g/liter) were applied as a spray on harvested Tilton apricots. After drying, the fruit received either the commercial postharvest treatment with or without wax. The fruit was then packed and stored at 0.5 C.

Postharvest treatments.—During the postharvest treatment, fruit was brushed with nylon brushes (peaches and nectarines) or horsehair brushes (apricots) to clean the fruit and to improve the coverage of the benomyl and/or Botran 75W® in wax. This brushing injures the surface of the fruit, but the injury usually is not macroscopically visible. To determine the importance of brushing injury on sensitivity to captan, Tilton apricots sprayed with captan (2.4 g/liter) and unsprayed fruits were partly covered with a polyethylene sheet while a portion of the surface of each fruit was gently brushed with a test-tube brush. These fruit were placed on wire racks in plastic containers and sprayed with WT-52 peach-grade wax diluted 1:8 with water until completely wet. The containers were incubated at 24 ± 2 C for 2 days.

An injury rating based on the amount of fruit surface discoloration was used for all tests. The rating was as follows: 0 = none, 1 = 1-25% of surface discolored, 2 = 26-50% of surface discolored, and 3 = greater than 50% of surface discolored. An average injury rating of 1 for a box of fruit would result in commercial rejection.

RESULTS

Preharvest captan applications.—Blenheim apricots sprayed with captan 20 days before harvest had residues of 4.39 μg/g at harvest. These fruit developed no surface discoloration during storage, but sprayed fruit receiving the commercial postharvest treatment developed surface discoloration (Fig. 1-A) after 1 day of storage at 20 C. The captan residue after the postharvest treatment was 3.20 μg/g. Neither Blenheim apricots sprayed with captan just before harvest nor those receiving only the postharvest

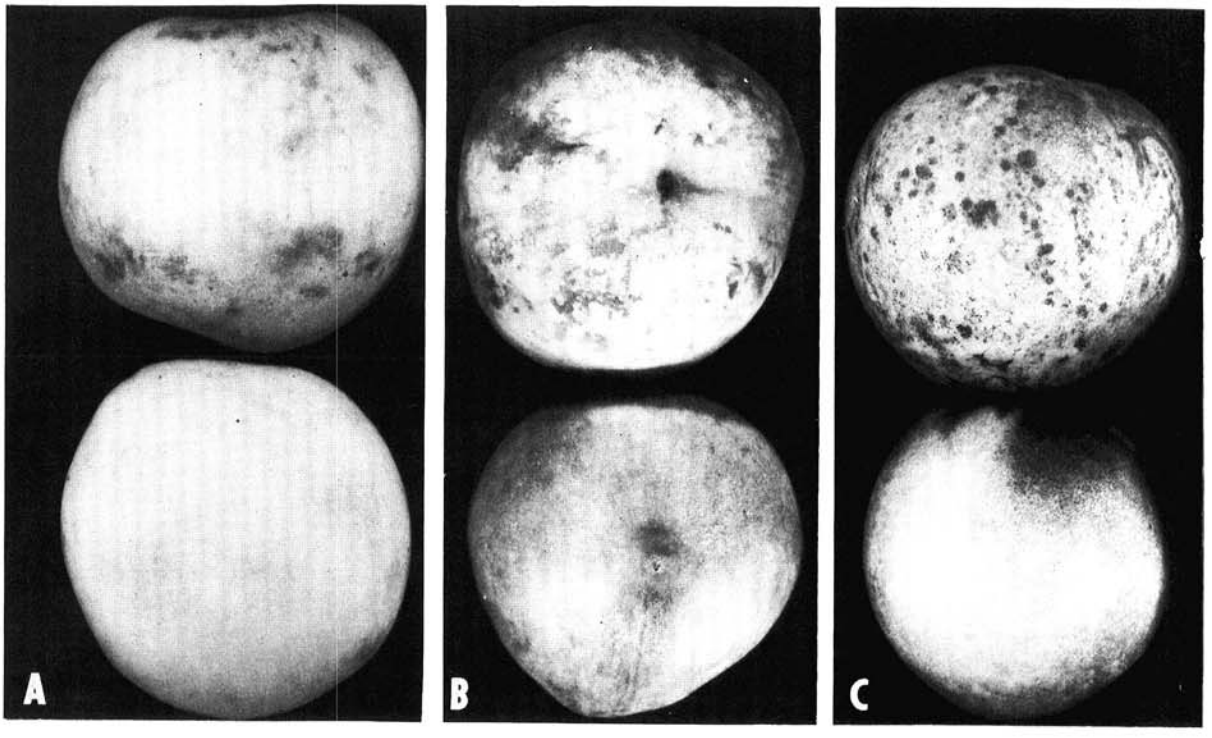

Fig. 1-(A to C). Injury of stone fruits following a preharvest captan spray and a commercial postharvest treatment. Upper fruit show injury on **A)** Blenheim apricot, **B)** Suncrest peach, and **C)** Le Grand nectarine. Lower fruit received commercial postharvest treatment only.

treatment developed surface discoloration during storage at 20 C. However, surface discoloration developed in 1-2 days on fruits with the preharvest captan spray followed by postharvest treatment and storage at 20 C. When stored at 0.5 C for 7 days, slight discoloration developed. However, when these fruits were moved to 20 C for 2 days, injury was increased. The captan residue on these fruit was 7.68 μg/g.

The captan-treated Suncrest peaches that had received the postharvest treatment developed surface discoloration after 3 days of storage at 0.5 C (Fig. 1-B). The severity of discoloration did not increase with time when the fruits were moved to 20 C storage (Table 1). Irregular or circular surface discoloration (Fig. 1-C) developed on captan-treated Le Grand nectarines that had received the commercial postharvest treatment and were stored at 0.5 C for 7 days (Table 2). Injury was not observed on Fay Elberta, Halloween, and Carnival peaches.

TABLE 1. Effect of a preharvest captan spray followed by postharvest wax treatment on injury of Suncrest peaches

Treatment[x]			Average injury rating[z]
Preharvest	Concentration (g/liter)	Postharvest[y]	
Captan 50W	2.4	+	1.44 d
Captan 50W	1.2	+	0.94 c
Captan 50W	2.4	−	0.14 ab
None		+	0.27 b
None		−	0.00 a

[x]Storage conditions: 7 days at 0.5 C, then 5 days at 20 C.

[y]Postharvest treatment: Benomyl 50W (300 μg/ml) and Botran 75W® (900 μg/ml) in WT-52 peach-grade wax diluted 1:8.

[z]Average of three boxes (138-150 fruit). Injury rating: 0 = none; 1 = 1-25% of surface discolored; 2 = 26-50% of surface discolored; 3 = greater than 50% of surface discolored. (Rating of 1 or more would result in rejection of fruit). Numbers followed by the same letter are not significantly different, $P = 0.05$, according to Duncan's multiple range test.

TABLE 2. Effect of a preharvest captan spray followed by postharvest wax treatment on injury of Le Grand nectarines

Treatment[x]			Average injury rating[z]
Preharvest	Concentration (g/liter)	Postharvest[y]	
Captan 50W	2.4	+	1.32 b
Captan 50W	2.4	−	0.06 a
None		+	0.02 a
None		−	0.00 a

[x]Stored 7 days at 0.5 C.

[y]Postharvest treatment: Benomyl 50W (300 μg/ml) and Botran 75W® (900 μg/ml) in WT-52 peach-grade wax diluted 1:8.

[z]Average of 50 fruit. Injury rating: 0 = none; 1 = 1-25% of surface discolored; 2 = 26-50% of surface discolored; 3 = greater than 50% of surface discolored. (Rating of 1 or more would result in rejection of fruit). Numbers followed by the same letter are not significantly different $P = 0.05$, according to Duncan's multiple range test.

Postharvest treatments.—Severity of the phytotoxicity from captan on Tilton apricots was reduced in the presence of the filler (Table 3). Laboratory experiments with Tilton apricots confirm that injury from brushing promotes phytotoxicity and that wax increases the severity of the problem (Table 4).

TABLE 3. Effect of captan formulation, waxing, and brushing on injury of Tilton apricots

Treatment[w]				Average injury rating[z]
		Commercial postharvest[y]		
Preharvest[x]	None	Complete	Without wax	
None	+	−	−	0.03 a
None	−	+	−	0.23 a
None	−	−	+	0.80 b
Captan filler	+	−	−	0.03 a
Captan filler	−	+	−	0.20 a
Captan filler	−	−	+	0.16 a
Captan 50W	+	−	−	0.23 a
Captan 50W	−	+	−	1.70 c
Captan 50W	−	−	+	1.50 c
Technical captan	+	−	−	0.33 a
Technical captan	−	+	−	2.60 d
Technical captan	−	−	+	2.53 d

[w]Storage conditions: 7 days at 0.5 C, then 4 days at 20 C.

[x]Captan filler (1.2 g/liter), captan 50W (2.4 g/liter) and technical captan (90% active ingredient, 1.3 g/liter) applied to fruit after harvest and allowed to dry before postharvest treatments.

[y]Commercial postharvest treatment: Benomyl 50W (300 μg/ml) in WT-52 peach-grade wax (diluted 1:8 with water) and applied by a Decco apricot treater.

[z]Average of 30 fruit. Injury rating: 0 = none; 1 = 1-25% of surface discolored; 2 = 26-50% of surface discolored; and 3 = greater than 50% of surface discolored. (Rating of 1 or more would result in rejection of fruit). Numbers followed by the same letter are not significantly different, $P = 0.05$, according to Duncan's multiple range test.

TABLE 4. Importance of brushing and waxing on development of captan toxicity to Tilton apricots

Treatment[y]			Average injury rating[z]
Captan	Waxed	Brushed	
+	−	−	0.0 a
+	−	+	1.9 c
+	+	−	0.0 a
+	+	+	2.6 d
−	−	−	0.0 a
−	−	+	0.1 ab
−	+	−	0.0 a
−	+	+	0.3 b

[y]Orthocide 50W (captan, 2.4 g/liter). Brushed = gently brushed with a test-tube brush, 20 times per fruit. Wax = WT-52 peach-grade wax diluted 1:8 with water and sprayed over fruit. Fruit stored at 24 C for 2 days.

[z]Average of three replications, three fruit per replication. Injury rating: 0 = none; 1 = 1-25% of surface discolored; 2 = 26-50% of surface discolored; and 3 = greater than 50% of surface discolored. (Rating of 1 or more would result in rejection of fruit). Numbers followed by the same letter are not significantly different, $P = 0.05$, according to Duncan's multiple range test.

DISCUSSION

This study provides evidence for the involvement of captan in the development of injury in certain stone fruits. However, there is an interaction between the captan residue on the fruit and the commercial postharvest treatment that results in this phytotoxicity.

Phytotoxicity from captan has been reported earlier (1, 3). Daines et al. (3) found that captan injury to bean foliage increased with increasing temperature and decreasing light intensity. Increased phytotoxicity when bean plants were grown under low light intensity was explained as increased captan uptake by leaf cells because of a thinner cuticle. They suggested that captan phytotoxicity was due to a high hydrogen-ion concentration during decomposition of the captan. Daines et al. (3) also found that as the pH of a captan solution was increased above 7.0, the rate of captan decomposition increased. The pH of the wax solution used in the postharvest treatment was about 8.0 and we were unable to detect a pH drop when mixtures of captan, wax, and fruit juices were stored under conditions similar to those used for the fruits in these experiments.

Brushing injury to the fruit during the commercial postharvest treatment is necessary for the development of moderate to severe phytotoxicity. Captan and wax are not phytotoxic to uninjured fruit. However, when wax is applied to captan-treated fruit after brushing, phytotoxicity was significantly increased.

The filler in Orthocide 50W® reduced the phytotoxicity of the technical captan and Daines et al. (3) reported a similar safening effect.

The exact nature of captan phytotoxicity has not been determined, but the conditions that enhance development of injury are related to postharvest brushing and waxing.

LITERATURE CITED

1. CHASTAGNER, G. A, and J. M. OGAWA. 1973. Phytotoxicity to stone fruits from preharvest captan followed by postharvest wax treatment. Abstract No. 0052 *in* Abstracts of Papers, Second Int. Congr. Plant Pathol, September 5-12, Minneapolis, Minnesota. (unpaged).
2. CHEVRON CHEMICAL COMPANY, Richmond, California, 94802. Label for Volck Supreme Spray®, Hydro fine code: R20802 G-B, 145.
3. DAINES, R. H., R. J. LUKENS, E. BRENNAN, and I. A. LEONE. 1957. Phytotoxicity of captan as influenced by formulation, environment, and plant factors. Phytopathology 47:567-572.
4. ENVIRONMENTAL PROTECTION AGENCY. 1973. Compendium of Registered Pesticides, Vol. II. Fungicides and Nematicides. U.S. Environmental Protection Agency, Washington, D.C. Part I, Pages C-10-00.01 to C-10-00-.20.
5. KILGORE, W. W., W. WINTERLIN, and E. R. WHITE. 1968. Gas chromatographic determination of captan residues. J. Agric. Food Chem. 15:1035-1037.
6. LUKENS, R. J. 1969. Heterocyclic nitrogen compounds—captan and the R-SCCl$_3$ compounds. Pages 419 - 432 *in* D. C. Torgeson, ed. Fungicides; an advanced treatise, Vol. II. Academic Press, New York. 742 p.
7. MILLER, P. M. 1957. Heat decomposition products of captan as phytotoxic agents. Phytopathology 47:245 (Abstr.).