

## **TOLERANCE OF AVOCADO FRUITS OF DIFFERENT VARIETIES TO FUMIGATION WITH ETHYLENE DIBROMIDE**

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Avocado fruits are known to be host to various species of fruit flies which do not occur in California, but which may be introduced and thus may become established. If these insects should become established in the state, the movement of fruit from infested areas would require sterilization against eggs and larvae of fruit flies. These treatments should not only free the commodity from live fruit-fly infestations but also have no adverse physiological effects on the fruit.

As previously shown, avocados were severely injured by fumigation with ethylene oxide, acrylonitrile, and a mixture of 50 percent acrylonitrile and 50 percent carbon tetrachloride, at dosages of 1 to 5 pounds per 1000 cubic feet for 2 hours (Lindgren and Sinclair, 1951). These fruits were also susceptible to injury by methyl bromide fumigation at a dosage of 2 pounds per 1000 cubic feet for 4 hours. Avocados absorb considerable amounts of bromine when fumigated with methyl bromide, and at the end of 7 days the edible portion of the fruit tested retained 70 percent of the total bromine absorbed.

The general problem has therefore been to find a fumigant that would kill the eggs and larvae of fruit flies without injuring the fruit and without leaving a harmful toxic residue. The problem is complicated not only by varietal differences, but also by seasonal differences, by differences in time of fruit maturity, and by variations in individual fruits and in the environments in which the fruits are grown. To find a fumigant to fit these conditions is not easy. The task involves fumigation of numerous varieties of avocados with different fumigants at various concentrations and for different lengths of time, and subsequent storage of the fruit for a designated period so that the development of injury may be noted. This report is concerned specifically with the tolerance of avocado fruits to various concentrations of ethylene dibromide when used as a fumigant.

### **MATERIALS AND METHODS**

The avocado varieties tested (Fuerte, Anaheim, Dickinson, El Tropic, and Mac Arthur) were obtained from the Calavo Growers of California. Each sample consisted of 10 to 30 flats, and the fruit was fumigated in the packed flats, from which the tops had been removed.

Before fumigation, the fruit samples were placed in a temperature-controlled chamber and brought to a temperature of 70° F., at 80 percent relative humidity. All fruits were

fumigated in a gastight metal fumatorium (100 cu. ft. capacity) at 70° F. In all fumigation experiments the relative humidity was maintained at 70 percent or above. All fruit samples were held for 24 hours at room temperature after fumigation. Unless otherwise stated, the fruit samples were then stored at 55° F. and at 75-80° F. for various periods and any injurious effects were subsequently observed and noted.

### **SUSCEPTIBILITY OF AVOCADO VARIETIES TO FUMIGATION INJURY**

The data recorded in table 1 show that no injury to Fuerte avocado fruits was observed when they were fumigated with ethylene dibromide at 1, 2, or 3 pounds per 1000 cubic feet for 2 hours exposure at 70° F. and 70 percent relative humidity. As determined by the taste test no off-flavor occurred in these fumigated fruit.

Table 1. Injury to avocados (Fuerte) when fumigated with various dosages of ethylene dibromide in a 100 cu. ft. fumatorium at 70° F. and 70 percent relative humidity.

Dosage lbs. EDB per 1000 cu. ft. 2 hrs. exposure <sup>1</sup>	Temp. held following fumigation °F.	Storage Days	External Injury (per cent)	Remarks
Control	75-80	3	00	No off-flavor or effect on maturity
	55	4	00	
1 lb.	75-80	3	00	No off-flavor or effect on maturity
	55	4	00	
2 lbs.	75-80	3	00	No off-flavor or effect on maturity
	55	4	00	
3 lbs.	75-80	3	00	No off-flavor or effect on maturity
	55	4	00	

<sup>1</sup>Date fumigated: June 17, 1954.

Similar experiments were carried out on the MacArthur variety (table 2). Some external injury occurred in the control samples and in those treated with a 1-pound dosage and subsequently stored at 75-80° F., the temperatures at which the ripening processes were accelerated. In general this variety can tolerate without injury a fumigation dosage of 1 pound of ethylene dibromide per 1000 cubic feet. A dosage of 2 pounds of ethylene dibromide per 1000 cubic feet produced significant external injuries on the MacArthur variety when the samples were stored at 75-80° F. No injuries were observed on the fruits stored at 55° F., but when they were subsequently stored at the higher temperatures (75-80° F.) external injuries were markedly accelerated. Fruit samples fumigated at the 3-pound level were severely injured (100 percent) when stored at 55° F. or 75-80° F.

Table 2. Injury to avocados (MacArthur variety) when fumigated with various dosages of ethylene dibromide in a 100 cu. ft. fumatorium at 70° F. and 70 percent relative humidity.

Dosage lbs. EDB per 1000 cu. ft. 2 hours Exposure <sup>1</sup>	Flat No.	Temp. held following fumigation ° F.	Storage Days	External Injury (per cent)	Remarks
Control	1	75-80	6	9.5	No off-flavor; injury— browning & blackening
	2	55	6	00	No off-flavor; no injury
	2	plus 75-80	3	8.3	No off-flavor
	3	55	13	00	No off-flavor
	3	plus 75-80	3	00	No off-flavor
1 lb.	1	75-80	6	20.8	No off-flavor
	2	55	6	00	No off-flavor
	2	plus 75-80	3	00	No off-flavor
	3	55	13	00	No off-flavor
	3	plus 75-80	3	00	No off-flavor
2 lbs.	1	75-80	6	45.8	No off-flavor
	2	55	6	00	No off-flavor
	2	plus 75-80	3	16.7	No off-flavor
	3	55	13	00	No off-flavor
	3	plus 75-80	3	29.2	Peel brittle; internal discoloration, physical breakdown
3 lbs.	1	75-80	6	100	No off-flavor; peel brittle
	2	55	6	100	No off-flavor; peel brittle
	2	plus 75-80	3	100	No off-flavor
	3	55	13	100	No off-flavor
	3	plus 75-80	3	100	Peel brittle; internal discoloration, physical breakdown

<sup>1</sup>Date fumigated: June 16, 1954.

Avocado samples of the Anaheim variety were fumigated with various dosages of ethylene dibromide and subsequently stored at 55° F. and at 75-80° F. for observing the external injury of the fruit (table 3). Slight injury occurred at a dosage of 2 pounds of ethylene dibromide, but severe external injury occurred at a dosage of 3 pounds per 1000 cubic feet.

Table 3. Injury to avocados (Anaheim variety) when fumigated with various dosages of ethylene dibromide in a 100 cu. ft. fumatorium at 70° F. and 70 percent relative humidity.

Dosage lbs. EDB per 1000 cu. ft. 2 hrs. exposure <sup>1</sup>	Flat No.	Temp. held following fumigation °F.	Storage Days	External Injury (per cent) <sup>2</sup>
Control	1	55	7	00
	2	55	14	00
	3	55	19	00
	4	75-80	6	00
	5	55	7	00
	5	plus 75	3	00
	6	55	14	00
	6	plus 75	3	00
1 lb.	1	55	7	00
	2	55	14	00
	3	55	19	00
	4	75-80	6	00
	5	55	7	00
	5	plus 75	3	00
	6	55	14	00
	6	plus 75	3	00
2 lbs.	1	55	7	00
	2	55	14	00
	3	55	19	1.7
	4	75-80	6	00
	5	55	7	00
	5	plus 75	3	2.2
	6	55	14	00
	6	plus 75	3	7.7
3 lbs.	1	55	7	100
	2	55	14	83
	3	55	19	100
	4	75-80	6	100
	5	55	7	100
	5	plus 75	3	100
	6	55	14	100
	6	plus 75	3	100

<sup>1</sup>Date fumigated: August 5, 1954.

<sup>2</sup>No off-flavor was observed.

Similar experiments were carried out on a thin-skin variety commonly known as the El Tropic. After fumigation, all samples were stored at 55° F. for 7 days and subsequently examined for surface injuries. An inspection of table 4 shows that the 2 and 3-pound dosages of ethylene dibromide produced severe external injuries to the fruit.

Table 4. Injury to avocados (El Tropico) when fumigated with various concentrations of ethylene dibromide in a 100 cu. ft. fumatorium at 70° F. and 70 percent relative humidity.

Dosage lbs. EDB per 1000 cu. ft. 2 hrs. exposure <sup>1</sup>	Temp. held following fumigation °F.	Storage Days	External Injury (per cent)	Off-flavor
Control	55	7	00	none
1 lb.	55	7	00	none
2 lbs.	55	7	70.8	none
3 lbs.	55	7	100	none

<sup>1</sup>Date fumigated: October 27, 1954.

Investigators in the Division of Fruit Insects (U. S. Department of Agriculture in Honolulu, Hawaii) have placed emphasis on the need for the longer exposure periods for the fumigation of avocados with ethylene dibromide. As a result, it was decided to determine the tolerance of the Fuerte variety to 1.5 pounds of ethylene dibromide for an exposure period of 4 hours. The data of table 5 show that Fuerte avocados are severely injured when fumigated under these conditions. Furthermore, the fumigated fruit seemed to ripen faster and became softer than the control fruit under identical storage conditions.

It is well known that differences in maturity of avocado fruits are related to differences in physical and chemical properties of the fruit surfaces, and that these, in turn, are certainly correlated in various degrees, with the amount of injury that occurs during fumigation. Under conditions in which fumigations were performed at the higher dosages and longer exposures, the maturity of the fruit is an important factor in the degree of injury that may occur. If the fruit samples are at the climacteric stage, the period at which rapid increase of CO<sub>2</sub> occurs, the amounts of external and internal injuries are usually increased. It should also be noted that the thin-skin varieties appear to be more susceptible to fumigation injury than the thick-skin varieties. As has been shown experimentally, some varieties of avocados are not tolerant to the higher dosages or to the longer exposures when fumigated with ethylene dibromide.

The storage temperature had an effect on the development of external injury of the fumigated fruit. Many fumigated samples failed to develop injury in storage at 55° F. and 75 percent relative humidity, but when these samples were subsequently transferred to storage conditions of 75-80° F. and 75 percent relative humidity, the rate of development of injury was accelerated and the fruit failed to ripen uniformly as in the controls.

Table 5. Injury to avocados (Fuerte variety) when fumigated with 1½ lbs. of ethylene dibromide in a 100 cu. ft. fumatorium at 70° F. and 70 percent relative humidity.

Date fumigated	Dosage lbs. EBD per 1000 cu. ft. 4 hr. exposure	Flat No.	Temp. held following fumigation °F.	Storage Days	External Injury (per cent)
1-12-55	Control <sup>1</sup>		70	6	00
	1-1/2 lbs. <sup>2</sup>		70	6	65
2-3-55	Control <sup>3</sup>	1	70	5	00
		2	55	9	
		2	plus 75	1	00
	1-1/2 lbs. <sup>4</sup>	1	70	5	66
		2	55	9	
		2	plus 75	1	16

Maturity Check	Percent	
	Firm	Soft
<sup>1</sup> Control fruit held for 11 days at 55° F. Control fruit peel bright green.	85.0	15.0
<sup>2</sup> Fumigated fruit held for 11 days at 55° F. Slight bronzing of peel of all treated fruits.	52.5	47.5
<sup>3</sup> Control fruit held for 9 days at 55° F. and 1 day at 75° F.	83.3	16.7
<sup>4</sup> Fumigated fruit held for 9 days at 55° F. and 1 day at 75° F.	59.0	41.0

## SUMMARY

Different varieties of avocados were fumigated in a gastight metal fumatorium (100 cu. ft. capacity) with various concentrations of ethylene dibromide at different exposure periods, and were subsequently placed in storage for observing and recording the development of tissue injury and breakdown. The results reported are of practical value in that they show the maximum dosages of ethylene dibromide that can be used to treat avocados against eggs and larvae of fruit flies without injurious effects to the fruit.

Fumigation injury to the fruits did not appear until several days after treatment, the rate of development depending upon such factors as storage temperature, varietal tolerance, maturity of the fruit, district in which the fruit was grown, the dosage of the ethylene dibromide used, and the time of exposure during fumigation.

No injury occurred to Fuerte avocados fumigated with dosages of 1, 2, and 3 pounds of ethylene dibromide per 1000 cubic feet for 2 hours exposure.

The MacArthur, Anaheim, and El Tropicico varieties were injured upon fumigation with ethylene dibromide at 2 pounds per 1000 cubic feet for 2 hours exposure. Dosages of 3 pounds of ethylene dibromide caused severe injury to these varieties.

The Fuerte avocado was severely injured when fumigated with 1.5 pounds of ethylene dibromide for a 4-hour exposure period.

### **LITERATURE CITED**

1. Lindgren, David L., and Walton B. Sinclair. *Tolerance of citrus and avocado fruits to fumigants effective against the oriental fruit fly*. *Jour. Econ. Ent.* 44(6): 980-990. 1951.