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# ETHYLENE DIBROMIDE FUMIGATION OF GRAPEFRUIT PACKED IN TRAY-PACK CONTAINERS AND IN BULK BINS[1]

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*Abstract.* **Florida grapefruit packed in newly developed tray-pack shipping containers and in bulk, wirebound and fiberboard bins were tested under Animal and Plant Health Inspection Service, USDA (APHIS) approved ethylene dibromide (EDB) fumigation procedures to determine whether grapefruit packed in these special containers could be effectively fumigated with EDB for the quarantine control of the Caribbean fruit fly without causing fumigation injury to the fruit. Data obtained with the use of a halide detector to monitor concentrations of gaseous EDB during fumigation and aeration processes indicated that concns in the tray-pack containers, wirebound bins, and fiberboard bins were almost the same as in the standard fiberboard boxes. No Caribbean fruit fly survivors were obtained from infested grapefruit fumigated in each type of container.**

Fresh grapefruit is the most important citrus fruit exported from Florida, and Japan is the leading importer. In the near future, the market value of fresh grapefruit exports will probably exceed $50 million (4). Consequently, fresh grapefruit must be packaged and handled properly so they will arrive at their destination in the best possible condition. Currently, some Florida shippers are interested in using special tray-pack containers to help maintain the condition and appearance of size-27 grapefruit (average diam of 4-9/16 inches[2]) shipped to Japan. Results of 11 overseas test shipments of grapefruit showed that serious deformation of tray-packed fruit was reduced to an average of 2.7%, compared with 27.9% for fruit shipped in the standard export box (5). Other shippers are investigating the feasibility of shipping fresh grapefruit in bulk bins to reduce total marketing costs. The Japanese Ministry of Agriculture and Forestry requires that grapefruit exported to Japan from Florida undergo an ethylene dibromide (EDB) fumigation to eliminate infestation by the Caribbean fruit fly, *Anastrepha suspensa* (Loew). In 1975, it was reported that when a truck body was used as a fumigation chamber, the major hazard to grapefruit in standard boxes was not caused by fumigation itself, but by inadequate ventilation (and, possibly, by too prompt refrigeration) after fumigation (7). The objective of the work reported in this paper was to determine whether grapefruit packed in tray-pack containers and in bulk bins could be effectively fumigated with EDB to eradicate the Caribbean fruit fly, *without causing fumigation* injury (EDB burn) to the fruit.

[1]Trade names are used in this publication solely to provide specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

[2]For metric conversion see table near the front of these proceedings.

## Materials

### *Tray-pack Containers*

The master shipping container for the trays is a full-telescope single-wall, fiberboard container with inside dimensions of 18 x 12 x 11-3/4 inches (Fig. 1). Each master container holds three trays vacuum-formed from extruded, high-impact polystyrene sheets. The trays measure 17-7/8 x 11-7/8 inches, and have 9 cells to accommodate size-27 fruit, or 11 cells for the size-32 fruit. Three trays are packed in each master container. Holes, with a 1/8-inch diam, are located in the bottom of each tray cell, and six 1/2-inch, half-moon cutouts are located along the perimeter of each tray to permit airflow between tray layers. Each end panel of the master shipping container has one 5/8- x 2-inch ventilation slot, and each side panel has two 5/8- x 3-inch ventilation slots. One side panel slot permits airflow to the top and middle tray layers, and the other permits airflow to the middle and bottom tray layers. The gaps in the outer flaps of the cover and body measure 7/8 x 6-1/2 inches. The cover and body of the master container are fabricated from 275-lb-test fiberboard. Two biphenyl pads with six 1/2-inch ventilation slots were used in the tray-pack containers, one between each layer of fruit.


Fig. 1. Body of master shipping container with plastic trays (without matching cover) packed with size-27 Florida grapefruit. Note ventilation slots in side and end panels to provide ventilation to the three fruit layers.)

### *Bulk Bins*

Two types of bulk bins were selected for the fumigation tests: a wooden, wirebound bin and a triple-wall, fiberboard bin.

The wirebound bin is constructed from 5/16-inch-thick southern hardwoods and 1/6-inch-thick veneer slats (Fig. 2). Its outside dimensions are 46 x 40-1/2 inches, and the inside depth is 33 inches. The wirebound bin has a self-contained wooden pallet base 4 inches high. The bin is filled with loose grapefruit in an amount equivalent to 30 four-fifths bu, resulting in a gross weight of about 1,344 lb. Spaces, 3/16-inch wide, between the deckboards of the pallet base and an open top permit vertical ventilation

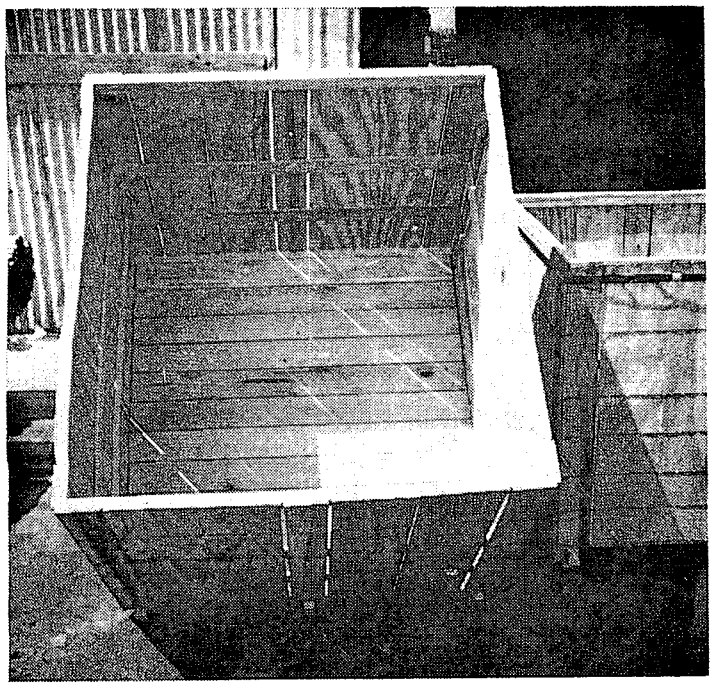

Fig. 2. Wirebound pallet bin on self-contained, wooden pallet base.

through the bin. Each side of the bin has six 3/16-inch side spaces between the vertical wooden slats that extend from top to bottom of the bin to provide crosswise airflow through the bin.

The fiberboard bin is an irregular octagon made of different-width panels (Fig. 3). The bin's inside, lengthwise, and crosswise dimensions between the principal sidewalls are 47 inches and 35-1/2 inches, respectively, and it is 36 inches deep. Self-locking fiberboard caps form the bottom and cover of the bin. The caps overlap the outside sidewalls 6 inches at the bottom and at the top of the bin. Each bottom and cover cap has thirteen 5/8- x 5-inch ventilation slots to permit vertical airflow through the bin. The sidewalls of the bin are fabricated from 1,100-lb-test fiberboard, and the bottom and cover caps from 275-lb-test fiberboard. A standard 48- x 40-inch wooden pallet base, 5-1/2 inches high, is used under the fiberboard bin. The bin is filled with loose grapefruit in an amount equivalent to 30 four-fifths bu, resulting in a gross weight, including the weight of the pallet base, of about 1,350 lb.

During bin filling, we placed 60 biphenyl pads in each type of bin.

*Standard Container*

The standard export container is a four-fifths-bu, full-telescope, single-wall fiberboard box with inside dimensions of 17 x 10-5/8 x 9-5/8 inches. Each side panel of the box has two 5/8- x 3-inch ventilation slots. The gaps in the outer flaps of the cover and body measure 5/8 x 7 inches. The cover is fabricated from 200-lb-test fiberboard, and the body from 350-lb-test fiberboard. Two biphenyl pads were placed in the box, one between each layer of fruit.

## Methods

'March' grapefruit (*Citrus paradisi* Macf.) used in the fumigation tests were harvested from the Indian River area of Florida. Standard four-fifths-bu boxes were packed on regular packinghouse lines of cooperating commercial shippers. Researchers packed the tray-pack containers at the packinghouses. The fruit were then transported by personnel of the U.S. Department of Agriculture (USDA) to the chamber site at the Subtropical Horticulture Research

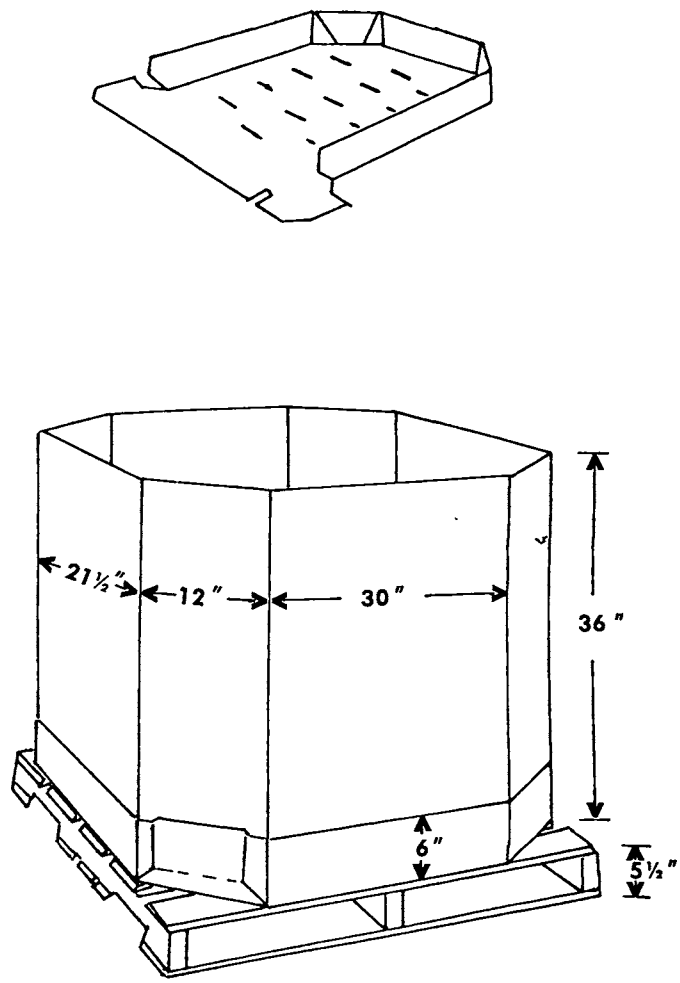


Fig. 3. Diagram illustrating octagonal fiberboard bin. (Note slots in cover cap to provide ventilation through the bin.)

Station, Miami, Florida. The bulk bins were assembled manually at the chamber site, placed in the load, and manually filled with grapefruit from standard four-fifths-bu boxes. All of the experimental containers were placed in a central location in the semitrailer vanload (Fig. 4). The tray-pack containers were placed on a fiberboard slipsheet,

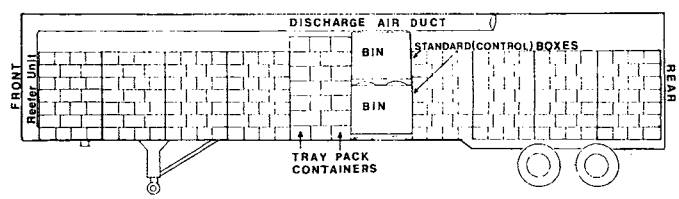


Fig. 4. Diagram showing location of experimental tray-pack containers, bins, and standard (control) boxes in semitrailer van.

8 per layer, 6 layers high, to form a tightly stacked unit of 48 containers. The four-fifths-bu standard boxes were placed on slipsheets, 9 per layer, 6 layers high, to form chimney-stacked units, each containing 54 boxes. Standard four-fifths-bu boxes that were packed with grapefruit of a size and quality comparable to those of grapefruit packed in test bins and tray-pack containers were placed in selected locations in the test loads. The remainder of the load consisted of standard four-fifths-bu boxes filled with 3-inch-diam polystyrene balls and 2 biphenyl pads to simulate a full semitrailer vanload of fruit. The semitrailer van was then backed into the chamber for fumigation. The semitrailer and chamber used in these tests were described in detail by Burditt and von Windeguth (3).

The back doors and front vents of the semitrailer remained open during fumigation, but the side door was closed. The fumigations were performed in accordance with procedures approved by the Animal and Plant Health Inspection Service, USDA (1). Ethylene dibromide (EDB) was applied at a dosage rate of 8 oz/1,000 ft³ (991 ml) per *trailerload as required* for temps above 70°F and a less-than-25% chamberload factor. The fumigation exposure period was 2 hr, followed by postfumigation aeration of 1 hr.

*Infested Grapefruit*

Two fumigation treatments were conducted with infested grapefruit in standard boxes, 5 with infested grapefruit in tray-pack containers and one with infested grapefruit in each type of bulk bin. Grapefruit for the tests were exposed to a captive population of gravid Caribbean fruit flies in 12- x 12- x 9-ft cages for 7 days. Then they were removed and packed in the standard and experimental shipping containers. The packed shipping containers were held 1 week at 75°F (24°C) to allow insects to develop and mature within the fruit. Then the containers with the infested grapefruit were placed in the semitrailer vanload.

After fumigation and postfumigation aeration, the infested grapefruit were recovered, emptied from their respective containers, and placed in trays located in bioassay holding cages, as previously described by Burditt and von Windeguth in 1975 (2). The trays were sifted once each week for a *minimum* 4 weeks to recover any immature fruit flies that may have survived the treatment. Untreated control fruit were examined in the same sequence.

*Gas Concentrations*

A teflon gas sampling probe with a 1/8-inch inside diam was placed in each type of container, including those with infested and noninfested grapefruit, to record gas concns during the volatilization of the EDB (ca. 15 min); at 15-min intervals during fumigation, and at 20-min intervals during posttreatment aeration. Each gas sampling probe was connected to a Gastech® halide detector (model No. 1257). Five fumigation tests were made in which gas concns in tray-pack containers were compared with gas concns in standard boxes. Two tests were made in which gas concns in wirebound and fiberboard bins were compared with gas concns in standard boxes.

*Residues in Grapefruit*

Following 2 test fumigation treatments, samples of grapefruit were removed from each type of container to determine the amount of EDB residue in the grapefruit. These samples of grapefruit were prepared for analysis according to the method of Kennett and Huelin (6). We then determined the EDB residue by gas chromatography, using an electron capture detector.

*Fumigation Injury*

We made visual examinations of 2,289 grapefruit packed in wirebound bins, 2,273 grapefruit packed in fiberboard bins, 1,043 grapefruit packed in tray-pack containers, and 488 grapefruit packed in standard boxes to determine the amount of EDB injury to the peel. The grapefruit were held at 60°F storage after fumigation until individual fruit examinations were made after 6 and 19 days.

Table 1 indicates fumigation test dates, types of containers in each test, and the tests in which infested grapefruit were fumigated.

Table 1. Dates of fumigation tests of Florida grapefruit and types of shipping containers used, Florida, 1976-77.

| Date treated | Standard box | Tray-pack container | Wirebound bin | Fiberboard bin |
|---|---|---|---|---|
| 1976: | | | | |
| December 15 | X[z] | X | X | X |
| 1977: | | | | |
| January 26 | X[z] | X[z] | X[z] | X[z] |
| April 6 | X | X[z] | | |
| April 13 | X | X[z] | | |
| May 17 | X | X[z] | | |
| May 24 | X | X[z] | | |

[z]Contained infested fruit.

## Results

*Infested Grapefruit*

Based on insect yield from untreated fruit, the total estimated larvae population treated by containers was 7,741 in the standard box, 19,936 in the tray-pack container, and 737 in each of the bulk bins. No surviving larvae were recovered from treatments in the standard boxes or from the 3 types of experimental shipping containers (Table 2).

Table 2. Recovery of larvae of the Caribbean fruit fly, *Anastrepha suspensa* from infested grapefruit packed in 4 types of shipping containers after ethylene dibromide fumigation in semitrailer van in fumigation chamber.

| Date treated | Type of shipping container | No. of fruit | Estimated population[z] | No. of larvae recovered |
|---|---|---|---|---|
| 1976 | | | | |
| December 15 | Standard box | 288 | 6635 | 0 |
| 1977 | | | | |
| January 26 | Standard box | 108 | 1106 | 0 |
| January 26 | Fiberboard bin | 72 | 737 | 0 |
| January 26 | Wirebound bin | 72 | 737 | 0 |
| January 26 | Tray-pack container | 132 | 1352 | 0 |
| April 6 | Tray-pack container | 720 | 6286 | 0 |
| April 13 | Tray-pack container | 720 | 5645 | 0 |
| April 17 | Tray-pack container | 693 | 1795 | 0 |
| April 24 | Tray-pack container | 693 | 4858 | 0 |

[z]Based on insect yield from untreated fruit. Total estimated larvae population treated by containers were 7,741 in the standard box, 19,936 in the tray-pack container, and 737 in each of the bulk bins.

*Gas Concentrations*

The tray-pack containers in the first fumigation test were stacked tightly, not typical of commercial loading practices. As a result, gas concns were not as high in the tray-pack containers in the floor layer of the load as those in standard boxes. The tray-pack containers in the next four tests were loaded as in commercial practice. Results of those tests indicated that gas concns in tray-pack containers were similar to those in standard boxes (Fig. 5). The gas concn curves for the wirebound and fiberboard bins illustrated in Figs. 6 and 7 indicate that concns in the experimental bin containers were similar to concns in standard boxes throughout the 2-hr fumigation and 1-hr aeration periods.

*Residues in Grapefruit*

The residues of EDB present in grapefruit fumigated in each type of shipping container are summarized in Table

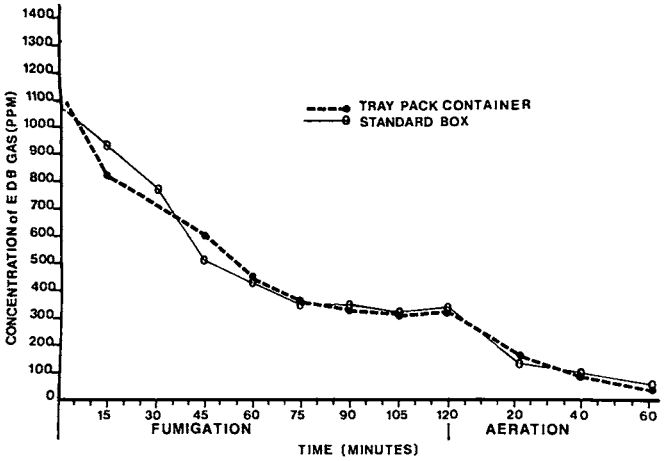


Fig. 5. Concentration of EDB gas (ppm) in a semitrailer van in chamber for grapefruit packed in tray-pack containers and in standard boxes and placed in a central location of the loads, average of four tests, Florida, 1976-77.

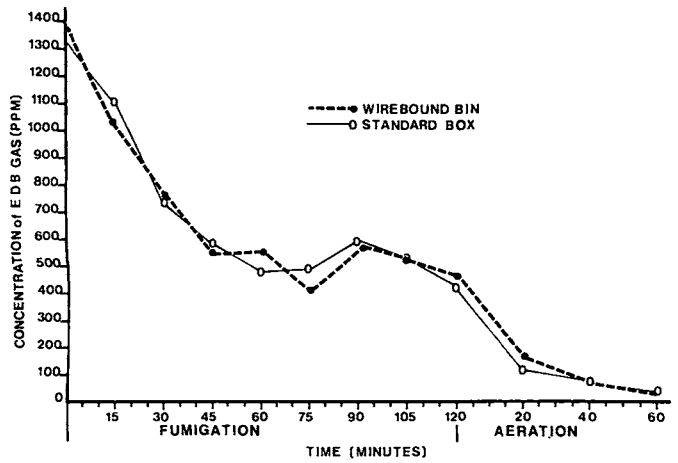


Fig. 6. Concentration of EDB gas (ppm) in semitrailer van in chamber for grapefruit packed in wirebound bins and in standard boxes and placed in a central location of the loads, average of two tests, Florida, 1976-77.

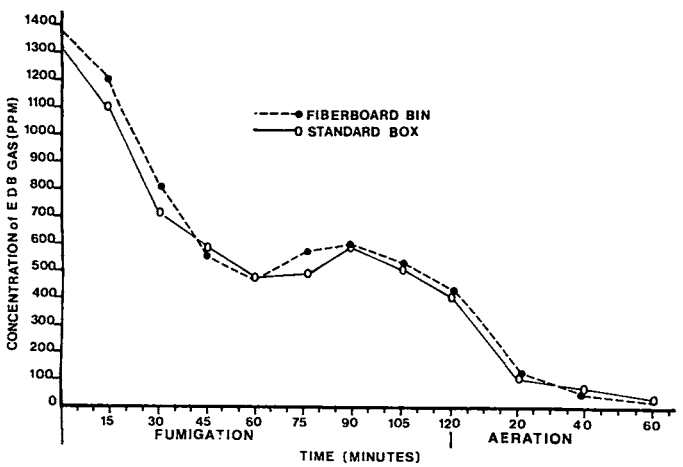


Fig. 7. Concentration of EDB gas (ppm) in semitrailer van in chamber for grapefruit packed in fiberboard bins and in standard boxes and placed in a central location of the loads, average of two tests, Florida, 1976-77.

3. As data indicate, residues were higher in fruit from the 2 types of bulk bins than for fruit treated in the standard and tray-pack containers. The data indicate that the EDB gas was reaching the grapefruit in all containers.

Table 3. Residues of EDB in whole grapefruit by container type after 2-hr fumigation and 1-hr aeration, 2 tests, Florida, 1976-77.

| In shipping container | Avg EDB residue grapefruit (ppm) |
|---|---|
| Standard box | 10.2 |
| Tray-pack container | 10.6 |
| Wirebound bin | 13.8 |
| Fiberboard bin | 16.4 |

*Fumigation Injury*

For all types of shipping containers, the total amount of EDB injury to grapefruit examined from 2 tests was slight, averaging less than 1%, and would be considered of no consequence for grapefruit in commercial shipments. Slight EDB injury is injury affecting less than 10% of fruit surface area, but not detrimental to salability.

## Discussion and Summary

Florida shippers exporting grapefruit to Japan are interested in using tray-pack containers, to provide maximum protection to their large size-27 fruit; and bulk bins, to reduce total marketing costs. Numerous inquiries have been made by exporters, importers, and manufacturers of shipping containers as to what effect the tray-pack containers and bins will have on the application and removal of EDB during the fumigation and aeration treatments. Data from tests conducted with simulated semitrailer loads of grapefruit indicated that tray-pack containers and fiberboard and wirebound bulk bins are acceptable for use for the export of grapefruit requiring fumigation with EDB. The Methods Development Laboratory, Animal and Plant Health Inspection Service, U.S. Department of Agriculture, Hoboken, New Jersey, tested and approved prototypes of each tray-pack container and/or bin for fumigation with EDB for export. However, when full commercial semitrailer vanloads are initiated with tray-pack containers or with bins, it is recommended that they be monitored carefully to determine whether adjustments are needed in EDB dosages or in the length of the postfumigation aeration period, or both.

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