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POSTHARVEST EFFECTS OF DIPPING AND FUMIGATING FLORIDA AVOCADOS WITH ETHYLENE DIBROMIDE AND ETHYLENE CHLOROBROMIDE

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SUMMARY

Several infestations of the Mediterranean fruit fly in Florida necessitated investigations to determine the effects of dips and fumigants on harvested Florida avocados. The effects of treatment with various dosages of ethylene dibromide (EDB) and ethylene chlorobromide (ECB) were evaluated during 3 crop years.

In most instances, treatments significantly accelerated ripening. Treatments which caused the most injury also resulted in the most rapid ripening. An average of 5 to 7 days and 6 to 8 Jays were required for treated and untreated fruit, respectively, to ripen.

When present, injury was manifested as a discoloration of the skin, usually brown and scald-like in appearance, and in cases of severe injury, fruit ripened unevenly, the skin became brittle, and occasionally off-flavor was detected. ECB treatments usually caused less injury than EDB. Dipping generally caused less, but more erratic, injury than fumigation. Differences in varietal tolerance were observed. Generally, the most promising treatments were 1 pound of ECB per 1,000 cubic feet as a fumigant and 1:6000 and 1:4000 ECB as a dip. None of these treatments caused injury or off-flavor in Waldin, Booth 8, Booth 7, or Lula avocados.

INTRODUCTION

The Mediterranean fruit fly (*Ceratitis capitata,* Wied.) is found in most tropical and subtropical countries throughout the world. It first appeared in Florida during 1929. At that time the insect was discovered in 20 counties. In 1930, at a cost of $7,500,000, it was eradicated by chemical treatments, by the destruction of thousands of boxes of fruits and vegetables, and by prohibiting the shipment of such fruits and vegetables (1, 4, 21). The second and most widespread infestation of the Mediterranean fruit fly occurred during 1956 and spread into 28 Florida counties. In 1957, eradication, primarily by means of aircraft spray operations, cost $11,000,000 (1, 4, 21). Between July 1, 1958, 'and June 30, 1960, 21 interceptions of the Mediterranean fruit fly were reported at the ports of Florida by inspectors of the U. S. Department of Agriculture (22). The third entry of the Mediterranean fruit fly occurred during 1962 but the infestation was restricted to the urban areas of 3 counties (4, 8). Eradication, estimated to have cost $1,000,000, was completed during the spring of 1963 and quarantine restrictions were removed May 7, 1963 (4), (23). During this infestation the fly never appeared to any great extent in the commercial avocado areas.

The avocado is a host of the Mediterranean fruit fly (21). During the 1956 infestation, when the Mediterranean fruit fly was prevalent throughout the commercial avocado areas of Florida, many fruits and vegetables were subject to fumigation prior to shipment (24).

In Hawaii, West Indian-type avocados are reported to be more susceptible to the Mediterranean fruit fly than Guatemalan-type avocados (10). Practically no information is available concerning the tolerance of Florida avocados, many of which are West Indian or West Indian hybrids, to various fumigants (17).

In lieu of fumigating avocados, specified restrictions were imposed during the 1956 infestation on the movement of fruit from infested areas to states south of certain latitudes (24). Shipping certificates were issued only after a complicated sanitation and spray program was carried out. The program required spraying avocado trees 3 times with certain insecticides. This included a final application 10 days prior to harvest.

The merits of a number of fumigants have been investigated (3, 11, 13, 15). Methyl bromide, ethylene oxide, acrylonitrile, and *Acrylon* produced injury to avocados. Cold storage and vapor heat treatments of avocados have been unsatisfactory (19).

Treatments with ethylene dibromide (EDB) and ethylene chlorobromide (ECB) were developed in California and Hawaii to destroy the eggs and larvae of the Mediterranean and other fruit flies (2, 3, 11, 14). Sinclair and Lindgren reported that ECB leaves less bromine residue on avocados than EDB (21). No work was reported on the response of Florida avocados to EDB or ECB treatments prior to preliminary results given by Wolfenbarger (25) which included initial phases of the present study. Several reports are available, however, on the effects of such treatments with vapor on California citrus and avocados (7, 12, 13, 14, 18, 20) and on Florida citrus (9). In addition, an aqueous dip of EDB has been reported as promising on various fruits (16).

Since the number of interceptions of the Mediterranean fruit fly has almost doubled in the past few years (4) the prospect of its reappearance is likely.[1] As a result of the 1956 infestation, members of the Florida avocado industry and the Federal and State regulating organizations have requested information concerning the fumigation of

Florida avocados. The purpose of this study was to determine the effects of fumigating and dipping treatments with EDB and ECB on the quality of several varieties of Florida avocados.

MATERIALS AND METHODS

Fruit selected for the investigations was picked in the mature stage in compliance with the harvest schedules adopted by the commercial avocado industry in Florida.

Fruit of five varieties, Waldin, Booth 8, Booth 7, Lula, and Taylor, was obtained from the University of Florida Sub-Tropical Experiment Station, Homestead, Florida and from commercial groves in the Homestead area. Each variety was harvested and treated twice during each crop year (table 1). Ten avocados of each variety were used for each treatment at each harvest date. Treatments were made within 6 hours after harvest. Following treatment, the fruit was stored at 70° F. until ripe.

Observations were made daily on the stored fruit, until it ripened, to determine extent, type, and time of occurrence of skin injury, days required to ripen, and off-flavor in fruit when ripe. Skin injury was evaluated on this percentage basis: slight injury, up to 25 percent of the surface discolored; moderate injury, up to 50 percent of the surface discolored; and severe injury, over 50 percent of the surface discolored. Fruit was judged ripe when it had softened to the extent suitable for eating. Ripening data were statistically analyzed by mean separation of the functional analysis of variance and multiple comparisons (5).

Dipping.—Ten fruits were dipped in a 60gallon tank with a self-contained thermostat controlled heater and an agitator and were immersed for 20 minutes at 115° F. for each treatment. Stock emulsion formulations were prepared by mixing 90 ml. of ECB or EDB, 10 ml. of a surfactant (Atlas G-672) and 50 ml. of water. The stock formulation was diluted with water to given the desired concentration, by volume, of ECB or EDB.

Fumigating.—Ten fruits were fumigated in a 54.6 cu. ft. chamber with a "squirrel cage" circulating fan to mix air and fumigant. Fumigant materials were measured as pounds per 1000 cu. ft. of air. Since the fumigation chamber was in a non-air conditioned room, the temperature varied. Most fumigations were conducted at 73° to 88° F. On a few days the temperature was below 70°. All fruit was fumigated for 2 hours.

Table 1.--Dipping and fumigation dates of Florida avocados.

Variety	Crop year and date of treatment		
	1959-60	1960-61	1961-62
Waldin	Sept. 17	Sept. 20	Sept. 12
	24	27	19
Booth 8	Oct. 1	Oct. 4	Sept. 26
	15	11	Oct. 3
Booth 7	Oct. 29	Oct. 18	Oct. 17
	Nov. 12	25	24
Lula	Nov. 24	Oct. 18	Oct. 31
	Dec. 10	25	Nov. 7
Taylor	Dec. 22	Nov. 1	Nov. 7
	Jan. 7	8	14

RESULTS AND DISCUSSION

Injury and off-flavor caused by fumigating and dipping with various dosages of ethylene chlorobromide and ethylene dibromide, are shown in table 2. Data for slight, moderate, and severe injuries were combined since all were commercially objectionable. Slight injury was most prevalent on fruit with a small percentage of injury; moderate and severe injury was most prevalent on fruit with a high percentage of injury.

Injury was manifested as a discoloration of the skin, usually brown and scald-like in appearance. Where severe injury occurred, the fruit ripened unevenly, the skin became brittle, and pitting was present. Injury did not usually become fully developed until the fruit became ripe. In cases of severe injury, however, the discoloration often appeared within 24 hours after treatment and reached full discoloration within 72 hours after treatment. Off-flavored avocados in most cases were directly related to those treatments resulting in severe injury (table 2); this relationship is in agreement with studies reported by Sinclair and Lindgren (20).

Lula avocados showed no injury with dosages of 1, 2, and 3 pounds of ECB fumigant; however, Taylor avocados were injured by all three dosages. Booth 7 and Booth 8 avocados sustained no injury at dosages of 1 and 2 pounds of ECB fumigant, but injury was present at the 3 pound dosage. Waldin avocados were injured with 2 and 3 pounds of ECB fumigant, and had off flavor at the 3 pound dosage; no injury was observed with 1 pound. Dosages of 1:6000, 1:4000, and 1:2000 of ECB dip resulted in little or no injury to Waldin, Booth 8, Booth 7, and Lula avocados, but resulted in injury to Taylor avocados. Generally, ECB dip resulted in less injury that ECB fumigant.

Booth 8, Booth 7, and Lula avocados showed no injury with 1 pound of EDB fumigant, but Waldin and especially Taylor avocados were injured at this dosage. Dosages of

EDB fumigant higher than 1 pound resulted in injury for all tested avocados and the extent of injury increased with increased dosages. Off-flavor was detected in concentrations of $1^1/_2$ and 2 pounds of EDB fumigant in Waldin, Lula, and Taylor avocados; in addition, Taylor avocados had an off-flavor with 1 pound. Dosages of 1:12000, :8000, and 1:4000 EDB dip resulted in no injury to Lula avocados, but resulted in injury to Waldin, Booth 8, and Taylor avocados; Booth 7 avocados were not injured at a dosage of 1:12000 3DB dip, but were injured at dosages of 1,8000 and 1:4000. The extent of injury was generally erratic with increased dosages of EDB dip.

Generally, ECB fumigant and dip treatments resulted in less injury than treatments of EDB fumigant and dip. A dosage of 1 pound of EDB per 1000 cu. ft. was the safest of the fumigant treatments. Dosages of 1:6000 and 1:4000 of ECB were the safest of the dipping treatments.

Differences in varietal tolerance to EDB and ECB were evident (table 2); Lindgren, *et al.,* (12) also reported varietal differences in the tolerance of avocados to fumigation. They found hat no injury occurred to Fuerte avocados fumigated with dosages of 1, 2, and 3 pounds of EDB per 1000 cu. ft. for 2 hours while Mac Arthur, Anaheim, and El Tropico avocados were injured with 2 pounds and severely injured with 3 pounds.

Treated avocados ripened more rapidly than those that were untreated; however, no significant difference was found between those fumigated with 1 pound of ECB and those that were untreated (table 3). An average of 5 to 7 days was required for treated avocados to ripen; an average of 6 to 8 days was required for untreated avocados to ripen. Generally, the more concentrated the treatment, the more rapid was the ripening. The dosages of fumigants which caused the most injury to avocados also caused the most rapid ripening. Taylor avocados, which showed injury with all treatments, ripened more rapidly than avocados of other varieties. Previous work also has shown that treatment of avocados with EDB and ECB caused more rapid softening of the fruit concurrent with increased respiration (6, 7, 11).

Table 2.--Percentage injury to Florida avocados after fumigating and dipping with various dosages of ethylene chlorobromide and ethylene dibromide, (1959-62)[1/]

Treatment	Variety				
	Waldin	Booth 8	Booth 7	Lula	Taylor
	percent	percent	percent	percent	percent
Untreated	0	0	0	0	0
Ethylene chlorobromide: (ECB)					
Fumigant (lbs./1000 cu. ft.)					
1	0	0	0	0	5
2	5	0	0	0	28
3	33[2/]	12	17	0	52
Dip					
1:6000	0	0	0	0	13
1:4000	0	0	0	0	20
1:2000	0	2	0	0	25
Untreated	0	0	0	0	0
Ethylene dibromide: (EDB)					
Fumigant (lbs./1000 cu. ft.)					
1	5	0	0	0	22[2/]
1½	48[2/]	17	8	18[2/]	42[2/]
2	63[2/]	33	27	85[2/]	52[2/]
Dip					
1:12000	25	3	0	0	8
1:8000	38	20	8	0	2
1:4000	7	5	17	0	7

1/ Sixty avocados per treatment were used; 10 avocados on each treatment date, 2 treatment dates per crop year, and 3 crop years. Percentage of injury, for the 3-year period, was computed from the total number of avocados. Data for slight, moderate, and severe injuries were combined since all were commercially objectionable.

2/ Off-flavor was detected.

Table 3.--Ripening time for Florida avocados after fumigating and dipping with various dosages of ethylene chlorobromide and ethylene dibromide, (averages 1959-62)[1/]

Treatment [2/]	Variety					Average [1/] all varieties	Statistical [3/] significance all varieties
	Waldin	Booth 8	Booth 7	Lula	Taylor		
	Days	Days	Days	Days	Days	Days	
Untreated	6.6	8.0	7.3	7.1	5.9	7.0	a
ECB, Fumigant, 1 lb.	6.6	7.4	7.3	6.7	5.7	6.8	ab
ECB, Dip, 1:2000	6.2	7.1	7.4	6.7	5.6	6.6	b
ECB, Dip, 1:4000	6.3	7.2	7.0	6.7	5.7	6.6	bc
ECB, Dip, 1:6000	6.3	7.1	6.8	6.3	5.8	6.5	bcd
EDB, Dip, 1:4000	6.1	7.5	6.2	6.2	5.3	6.3	cde
EDB, Dip, 1:8000	5.9	6.9	6.6	6.4	5.2	6.2	de
EDB, Fumigant, 1 lb.	6.0	6.7	6.8	6.5	5.3	6.2	de
ECB, Fumigant, 2 lbs.	6.0	6.3	6.8	6.2	5.5	6.2	de
EDB, Dip, 1:12000	6.1	6.8	6.3	6.4	4.9	6.1	e
ECB, Fumigant, 3 lbs.	5.3	5.9	6.1	6.3	5.3	5.8	f
EDB, Fumigant, 1½ lbs.	5.2	6.3	6.1	5.9	5.3	5.7	f
EDB, Fumigant, 2 lbs.	5.3	5.9	5.6	6.1	5.3	5.6	f

1/ Averages included 60 avocados per treatment and variety; 10 avocados on each treatment date, with 2 treatment dates per crop year, and 3 years of testing. Thus the averages for all varieties included 300 avocados per treatment.

2/ ECB represents ethylene chlorobromide; EDB represents ethylene dibromide.

3/ Duncan's Multiple Range Test. Means in the column, "average all varieties," followed by a like letter are not significantly different at the 5% level.

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[1]The fourth infestation was discovered in Miami, Fla. June 17, 1963. At the time this paper was released the infestation did not include an avocado-producing area.