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**Tests of Overseas Shipments  
Of California Citrus Fruit—  
Interrelations Between  
Fruit Condition, Biphenyl Content,  
Transit Temperature, Delayed Loading,  
And Biphenyl Pad Placement**

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## CONTENTS

	Page
Summary.....	1
Introduction.....	2
Procedure.....	3
Results.....	3
Oranges.....	3
Temperatures.....	3
Biphenyl absorbed by oranges.....	7
Biphenyl lost from oranges during airing.....	13
Condition of oranges.....	15
Biphenyl remaining in pads.....	15
Lemons.....	15
Transit temperatures.....	15
Biphenyl absorbed by lemons.....	16
Biphenyl lost from lemons during airing.....	18
Condition of lemons.....	18
Grapefruit.....	19
Transit temperatures.....	19
Biphenyl absorbed by grapefruit.....	19
Biphenyl lost from grapefruit during airing.....	21
Condition of grapefruit.....	21
Appendix.....	22

# Tests of Overseas Shipments Of California Citrus Fruit— Interrelations Between Fruit Condition, Biphenyl Content, Transit Temperature, Delayed Loading, And Biphenyl Pad Placement

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## SUMMARY

Penicillium-induced decay and soilage can be suppressed in shipments of citrus fruits if paper pads treated with biphenyl are placed in the shipping containers. However, varying quantities of biphenyl are absorbed by the fruit and under certain conditions of transport and handling, the fruit may retain biphenyl residues that exceed legally permissible tolerances. (The European Economic Community (EEC) accepts any residue value at or below 70 parts per million.)

To obtain data on the problem of giving citrus fruit maximum biphenyl protection without exceeding acceptable biphenyl residues, and to obtain information on transit temperature and condition of fruit transported by several methods, test shipments of citrus fruits were sent from California to Rotterdam, the Netherlands, in 1967. These test shipments consisted of 36 orange lots, nine lemon lots, and six grapefruit lots. Most of the fruit was sent by rail to the Atlantic seaboard for transit to Rotterdam by ship. Some, however, was sent by ship from California to Rotterdam via the Panama Canal.

The temperatures of most of the test shipments of oranges sent east by rail were higher than desirable while the oranges were in the railcars.

An appreciable rise in temperature occurred in some of the shipments during transfer from railcars to ships' holds at the Atlantic ports. Generally, temperatures in the holds were satisfactory, but some were higher than desired.

The transit period by rail-ship via the Atlantic coast ranged from 18 to 24 days but generally took 20 to 21 days. Transit by ship via the Panama Canal took 26 to 28 days.

Three percent of the oranges that were promptly loaded contained more than 70 p.p.m. biphenyl on arrival at Rotterdam, but 69 percent contained more than 70 p.p.m. after they were held without refrigeration for 1 week in post-transit storage. Of the oranges held 3 days at 75° F. before they were loaded at the packinghouses, 40 percent had more than 70 p.p.m. biphenyl on arrival at Rotterdam, and 81 percent exceeded this value after 1 week of non-refrigerated storage.

Biphenyl residue was increased by high transit temperatures.

Biphenyl residue in fruit shipped via the Panama Canal was usually higher than the residue in similar fruit shipped by rail to the Atlantic seaboard and then by boat to Rotterdam. The transit period via the Panama Canal was at least 1 week longer than that of the rail-ship route.

Biphenyl pads placed between fruit layers produced higher residues than pads placed above and below the fruit.

Fruit coatings did not affect the amount of biphenyl absorbed by the fruit.

Oranges lost only about 5 percent of their biphenyl content during 1 week's airing.

Delaying the loading of the oranges resulted in a 50-percent increase in decay and soilage, both on arrival and 1 week after arrival. Hold-

ing the fruit 1 week at 70° F. after arrival was accompanied by a threefold to fourfold increase in decay and soilage.

Placement of the biphenyl pads above and below the oranges was accompanied by three to four times as much decay and soilage as placement between layers of fruit. (The greater effectiveness of the layered pads is caused by the higher vapor pressure the pads emit in their immediate vicinity; citrus fruit gains little or no benefit from the biphenyl it absorbs.)

Biphenyl pads retained about one-half their initial biphenyl content on arrival if loaded promptly and one-third if loading was delayed. The arrival values were reduced by 60 percent during 1 week's holding at 70° F.

Transit temperatures of lemons in some of the tests were below 50° F. for 2 weeks and below 45° for 1 week.

All biphenyl residues in lemons were below 40 p.p.m. on arrival and only one value exceeded 42 p.p.m. 1 week after arrival.

Lemons in nonvented cartons contained slightly more biphenyl than those in vented cartons.

Lemons shipped by boat via the Panama Canal contained slightly more biphenyl than

the average of lemons shipped by rail-ship via the Atlantic Coast.

Lemons lost an average of 37 percent of their biphenyl during a week's airing.

The condition of the lemons was not affected appreciably by delayed loading, but decay and soilage approximately doubled during 1 week's nonrefrigerated storage after arrival.

The lemons packed in vented and in nonvented cartons were similar in condition; decay and soilage findings were highly variable for the fruit packed in both types of cartons.

The average transit temperature of the grapefruit shipments was acceptable in all tests except one; in this test, the temperature was much too warm.

The biphenyl residue in grapefruit was far below the EEC's 70 p.p.m. tolerance in the shipments that were handled well. Some of the values exceeded tolerance in the shipments that were loaded at high temperatures or had a high transit temperature.

Grapefruit did not lose biphenyl measurably on airing.

The average condition of grapefruit shipped by rail-ship was acceptable at nearly all inspections, but the long transit period at high temperatures in one test resulted in excessive decay and soilage.

## INTRODUCTION

Fifty-one test shipments of citrus fruits were sent from California to Rotterdam, the Netherlands, during the main part of the marketing season of 1967. The shipments extended from late April to the first of September. Forty-five of the shipments were sent by railcar from California to the Atlantic seaboard, where they were transferred to ships bound for Rotterdam. The six remaining shipments were routed from the Los Angeles-Long Beach port area to Rotterdam via the Panama Canal. Valencia oranges were used in 36 of the test shipments, lemons in nine, and grapefruit in six.

This series of test shipments was made to obtain data on the biphenyl residue in California citrus fruits protected by biphenyl pads, both on arrival of the fruit at western European ports and after it was held for a period equivalent to that needed for distribution to the various markets. These shipments also were designed to provide information on transit temperature and fruit condition associated with several methods of transportation.

To secure the necessary information, test shipments sent by all the principal routes and subjected to all the procedures customarily used

by commercial shippers were needed. The results of such a series of shipments should disclose which procedures were likely to produce excessively high biphenyl residues, and which, if any, would permit the fruit to be delivered with residues low enough to comply with tolerance limitations. (The legal tolerance for biphenyl residues in citrus fruits in the United States is 110 p.p.m. and in the European Economic Community (EEC), 70 p.p.m.)

The most severe test conditions were planned so as to be more rigorous than any likely to be experienced by ordinary commercial shipments. These included the high-temperature holding period that preceded loading the fruit at the packinghouse. Commercially used shipping procedures used in these tests included break bulk, palletized, ventilated ships' holds, refrigerated ships' holds, refrigerated railcars, and for the lemons, shipment in both ventilated and nonventilated cartons.

The test material consisted of 140 cartons of Valencia oranges, 36 cartons of lemons, and 22 cartons of grapefruit. In all, 252 fruit samples and 52 biphenyl pads were analyzed for biphenyl content.

## PROCEDURE

The test packages consisted of commercial citrus cartons of  $\frac{4}{5}$ -bushel capacity. Most of these had eighteen 1-inch perforations for ventilation. Cartons used in two lemon tests were without perforations. Four companion cartons constituted one test lot, except in three shipments where two cartons were used. Two of the four cartons contained recording thermometers. One carton with a thermometer and one without were prepared about 3 days before the shipping date and held at a temperature as near 75° F. as possible to simulate delayed handling at the harbor. The remaining two cartons, one of which contained a recording thermometer, were prepared at the time the commercial shipment was packed.

The test cartons were stowed in a railcar or on pallets, in the third or fourth layer of loads having six layers. The fruit in "delayed loading" cartons was usually not from the same lot as the fruit in "prompt loading" cartons in the same test. Hence, data on decay and soilage in these treatments are not directly comparable, but the biphenyl data are comparable.

Most of the test shipments were sent in ice-refrigerated railcars to the Atlantic seaboard, where they were transferred to ships bound for Rotterdam. One lemon, one grapefruit, and four orange test shipments were loaded on board ships at the Los Angeles-Long Beach area and routed through the Panama Canal to Rotterdam. The transit period for the rail-ship routing was usually 20 to 21 days, and for the routing by ship via the Panama Canal, about 4 weeks.

Preliminary arrangements were made with the shippers in California to have cartons of test fruit transported with commercial shipments, and with the receivers in Rotterdam to recover the test packages and transport them to the analytical laboratory in Zeist, the Netherlands. Contractual arrangements were made between the Foreign Agricultural Service of the U.S. Department of Agriculture and the Central Institute for Nutrition and Food Research TNO in Zeist to analyze samples from each test package for biphenyl residue and to note the amount of decay and soilage.

The holding and transit temperatures shown in the charts were obtained by taking the noon and midnight values on the recording-thermometer charts. Intermediate readings were taken when necessary to show high or low values on the curves.

On arrival at the laboratory at Zeist, the fruit in the cartons without recording thermometers was sampled as soon as the laboratory schedule permitted. During the intervening time, all the test cartons were stored at 39° F. (4° C.). At the time of the "arrival" analysis, the companion cartons containing the thermometers were transferred to nonrefrigerated storage at about 70°, where they were held unopened for 1 week to simulate wholesale distribution. Samples were then selected for biphenyl analysis.

The contents of each carton were divided into decayed and sound fruit. The sound fruit was further divided into clean and soiled (by dusting from spores on decaying fruit). The number of fruit in each group was counted. Sound fruit from some of the cartons was placed on trays in the laboratory and held 1 week to simulate retail store display. Samples of this fruit were analyzed for biphenyl residue to find the extent of loss during airing. Biphenyl pads from some of the cartons were analyzed at the termination of the tests, some at the time of the arrival examinations, and some after the 1-week holding period.

The biphenyl residues were measured by gas chromatography, and by thin layer chromatography combined with spectrophotometric analysis. With a few exceptions, the residue values used in this report are those obtained by the thin layer method, which is the method adopted officially by the European Economic Community. Gas chromatographic data are used in some of the early analyses, where thin layer data are not available. The report by the analytical laboratory stated that the results obtained by the two methods agreed closely and that both methods gave acceptable values. The average values of all orange analyses by the gas chromatographic method was 78.2 p.p.m., and by the thin layer method 80.0 p.p.m.; average residues in lemons were 23.9 and 24.0 p.p.m.; and in grapefruit 42.4 and 45.6 p.p.m.

## RESULTS

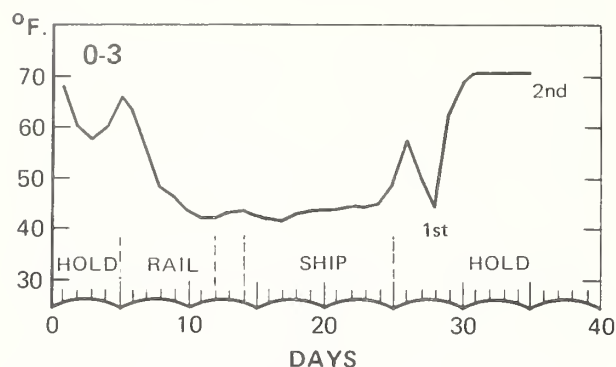
### Oranges

#### Temperatures

*Pretransit temperatures.*—The duration and temperature of the pretransit holding period

varied according to prevailing circumstances and are shown in figures 1 to 5. The pretransit treatment increased the exposure to biphenyl vapor in a manner that could occur in commercial shipments but is not customary. In

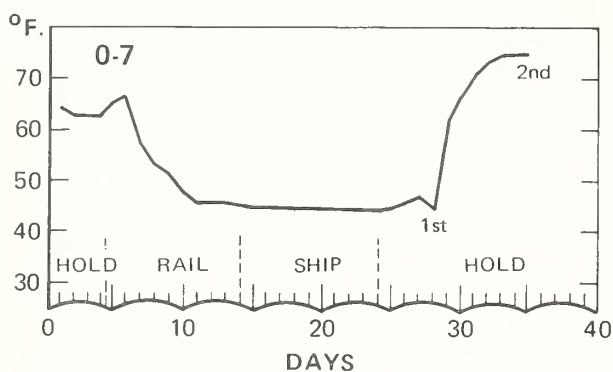




0-3; Transit Period 4/19-5/9/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	63	94	60	131
% DECAY	0	1.8	0	0
%SOILAGE	0	5.5	0	0

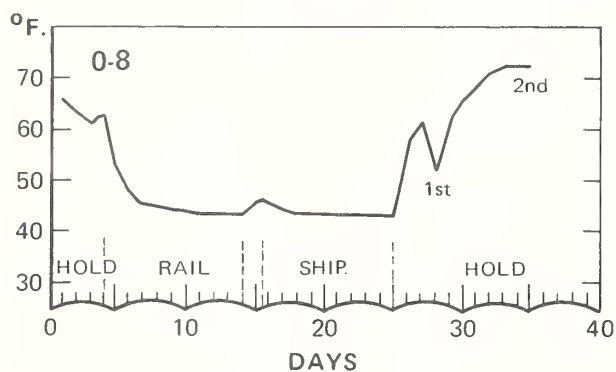
VIA NEW YORK, N.Y.; REFRIGERATED SHIP



0-7; Transit Period 5/9-5/29/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	58	88	58	115
% DECAY	0.7	2.2	1.4	3.6
%SOILAGE	0	2.9	0.7	2.2

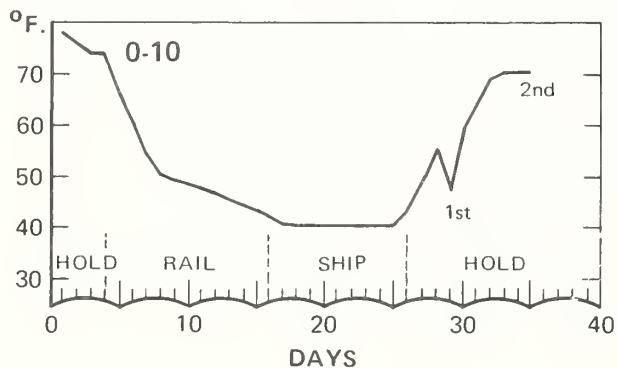
VIA ST. JOHN, N.B.; REFRIGERATED SHIP



0-8; Transit Period 5/17-6/7/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	51	50	49	104
% DECAY	0.7	1.5	0	1.5
%SOILAGE	0.7	3.5	0	5.1

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

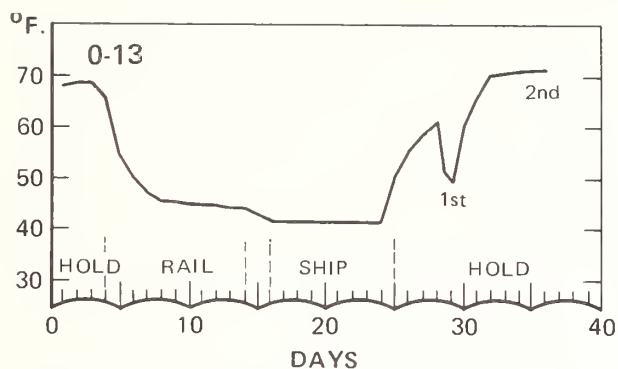


0-10; Transit Period 5/23-6/12/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	48	57	93	103
% DECAY	5.1	3.0	0	1.5
%SOILAGE	6.6	3.0	0	1.5

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

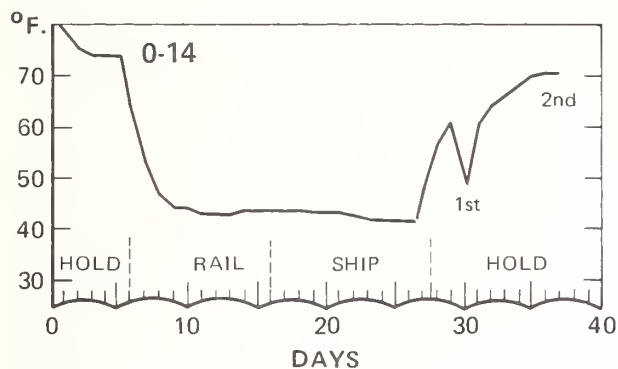
FIGURE 1.—Transit temperatures were satisfactory for the California oranges in these eight overseas shipments. Fruit from test cartons in each shipment was examined for decay and soilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later.



0-13; Transit Period 5/29-6/19/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	51	59	59	73
% DECAY	0	5.4	1.5	0
%SOILAGE	0	0.8	4.4	0

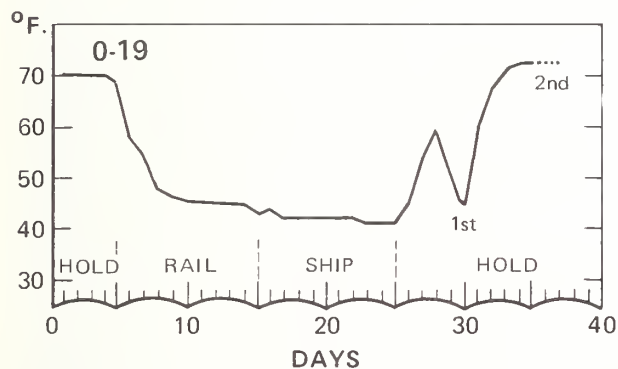
VIA ST. JOHN, N.B.; REFRIGERATED SHIP



0-14; Transit Period 5/29-6/19/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	66	99	85	107
% DECAY	0	0.6	0	1.9
%SOILAGE	0	0	0	3.8

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

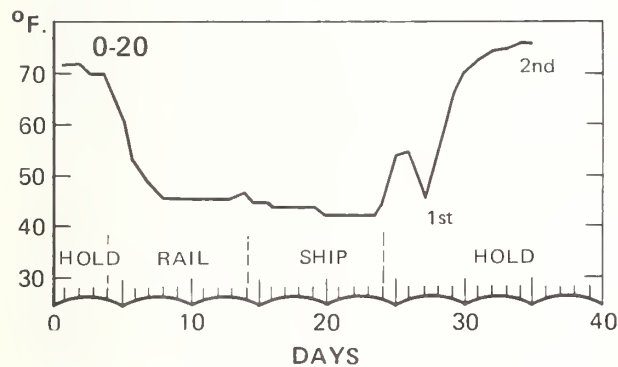


0-19; Transit Period 6/13-7/3/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	60	110	* 25	86
% DECAY	0	2.7	0	1.7
%SOILAGE	0	6.2	0	1.7

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

\* No Pad



0-20; Transit Period 6/13-7/3/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	48	98	86	120
% DECAY	0	0	0	3.6
%SOILAGE	0	0	0	4.4

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

FIGURE 1.—Transit temperatures were satisfactory for the California oranges in these eight overseas shipments. Fruit from test cartons in each shipment was examined for decay and soilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later. (Cont'd)

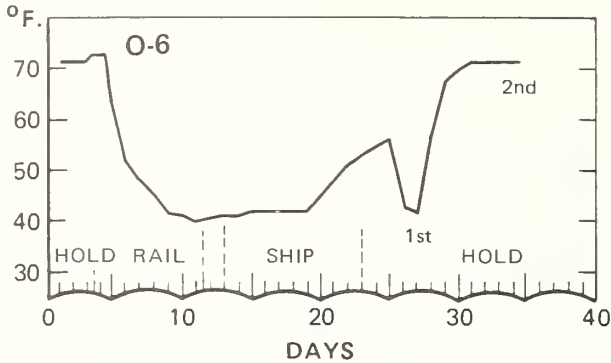


FIGURE 2.—Rail temperatures were satisfactory for oranges in overseas shipment 0-6, but ship temperatures were high. Fruit from test cartons in this shipment was examined for decay and soilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later.

about half of the test shipments the temperature was in the 70's at least part of the time, but in several instances facilities did not permit this temperature to be attained. The temperature of the fruit in tests 0-33 to 0-36 (fig. 5) was high for a longer time than was intended because of unplanned delay in loading into the ship's hold. Consequently the "promptly handled" fruit remained at a temperature above 75° F. for 4 days or longer, and the fruit deliberately subjected to delayed loading was held 7 to 9 days.

*Transit temperatures.*—Most of the test shipments were routed by rail from California to the Atlantic seaboard, then by ship to Rotterdam. The transit temperature records in these shipments are divided into rail and ship. A short addition to the temperature scale is evident in several of the charts where the temperature rose from 1 to 6 degrees during the transfer from the railcars to the ships' holds. Other shipments made by the same route did not show any warming during the transfer. Figures 1 to 5 show the rise or lack of rise in each of the test shipments. The rise in temperature is objectionable because it tends to allow an increase in biphenyl absorption by the fruit, gives an environment more favorable for decay development, and may be accompanied by "sweating" of the fruit with the result that it may be wet during much of the subsequent journey. Whether this wetting of the fruit is harmful or not has not been determined experimentally.

Average transit temperatures for oranges ranged from 44° to 57° F., with most ranging from 46° to 52°. Some of these averages are considerably higher than desired. The temperatures of many of the shipments never reached the desirable low 40's. In 31 combination rail-

### 0-6; Transit Period 5/8-5/29/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	45	81	52	73
% DECAY	1.7	5.3	5.3	3.6
% SOILAGE	0	0	2.6	0

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

ship orange shipments, the temperature of the fruit while it was in the railcars was lowered to 43° in only four shipments and to 42° in two. In the ships' holds, the temperature of the fruit reached 43° in 22 shipments and 42° in 16. Figures 1 to 5, which give the results of tests 0-1 to 0-36, show the transit temperatures in each of these shipments. More rapid cooling and consistent maintenance of a temperature in the low 40's tend to lower the biphenyl residue on arrival; these factors also aid in conserving the flavor and aroma of the fruit and in minimizing decay development and fungal spore production, which leads to fruit spoilage. Figures 3 and 4 (tests 0-1, 0-4, 0-18, 0-26, 0-29, and 0-32) show, however, that strong, sound fruit can arrive with little or no decay even when the transit temperature is considerably higher.

The pretransit, transit, and post-transit temperatures of all the orange tests except 0-23 appear in figures 1 to 5. (No data is available for test 0-23 because of thermometer failure.) The transit temperatures of the fruit in the rail-ship tests fall into four general groups:

(A) Acceptably low temperatures during the entire transit period: tests 0-3, 0-7, 0-8, 0-10, 0-13, 0-14, 0-19, and 0-20 (fig. 1).

(B) Temperatures satisfactory in the railcars and higher than desired in the ships' holds: test 0-6 (fig. 2).

(C) Temperatures higher than desired in the railcars and satisfactory in the ships' holds: tests 0-4, 0-9, 0-11, 0-12, 0-16, 0-17, 0-18, 0-21, 0-22, 0-25, 0-26, 0-27, 0-28, 0-29, and 0-30 (fig. 3).

(D) Temperatures higher than desired during the entire transit period: tests 0-1, 0-2, 0-5, 0-15, 0-24, 0-31, and 0-32 (fig. 4).

The transit temperatures of the test ship-

ments sent on pallets by ship via the Panama Canal (0-33, 0-34, 0-35, 0-36, fig. 5) differed considerably, even though all the test shipments were in the same ship's hold. Test 0-34 had a relatively warm 57° F. average transit temperature. Tests 0-33 and 0-35 were intermediate, with averages of 51° and 50°, respectively. Test 0-36 had a cool 46° average transit temperature.

### *Biphenyl Absorbed by Oranges*

The biphenyl residue in oranges shipped in the usual break-bulk (not palletized) manner and handled promptly both at loading and on arrival in Rotterdam ranged from 36 to 76 p.p.m. Only one sample (test 0-18, fig. 3) exceeded the EEC's current tolerance of 70 p.p.m., and this one was within the experimental error of 10 percent inherent in the procedures used at the analytical laboratory. Seventeen of thirty values, or 57 percent, were at or below 60 p.p.m.

*Effect of pretransit holding.*—The residues on arrival in fruit held 3 days before it was placed in refrigerated transit ranged from 33 to 125 p.p.m. Fourteen of thirty values, or 47 percent, were 60 p.p.m. or lower and 12 values, or 40 percent, were more than 70 p.p.m.

Four test shipments of oranges on pallets (fig. 5) were sent to Rotterdam on the same ship. The biphenyl residues in this fruit were high because of the long period at high temperatures between packing and loading aboard the ship. The biphenyl residue of "promptly handled" fruit ranged from 67 to 97 p.p.m. on arrival, and that of the fruit purposely delayed in loading from 108 to 130 p.p.m.

*Effect of transit temperatures.*—Temperature is one of the important factors that determine the amount of biphenyl residue in fruit. In these tests, however, a number of uncontrolled variables were involved, and the amount of residue was not always related to the average transit temperature. Nonetheless, the temperature effect was still noticeable: the average biphenyl residue in oranges afforded an average transit temperature of 50° F. or lower was 59 p.p.m. upon arrival, whereas that of oranges afforded an average transit temperature higher than 52° was 74 p.p.m. Only the rail-ship values were used to obtain these averages, so the transit periods were nearly alike in all tests used. The residue values in each of the tests appear in figures 1 to 5.

*Effect of post-transit holding.*—One week's holding without refrigeration (at about 70° F.) after arrival at Rotterdam resulted in substantial increases in residue. Of the oranges handled promptly at the beginning of the tests and

held 1 week after arrival, 20 of 29 samples, or 69 percent, had more than 70 p.p.m. residues.

The oranges exposed to the most severe conditions had residues ranging from 55 to 137 p.p.m. These conditions are not customary in commercial handling; that is, fruit is not usually held without refrigeration for 3 days before loading and for 1 week after arrival. Only two of 32 samples, or 6 percent of the oranges analyzed after arrival, had residues lower than 60 p.p.m., whereas 26 samples, or 81 percent, had residues higher than 70 p.p.m.

Table 1 summarizes the effect of handling methods on the general level of residues in oranges shipped by the rail-ship route.

*Effect of length of transit period.*—The long transit period of 28 days for test shipments sent via the Panama Canal contributed to the high biphenyl residues in the palletized oranges in tests 0-33 to 0-36 (fig. 5). (Most of the fruit shipped by rail to the Atlantic coast and by ship to Rotterdam was in transit only 20 or 21 days.)

*Effect of palletization.*—These tests did not show the effect of palletization on the level of biphenyl residue in fruit handled expeditiously during shipping and held at the recommended temperature.

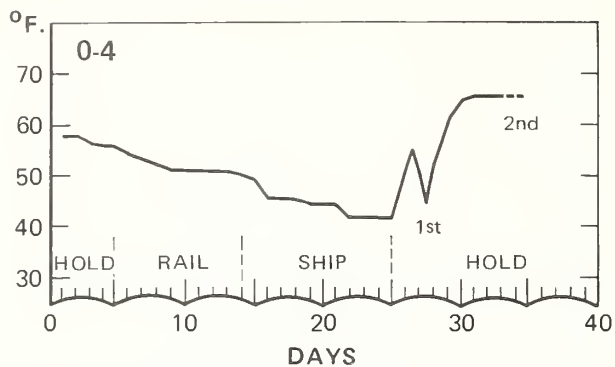
*Effect of fruit coating.*—Four commercial brands of wax were used on the test fruit. The brand did not noticeably affect the amount of biphenyl absorbed by the fruit. It is possible, however, that differences in the amount of natural and applied waxes on the fruit might influence the amount of biphenyl absorbed.

TABLE 1.—*General level of biphenyl residues in California oranges on arrival in Holland and 1 week after arrival, by the time of loading, 1967*

Biphenyl residue	Prompt loading		Delayed loading <sup>2</sup>	
	On arrival	1 week after arrival <sup>1</sup>	On arrival	1 week after arrival <sup>1</sup>
	Percent	Percent	Percent	Percent
More than—				
70 p.p.m.	3	69	40	81
80 p.p.m.	0	45	33	75
100 p.p.m.	0	3	3	34
110 p.p.m.	0	0	3	16
Average	59	80	76	99

<sup>1</sup> Held 1 week at about 70° F. after arrival at Central Institute for Nutrition and Food Research TNO Laboratory, Zeist.

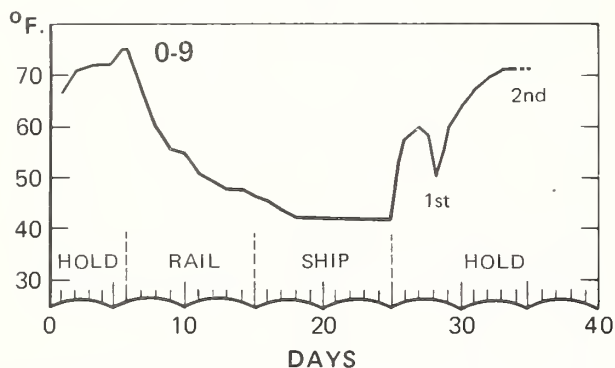
<sup>2</sup> After being packed in California, oranges were either loaded promptly or held approximately 3 days at about 75° F. before being loaded into a railcar for shipment via Atlantic seaboard or onto a ship for shipment via Panama Canal.



## 0-4; Transit Period 4/26-5/16/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	47	79	48	88
% DECAY	0	0.2	0.7	0
%SOILAGE	0	7.3	2.2	0

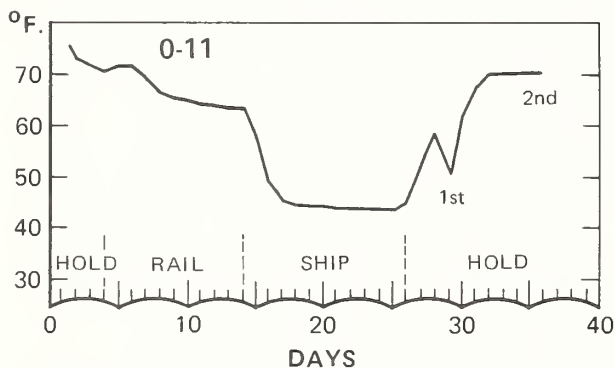
VIA NEW YORK, N.Y.; REFRIGERATED SHIP



## 0-9; Transit Period 5/17-6/7/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	69	64	76	119
% DECAY	0	1.8	1.7	0
%SOILAGE	0	1.8	4.4	0

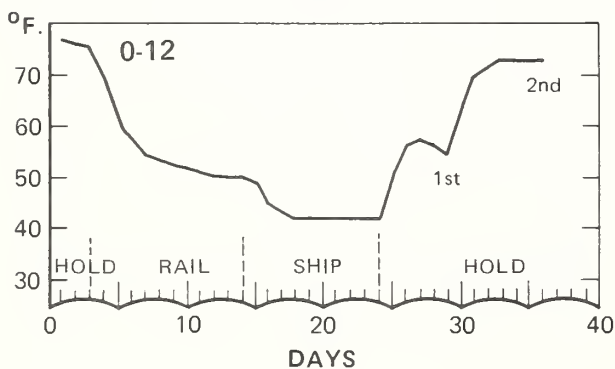
VIA ST. JOHN, N.B.; REFRIGERATED SHIP



## 0-11; Transit Period 5/23-6/12/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	67	79	99	110
% DECAY	1.7	6.2	2.2	3.1
%SOILAGE	12.4	35.1	10.2	5.3

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

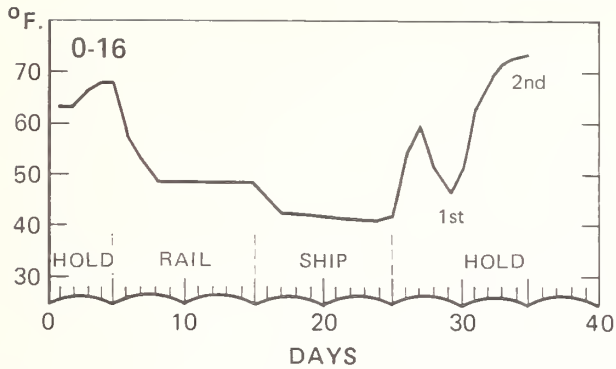


## 0-12; Transit Period 5/23-6/12/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	59	81	63	88
% DECAY	0	0	0.9	1.7
%SOILAGE	0	0	0	1.7

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

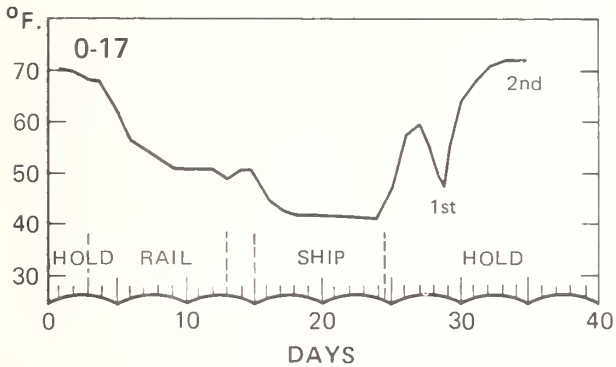
FIGURE 3.—Rail temperatures were high in these 15 shipments of California oranges, sent overseas, but ship temperatures were satisfactory. Fruit from test cartons in each shipment was examined for decay and soilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later.



0-16; Transit Period 6/6-6/26/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	45	83	67	95
% DECAY	0	3.6	0	0
%SOILAGE	0	4.4	0	0

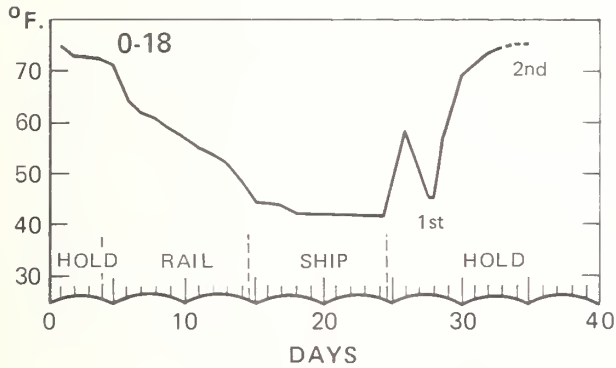
VIA ST. JOHN, N.B.; REFRIGERATED SHIP



0-17; Transit Period 6/6-6/26/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	51	73	56	91
% DECAY	0.9	0.9	0	0
%SOILAGE	2.7	0	0	0

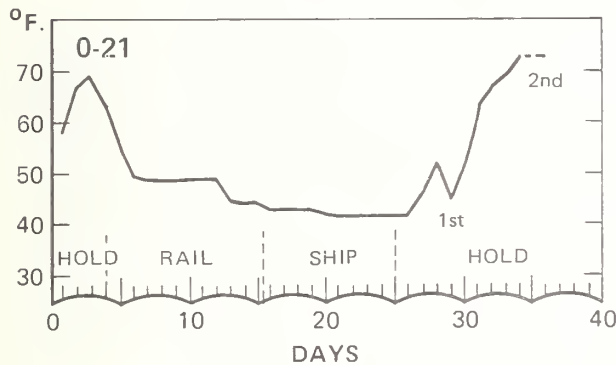
VIA ST. JOHN, N.B.; REFRIGERATED SHIP



0-18; Transit Period 6/6-6/26/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	76	98	55	66
% DECAY	0.9	0.9	0	1.8
%SOILAGE	0.9	0	0	2.7

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

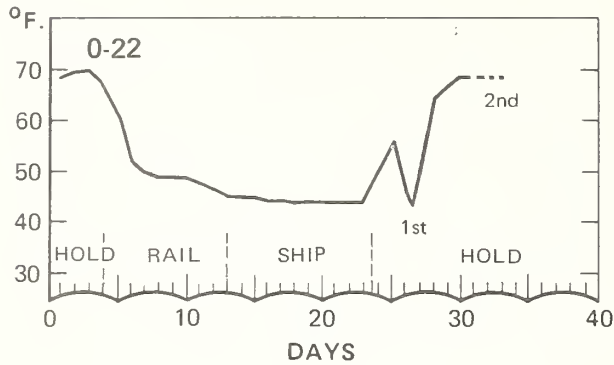


0-21; Transit Period 6/13-7/3/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	62	99	57	92
% DECAY	0	0.7	0	4.4
%SOILAGE	0	0	0	8.7

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

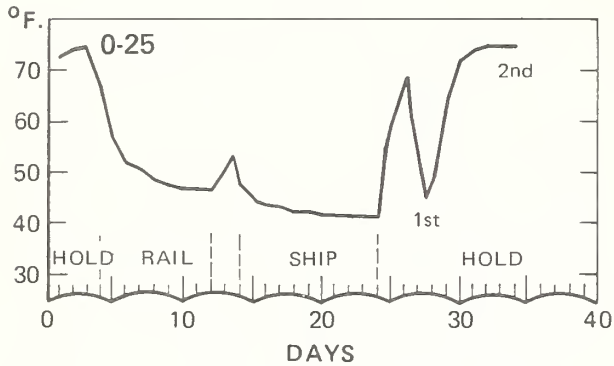
FIGURE 3.—Rail temperatures were high in these 15 shipments of California oranges, sent overseas, but ship temperatures were satisfactory. Fruit from test cartons in each shipment was examined for decay and soilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later. (Cont'd)



0-22; Transit Period 6/13-7/3/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	51	83	53	63
% DECAY	0	5.1	0	4.4
% SOILAGE	0	2.9	0	10.9

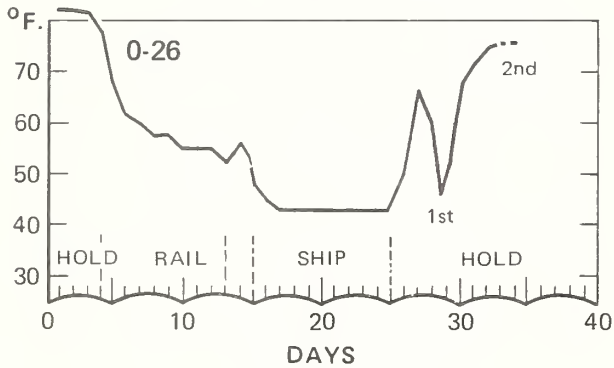
VIA ST. JOHN, N.B.; REFRIGERATED SHIP



0-25; Transit Period 6/26-7/17/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	60	57	62	95
% DECAY	0.8	1.5	2.2	13.8
% SOILAGE	0	0	0	10.9

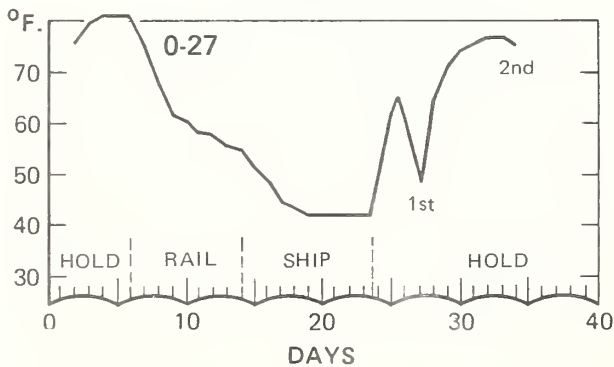
VIA ST. JOHN, N.B.; REFRIGERATED SHIP



0-26; Transit Period 6/26-7/17/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	36	89	81	75
% DECAY	0	3.6	0.7	1.5
% SOILAGE	0	9.4	0	4.4

VIA ST. JOHN, N.B.; REFRIGERATED SHIP



0-27; Transit Period 7/3-7/24/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	36	49	121	109
% DECAY	0	5.8	5.8	20.2
% SOILAGE	0	12.3	26.0	51.0

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

FIGURE 3.—Rail temperatures were high in these 15 shipments of California oranges, sent overseas, but ship temperatures were satisfactory. Fruit from test cartons in each shipment was examined for decay and soilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later. (Cont'd)

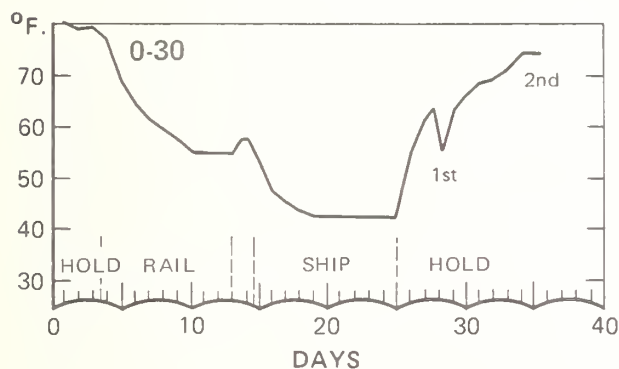
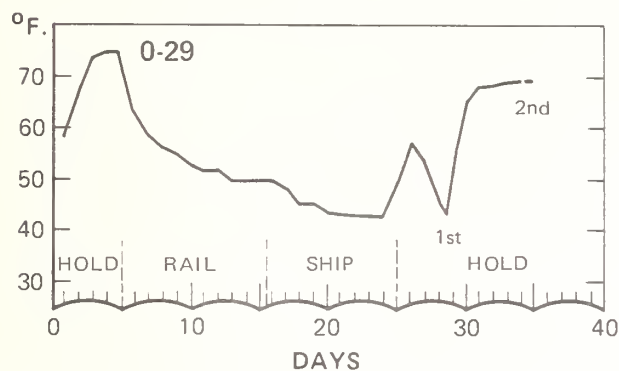
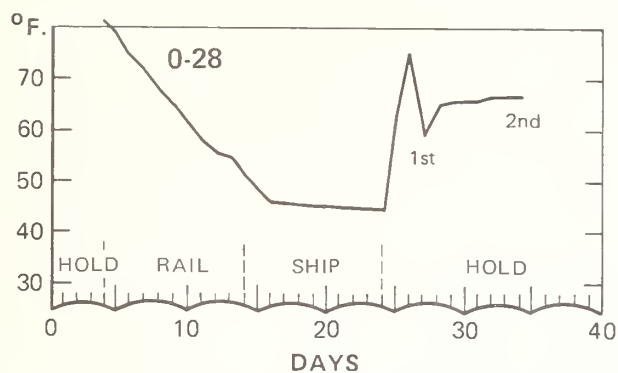


FIGURE 3.—Rail temperatures were high in these 15 shipments of California oranges, sent overseas, but ship temperatures were satisfactory. Fruit from test cartons in each shipment was examined for decay and soilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later. (Cont'd)

*Effect of pad placement.*—One of the biphenyl pads was placed on the bottom of the carton and the other between layers near the middle or above the middle in most cartons. However, in some shipments one of the pads was placed under the fruit and the other above the fruit, and in others one pad was placed above the bottom layer of fruit and the second pad under the top layer.

Few opportunities were available for valid direct comparisons of residues in relation to pad placement. Tests 0-13 and 0-14 (fig. 1)

### 0-28; Transit Period 7/11-8/1/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	69	80	*NA	92
% DECAY	2.3	3.8	0	3.0
% SOILAGE	2.3	17.7	0	1.5

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

\*NA = NOT AVAILABLE.

### 0-29; Transit Period 7/18-8/7/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	49	84.5	81.5	89
% DECAY	0	1.5	0.7	2.2
% SOILAGE	0	2.9	0	6.1

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

### 0-30; Transit Period 7/25-8/15/67

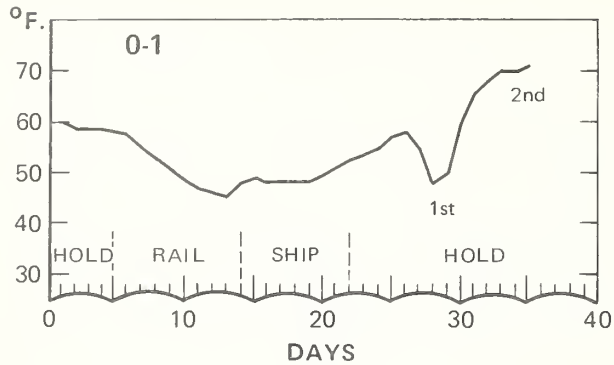
	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	61	59	81	39
% DECAY	0	8.0	1.5	2.9
% SOILAGE	0	16.7	0	2.2

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

provided such an opportunity. The pads in test 0-13 were placed at the top and bottom of the cartons and in test 0-14 they were placed between layers. The average transit temperature for both shipments was 44° F. The average biphenyl residue of the fruit in test 0-13 was 65 p.p.m., and in test 0-14 it was 89 p.p.m.

Similarly, in tests 0-10 (fig. 1) and 0-11 (fig. 3) the pads in cartons held several days before loading were placed between layers and those in promptly loaded cartons were placed at the top and bottom. In these shipments the

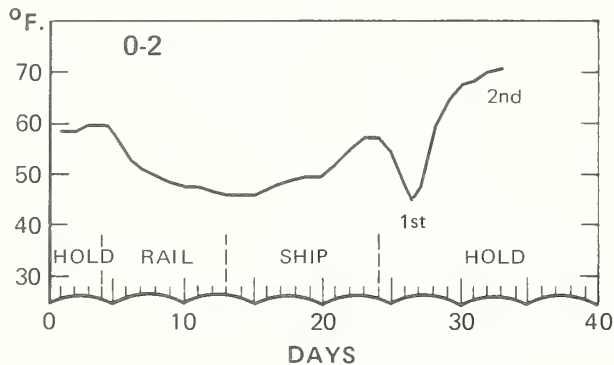




## 0-1; Transit Period 4/11-4/28/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	54	73	69	70
% DECAY	0.9	0	0	1.1
%SOILAGE	0.9	0	0	0

VIA NEW YORK, N.Y.; VENTILATED SHIP

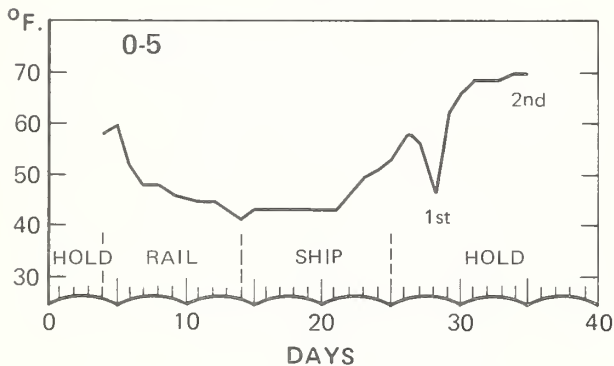


## 0-2; Transit Period 4/11-5/2/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	63	*NA	33	58
% DECAY	0	2.2	2.3	4.6
%SOILAGE	0	2.2	0	5.7

VIA NEW YORK, N.Y.; VENTILATED SHIP

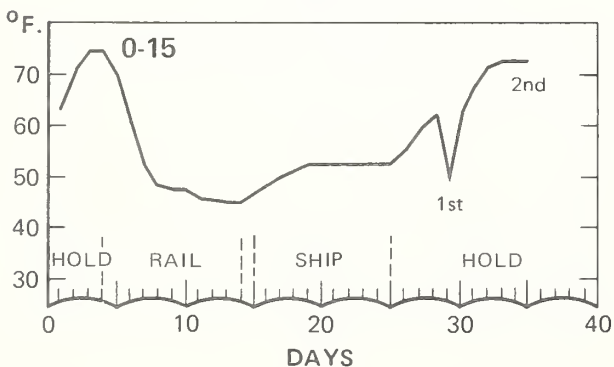
\*NA = NOT AVAILABLE.



## 0-5; Transit Period 5/2-5/23/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	48	70	54	66
% DECAY	0	0	0	4.6
%SOILAGE	0	0	0	8.4

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

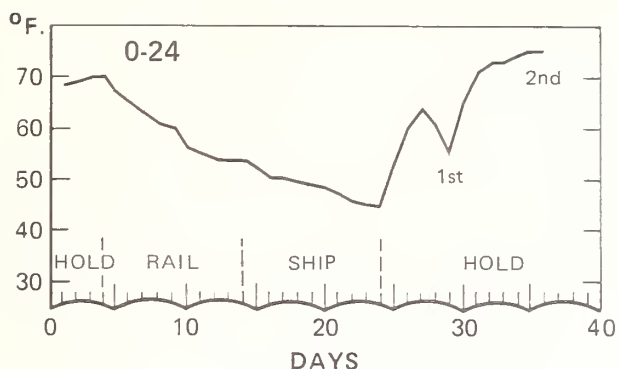


## 0-15; Transit Period 5/29-6/19/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	64	79	86	105
% DECAY	0.9	0	1.7	12.2
%SOILAGE	0	0	2.9	35.9

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

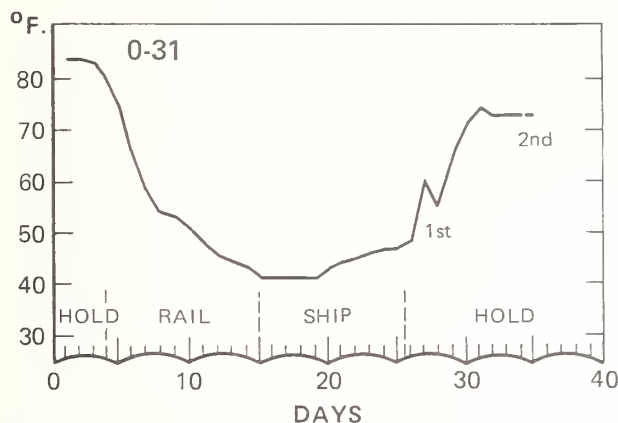
FIGURE 4.—Both rail and ship temperatures were high in these seven overseas shipments of California oranges. Fruit from test cartons in each shipment was examined for decay and soilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later.



0-24; Transit Period 6/20-7/10/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	*NA	*NA	40	93
% DECAY	*NA	*NA	4.8	11.5
% SOILAGE	*NA	*NA	10.3	28.0

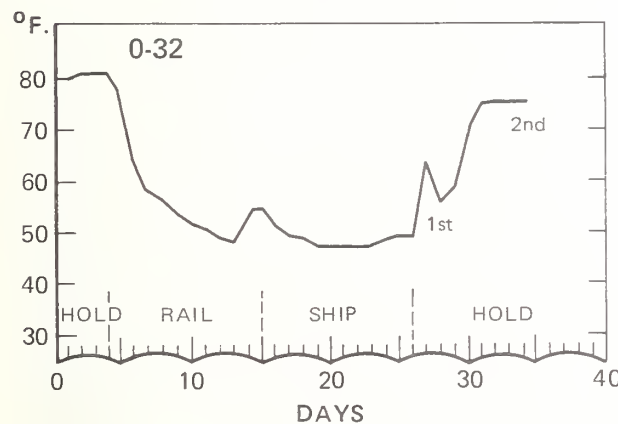
VIA ST. JOHN, N.B.; REFRIGERATED  
\*NA = NOT AVAILABLE.



0-31; Transit Period 8/1-8/21/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	44.5	63.5	71	96
% DECAY	0.7	2.2	0	7.2
% SOILAGE	7.2	3.6	0	14.5

VIA ST. JOHN, N.B.; REFRIGERATED



0-32; Transit Period 8/1-8/21/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	59	80	93	137
% DECAY	0.7	0.7	0	5.1
% SOILAGE	0	0.7	0	10.1

VIA ST. JOHN, N.B.; REFRIGERATED

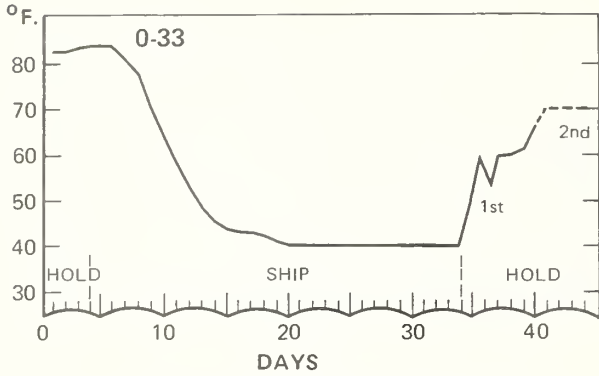
FIGURE 4.—Both rail and ship temperatures were high in these seven overseas shipments of California oranges. Fruit from test cartons in each shipment was examined for decay and soilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later. (Cont'd)

average residue of the oranges in cartons with the pads at the top and bottom was 62 p.p.m., and in cartons with the pads between layers it was 101 p.p.m. Pad placement may have caused some of this difference. The average residue in fruit from cartons in which the pads were placed at the bottom and near the middle was 73 p.p.m.

These results suggest that a substantial reduction in residue might be attained by placing the pads at the top and bottom of the carton. This placement undoubtedly would result in some sacrifice in decay and soilage control.

**Biphenyl Lost From Oranges During Airing**

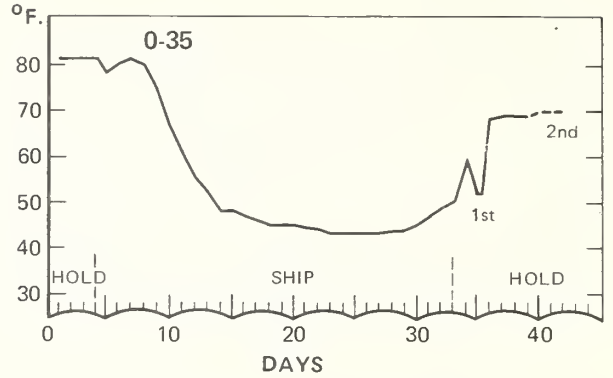
Comparison of biphenyl residue in 37 lots of



0-33; Transit Period 8/31-9/27/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	67	81	119	113
% DECAY	0	2.9	0.7	0
%SOILAGE	0	1.5	0	0

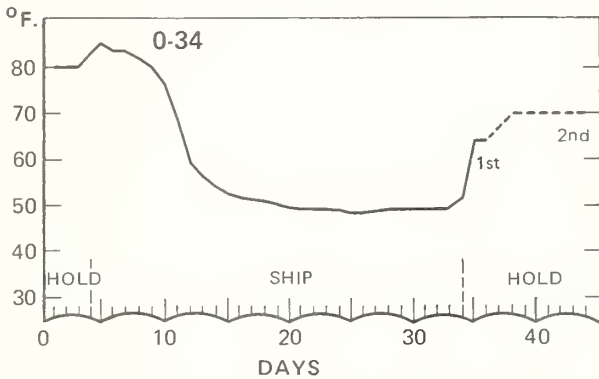
VIA PANAMA CANAL; REFRIGERATED SHIP



0-35; Transit Period 8/31-9/27/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	83	90	126	134
% DECAY	0.7	0.7	0	0
%SOILAGE	0	0	0	0

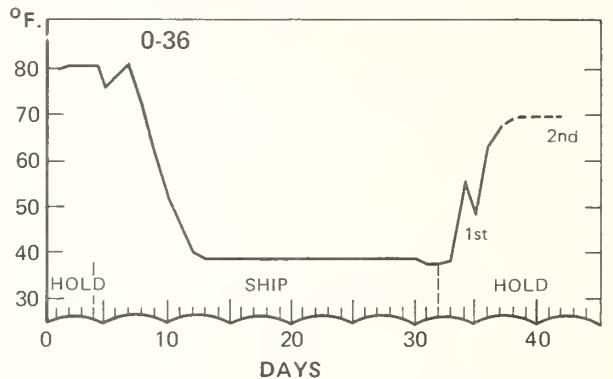
VIA PANAMA CANAL; REFRIGERATED SHIP



0-34; Transit Period 8/31-9/27/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	97	109	130	147
% DECAY	9.4	3.6	0	0.7
%SOILAGE	33.3	12.3	0	0

VIA PANAMA CANAL; REFRIGERATED SHIP



0-36; Transit Period 8/31-9/27/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	71	89	108	124
% DECAY	0	2.2	0	0.8
%SOILAGE	0	0	0	0

VIA PANAMA CANAL; REFRIGERATED SHIP

FIGURE 5.—These four shipments of California oranges sent overseas were loaded on pallets. Fruit from test cartons in each shipment was examined for decay and spoilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later.

TABLE 2.—*Decay and soilage of California oranges on arrival in Holland and 1 week after arrival, by time of loading, and average transit temperature, 1967*

Condition of fruit	Prompt loading		Delayed loading <sup>2</sup>		Average transit temperature	
	Arrival	1 week after arrival <sup>1</sup>	Arrival	1 week after arrival <sup>1</sup>	Below 50° F.	Above 52° F.
	Percent	Percent	Percent	Percent	Percent	Percent
Decay.....	0.6	2.4	1.0	3.7	1.3	3.5
Spoilage.....	1.1	4.6	1.8	6.7	1.2	11.5

<sup>1</sup> Held 1 week at about 70° F. after arrival at Central Institute for Nutrition and Food Research TNO Laboratory, Zeist.

<sup>2</sup> After being packed in California, oranges were either loaded promptly or held approximately 3 days at about 75° F. before being loaded into a railcar for shipment via Atlantic seaboard or onto a ship for shipment via Panama Canal.

oranges before and after a 7-day airing period at room temperature of about 70° F. showed an average loss of biphenyl of 5.4 percent.

#### *Condition of Oranges*

*Effect of holding before and after transit.*—Delayed loading of oranges resulted in a 50-percent increase in the average percent of decay and soilage over prompt loading, both on arrival and 1 week later. Average decay and soilage increased threefold to fourfold during 1 week's holding at 70° F. after arrival. This increase occurred in oranges loaded promptly and in oranges loaded after a 3-day delay. Table 2 gives the average values.

The highly variable percentage of decay and soilage in individual lots of fruit is largely due to the variable nature and condition of the fruit. Individual values in the charts give the results of each test (figs. 1 to 5).

*Effect of transit temperature.*—The beneficial effect of the more desirable transit temperatures is suggested in the average (arrival and 1 week after arrival) decay and soilage values of promptly loaded oranges. These values appear in table 2.

*Effect of pad placement.*—Results in tests 0-10, 0-13, and 0-14 (fig. 1) and 0-11 (fig. 3), although scanty, show three times as much decay and soilage in cartons with pads on top and bottom as in cartons with pads between layers. (See page 11 for description of pad placements.) These results are in harmony with commercial experience.

#### *Biphenyl Remaining in Pads*

The manufacturer of the biphenyl pads used in these tests gives the biphenyl content of the paper as 4 pounds per 1,000 square feet. This is equivalent to about 2.14 grams per pad. Under the best conditions—that is, prompt loading and prompt handling on arrival—the average amount of biphenyl remaining in the pads was about one-half of this amount; with delayed loading an average of less than one-third remained on arrival. The amount remaining 1 week after arrival was about 40 percent of the arrival value for both fruit that was promptly loaded and fruit where loading was delayed. In table 3, average amounts of biphenyl that are directly comparable are given in milligrams per pad and in percentage of initial value.

The amount of biphenyl remaining in the pads was not influenced by the kind of fruit in the carton.

## Lemons

#### *Transit Temperatures*

The transit temperatures in nearly all the lemon test shipments were as low as desired. Only during a part of the time that lemon tests L-8 and L-9 were in railcars were the temperatures higher than desirable (fig. 8). On the other hand, in several shipments the lemons were exposed to temperatures that are conducive to chilling injury. The temperature in tests L-1, L-3, and L-5 (fig. 7) was below

TABLE 3.—*Biphenyl remaining in pads in cartons of California oranges on arrival in Holland and 1 week after arrival, by time of loading, 1967*

Prompt loading				Delayed loading <sup>2</sup>			
On arrival		1 week after arrival <sup>1</sup>		On arrival		1 week after arrival <sup>1</sup>	
Milligrams	Percent <sup>3</sup>	Milligrams	Percent <sup>3</sup>	Milligrams	Percent <sup>3</sup>	Milligrams	Percent <sup>3</sup>
1075 (5) <sup>4</sup>	50			663 (5)	31		
1051 (9)	49	413 (9)	19			270 (9)	13
		518 (9)	24	649 (9)	30	296 (9)	14

<sup>1</sup> Held 1 week at about 70° F. after arrival at Central Institute for Nutrition and Food Research TNO Laboratory, Zeist.

<sup>2</sup> After being packed in California, oranges were either loaded promptly or held approximately 3 days at about 75° F. before being loaded into a railcar for shipment via Atlantic seaboard or onto a ship for shipment via Panama canal.

<sup>3</sup> Percentages are calculated on the assumption that each pad contained 2,140 milligrams biphenyl when placed in cartons.

<sup>4</sup> Numbers in parentheses indicate number of values averaged.

50° F. for 2 weeks and below 45° for 1 week. The tendency of commodities that are sensitive to chilling injury to become increasingly subject to attack by decay organisms after exposure to chilling temperatures is well known.<sup>1</sup>

As shown in figure 6, the temperature in test L-4 (via the Panama Canal) was at an acceptable level and uniform throughout the transit period. The temperatures in tests L-2, L-6, and L-7 (via the Atlantic seaboard) were not uniform but were still acceptable (fig. 6).

#### *Biphenyl Absorbed by Lemons*

This fruit presents no problem from excessive biphenyl residue. Lemons absorb much less biphenyl than oranges during exposure to biphenyl under similar conditions. The basis for this difference is not known but the relationship has been observed repeatedly.<sup>2</sup> Lemons loaded promptly after being packed contained from 15 to 32 p.p.m. biphenyl on arrival at the laboratory in Holland, and those loaded after a 3-day delay contained 16 to 38 p.p.m. Even after test lemons were held for 1 week in Holland, biphenyl residues exceeded 42 p.p.m. in only one out of 18 examinations and exceeded 30 p.p.m. in only seven out of the 18. Samples from all nine of the lemon test shipments were subjected to analysis.

The following tabulation shows the average biphenyl residue in lemons loaded promptly after being packed and those held about 3 days at approximately 75° F. before being loaded in railcar or ship:

	On arrival in Holland P.p.m.	1 week after arrival <sup>1</sup> P.p.m.
Loaded promptly .....	23	26
Delayed loading .....	26	30

<sup>1</sup> Held 1 week at about 70° F. after arrival at Central Institute for Nutrition and Food Research TNO Laboratory, Zeist.

*Effect of pad placement.*—All lemons were packed with the biphenyl pads placed at the top and bottom of the cartons; hence there was no opportunity to note the possible effect of pad placement upon biphenyl residue in this fruit.

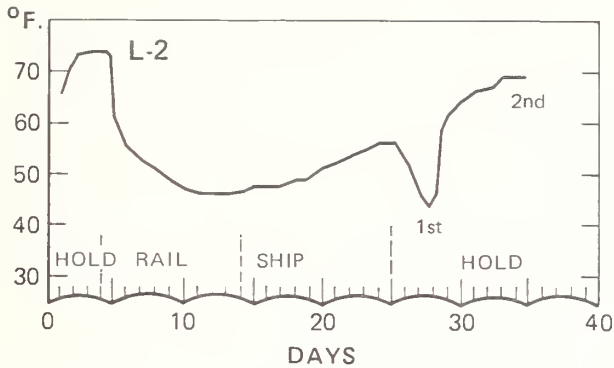
*Effect of length of transit period.*—The test lemons transported by ship via the Panama Canal (test L-4) had the highest average biphenyl residue (fig. 6). The most likely principal factor contributing to the high residue was the long transit period (28 days), as the average transit temperature was no higher than that of some of the other lemon test shipments in which the transit periods were usually 20 or 21 days. Fruit in this test had from 28 to 40 p.p.m. biphenyl.

*Effect of carton venting.*—Earlier work<sup>3</sup> showed that lemons in nonvented cartons absorbed more biphenyl than those in vented cartons. In the tests included in this study, the lemons in nonvented cartons (tests L-8 and L-9, fig. 8) absorbed more biphenyl than most, but not all, of those in vented cartons. All the residues in lemons in nonvented cartons were safely below the current legal tolerance.

<sup>1</sup> LAURITZEN, J. I. SOME EFFECTS OF CHILLING TEMPERATURES ON SWEET POTATOES. Jour. Agr. Res. 42: 617-627, illus. 1931.

<sup>2</sup> RYGG, G. L., WELLS, A. W., NORMAN, S. M., and ATROPS, E. P. BIPHENYL CONTROL OF CITRUS SPOILAGE—INFLUENCE OF TIME, TEMPERATURE, AND CARTON VENTING. U.S. Dept. Agr. Market. Res. Rpt. 646. 22 pp. 1964.

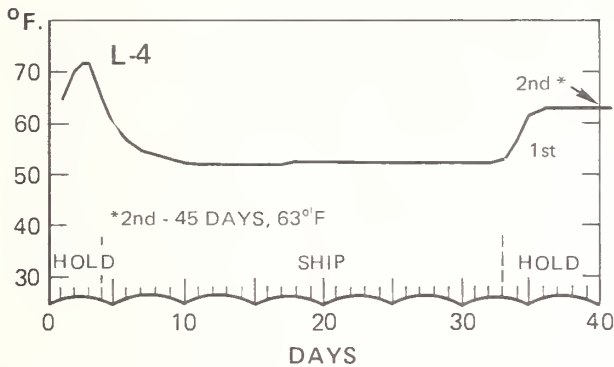
<sup>3</sup> RYGG, G. L., WELLS, A. W., NORMAN, S. M., and ATROPS, E. P. BIPHENYL CONTROL OF LEMON SPOILAGE—INFLUENCE OF TIME, TEMPERATURE, AND CARTON VENTING. U.S. Dept. Agr. Market. Res. Rpt. 569, 15 pp., illus. 1962.



L-2; Transit Period 4/11-5/2/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	15	16	16	15
% DECAY	1.8	6.1	0.6	3.1
%SOILAGE	1.2	6.1	3.1	0

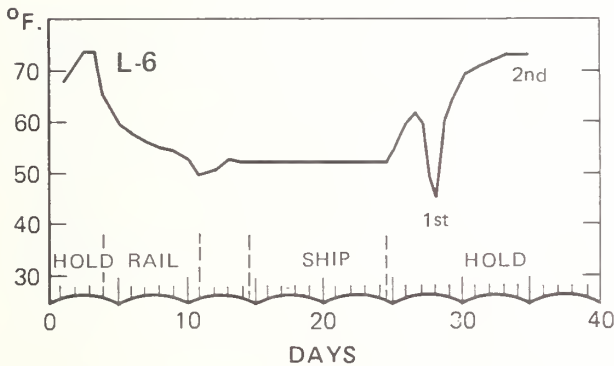
VIA NEW YORK, N.Y.; VENTILATED SHIP;  
VENTILATED CARTONS



L-4; Transit Period 4/28-5/26/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	32	40	34	28
% DECAY	7.9	1.2	0	2.4
%SOILAGE	0	1.8	0	1.2

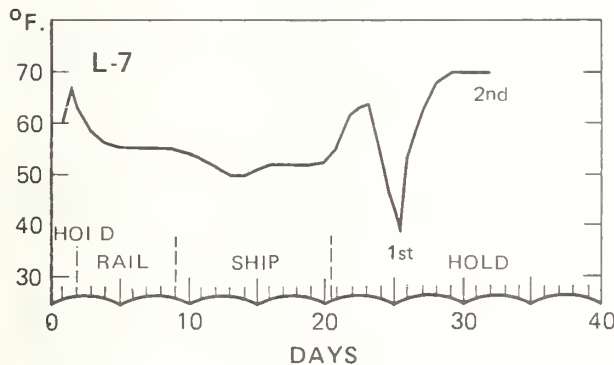
VIA PANAMA CANAL; REFRIGERATED SHIP;  
VENTILATED CARTONS



L-6; Transit Period 5/29-6/19/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	28	32	29	31
% DECAY	5.5	10.9	15.2	3.1
%SOILAGE	4.8	6.7	15.2	4.3

VIA ST. JOHN, N.B.; REFRIGERATED SHIP;  
VENTILATED CARTONS



L-7; Transit Period 6/6-6/26/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	14	18	18	28
% DECAY	1.2	0.6	0.6	1.2
%SOILAGE	0.6	0	0	0

VIA ST. JOHN, N.B.; REFRIGERATED SHIP;  
VENTILATED CARTONS

FIGURE 6.—Transit temperatures for these four overseas shipments of California lemons were satisfactory. Fruit from test cartons in each shipment was examined for decay and soilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later.

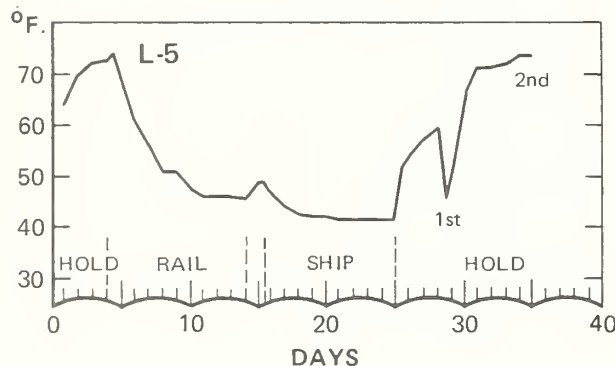
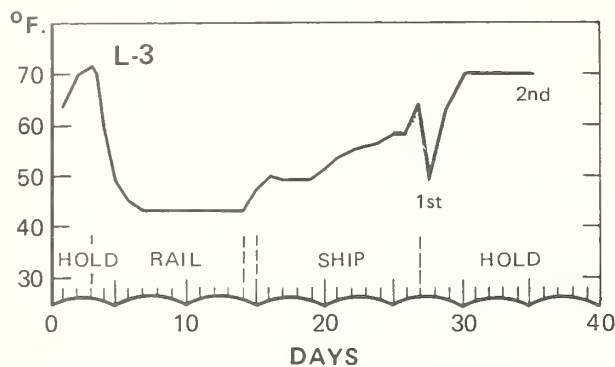
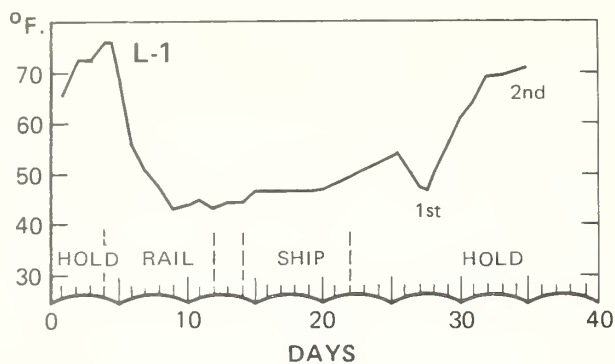


FIGURE 7.—Temperatures for these three overseas shipments of California lemons were too low during part of the transit period. Fruit from test cartons in each shipment was examined for decay and soilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later.

### Biphenyl Lost From Lemons During Airing

Analysis of 10 lots of lemons before and after a 7-day airing period at 70° F. showed an average biphenyl loss of 37 percent. The high loss from lemons, as compared with oranges, agrees with previously reported results.<sup>4</sup>

### Condition of Lemons

Delayed loading did not appreciably influence the amount of decay or soilage, either at arrival

### L-1; Transit Period 4/11-4/29/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	27	69	18	*10
% DECAY	1.2	10.3	3.1	2.4
% SOILAGE	0	20.6	6.2	2.4

VIA NEW YORK, N.Y.; VENTILATED SHIP;  
VENTILATED CARTONS  
\*1 Biphenyl Pad

### L-3; Transit Period 4/17-5/11/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	27	29	25	38
% DECAY	2.4	3.1	2.4	23.0
% SOILAGE	0	3.6	11.5	29.0

VIA NEW YORK, N.Y.; VENTILATED SHIP;  
VENTILATED CARTONS

### L-5; Transit Period 5/23-6/12/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	23	26	21	25
% DECAY	7.9	20.6	1.2	9.7
% SOILAGE	4.2	18.2	7.9	20.1

VIA ST. JOHN, N.B.; REFRIGERATED SHIP;  
VENTILATED CARTONS

or 1 week later, but both decay and soilage increased considerably during the week's holding at 70° F., as shown in table 4. The individual values appear in figures 6 to 8.

*Effect of carton venting.*—Most of the lemons in nonvented cartons (tests L-8 and L-9, fig. 8) were in acceptable condition, but considerable decay and soilage developed during the subsequent week of holding at 70° F. The condition of the fruit was generally no worse than that of some of the lemons shipped in vented cartons in other tests. No direct comparisons were available in these tests.

<sup>4</sup> See footnote 2.

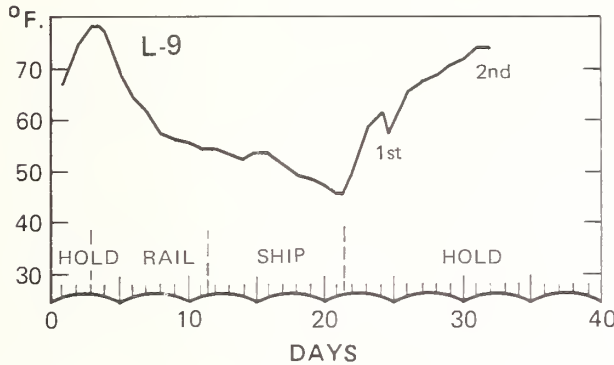
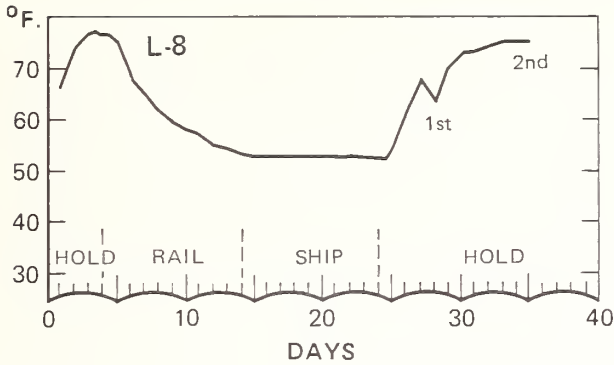


FIGURE 8.—Rail temperatures were high in these two overseas shipments of California lemons, but ship temperatures were satisfactory. Fruit from test cartons in each shipment was examined for decay and soilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later.

TABLE 4.—Decay and soilage of California lemons on arrival in Holland and 1 week after arrival, by time of loading, 1967

Condition of fruit	Prompt loading		Delayed loading <sup>2</sup>	
	Arrival	1 week after arrival <sup>1</sup>	Arrival	1 week after arrival <sup>1</sup>
	Percent	Percent	Percent	Percent
Decay.....	3.8	8.7	4.0	7.1
Spoilage.....	2.9	10.2	5.6	8.0

<sup>1</sup> Held 1 week at about 70° F. after arrival at Central Institute for Nutritional and Food Research TNO Laboratory, Zeist.

<sup>2</sup> After being packed in California, lemons were either loaded promptly or held approximately 3 days at about 75° F. before being loaded into a railcar for shipment via Atlantic seaboard or onto a ship for shipment via Panama Canal.

## Grapefruit

### Transit Temperatures

The average transit temperatures of tests G-1 to G-5 (fig. 9) were 47° to 54° F. These temperatures are within an acceptable range for grapefruit, but in test G-6 (fig. 10) the

### L-8; Transit Period 7/18-8/7/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	21	19	38	41
% DECAY	1.8	14.5	1.2	10.3
%SOILAGE	2.4	28.5	1.2	9.7

VIA ST. JOHN, N.B.; REFRIGERATED SHIP; NONVENTILATED CARTONS

### L-9; Transit Period 7/25-8/15/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	22	28	30	31
% DECAY	6.7	11.2	3.9	10.1
%SOILAGE	10.7	6.2	5.6	7.9

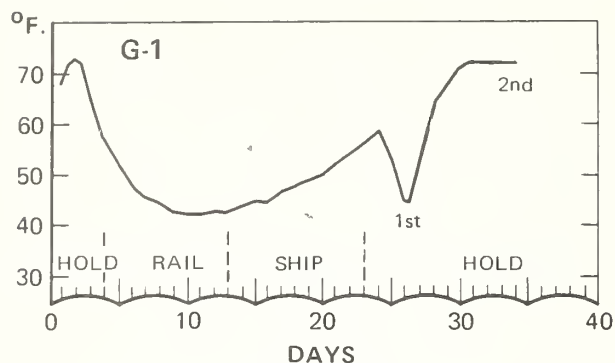
VIA ST. JOHN, N.B.; REFRIGERATED SHIP; NONVENTILATED CARTONS

average transit temperature was 64°. The fruit in this test had high biphenyl residue, a high percentage of decay, and much soilage. The average temperature in test G-3 (fig. 9) was acceptable, but the initial temperature was high, and an objectionable 10-degree rise occurred during the transfer from railcar to ship.

### Biphenyl Absorbed by Grapefruit

Most biphenyl residues in grapefruit were well below the legal tolerance of the European Economic Community (70 p.p.m.), both on arrival at Rotterdam and after 1 week's additional holding at about 70° F. (tests G-1 to G-6, figs. 9 and 10). The principal exception occurred in test G-6 (fig. 10) in which the average transit temperature was 65°, or 10 to 15 degrees higher than those in the other test shipments, and the transit period was 28 days, or 7 to 8 days longer than that of the other grapefruit test shipments. The biphenyl content of the fruit in this shipment ranged from 64 to 79 p.p.m. Other high values occurred in fruit that was loaded at unusually high temperatures (tests G-4 and G-5, fig. 9). Neither delayed loading nor holding after arrival affected the average biphenyl residue.

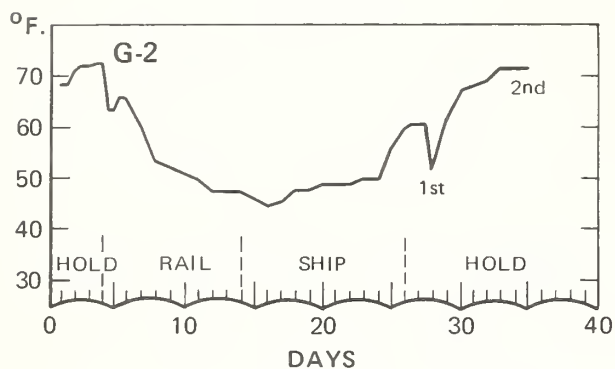




G-1; Transit Period 5/8-5/29/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	28	29	23	42
% DECAY	0	1.6	0	0
% SOILAGE	0	0	0	0

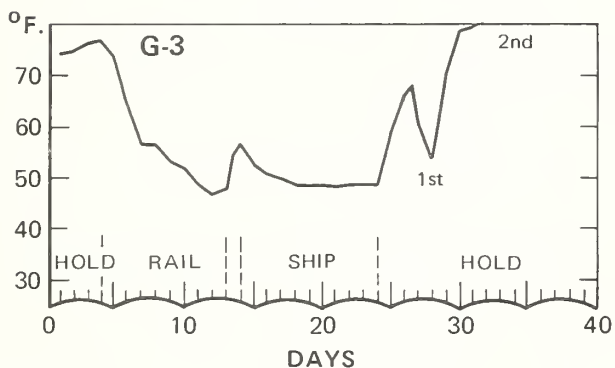
VIA ST. JOHN, N.B.; REFRIGERATED SHIP



G-2; Transit Period 5/17-6/7/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	30	33	31	16
% DECAY	0	0	1.6	6.2
% SOILAGE	0	0	0	1.6

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

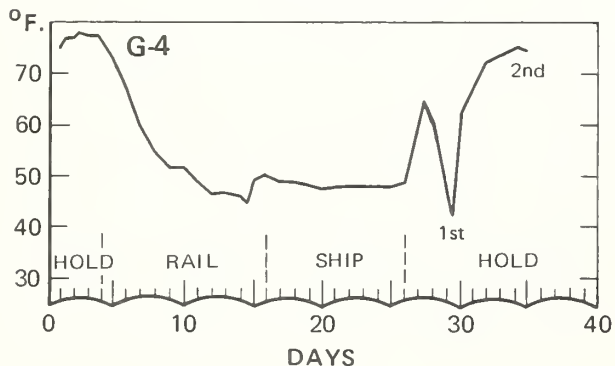


G-3; Transit Period 6/20-7/10/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	*NA	*NA	41	51
% DECAY	*NA	*NA	0	16.3
% SOILAGE	*NA	*NA	0	41.3

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

\*NA = NOT AVAILABLE.



G-4; Transit Period 7/3-7/24/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	36	57	71	72
% DECAY	1.5	8.3	0	0
% SOILAGE	0	8.3	0	0

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

FIGURE 9.—Average transit temperatures were satisfactory for these five overseas shipments of California grapefruit. Fruit from test cartons in each shipment was examined for decay and soilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later.

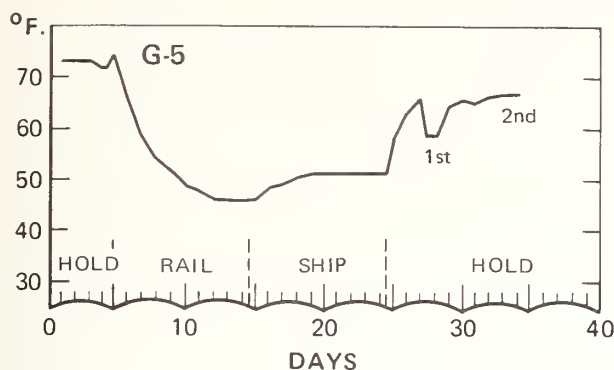


FIGURE 9.—Average transit temperatures were satisfactory for these five overseas shipments of California grapefruit. Fruit from test cartons in each shipment was examined for decay and soilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later. (Cont'd)

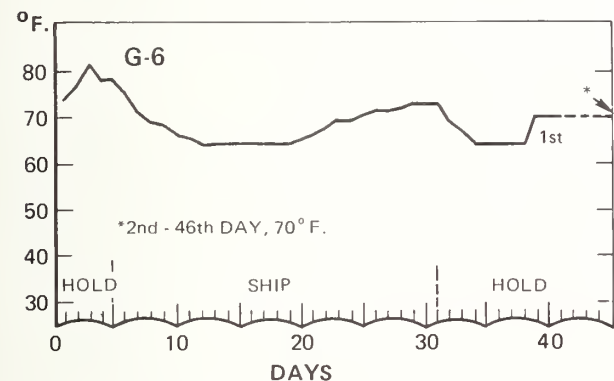
### G-5; Transit Period 7/11-7/31/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	55	70	76	83
% DECAY	0	1.7	12.5	3.1
%SOILAGE	0	0	3.1	3.1

VIA ST. JOHN, N.B.; REFRIGERATED SHIP

### Biphenyl Lost From Grapefruit During Airing

Five lots of grapefruit were analyzed before and after a 1 week airing period. No decrease in biphenyl occurred during the airing.



### G-6; Transit Period 8/9-9/9/67

	PROMPT LOADING		DELAYED LOADING	
	Arrival	1wk. after arrival	Arrival	1wk. after arrival
BIPHENYL, p.p.m.	64	77	79	74
% DECAY	15.9	10.0	3.2	16.7
%SOILAGE	38.1	11.7	1.6	16.7

VIA PANAMA CANAL; REFRIGERATED SHIP

FIGURE 10.—This overseas shipment of California grapefruit was loaded on pallets. The transit temperatures were high. Fruit from test cartons in each shipment was examined for decay and soilage and samples were taken for biphenyl analysis. Half of each test lot was examined and sampled (1st) soon after it arrived and the other half was similarly tested (2d) 7 days later.

### Condition of Grapefruit

Delayed loading was accompanied by an increase in average decay on arrival, but did not affect soilage materially either on arrival or 1 week later. One week's storage at the laboratory was not accompanied by a consistent increase in either decay or soilage. The average values of the rail-ship tests appear in table 5.

In test G-3, the excessive decay and soilage of fruit 1 week after arrival may have been caused by the high initial temperature plus the 10-degree rise during transfer from rail-car to ship at the Atlantic seaboard (fig. 9).

Much decay and soilage developed in the fruit in test G-6 (fig. 10), sent by ship via the Panama Canal. The transit period of this test was a week longer than that of tests G-1 to G-5 (fig. 9), and the average transit temperature was more than 10 degrees higher.

TABLE 5.—Decay and soilage of California grapefruit on arrival in Holland and 1 week after arrival, by time of loading, 1967

Condition of fruit	Prompt loading		Delayed loading <sup>2</sup>	
	Arrival	1 week after arrival <sup>1</sup>	Arrival	1 week after arrival <sup>1</sup>
	Percent	Percent	Percent	Percent
Decay.....	0.4	2.9	3.5	2.3
Soilage.....	0	2.1	.8	1.2

<sup>1</sup> Held 1 week at about 70° F. after arrival at Central Institute for Nutrition and Food Research TNO Laboratory, Zeist.

<sup>2</sup> After being packed in California, grapefruit were either loaded promptly or held approximately 3 days at about 75° F. before being loaded into a railcar for shipment via Atlantic seaboard or onto a ship for shipment via Panama Canal.

## APPENDIX

TABLE 6.—*Biphenyl residue in oranges, lemons, and grapefruit shipped from California to Holland, 1967*

Kind of fruit and test number	Prompt loading		Delayed loading		Kind of fruit and test number	Prompt loading		Delayed loading	
	On arrival	1 week after arrival	On arrival	1 week after arrival		On arrival	1 week after arrival	On arrival	1 week after arrival
	<i>Parts per million</i>	<i>Parts per million</i>	<i>Parts per million</i>	<i>Parts per million</i>		<i>Parts per million</i>	<i>Parts per million</i>	<i>Parts per million</i>	<i>Parts per million</i>
<i>Oranges</i>									
0-1	54	73	69	70	0-28	69	80	—	92
0-2	63	—	33	58	0-29	49	84	81	89
0-3	63	94	60	131	0-30	61	59	81	89
0-4	47	79	48	88	0-31	44	63	71	96
0-5	48	70	54	66	0-32	59	80	93	137
0-6	45	81	52	73	0-33	67	81	119	113
0-7	58	88	58	115	0-34	97	109	130	147
0-8	51	50	49	104	0-35	83	90	126	134
0-9	69	64	76	119	0-36	71	89	108	124
0-10	48	57	93	103	<i>Lemons</i>				
0-11	67	79	99	110	L-1	27	69	18	10 (1 pad)
0-12	59	81	63	88	L-2	15	16	16	15
0-13	51	59	59	73	L-3	27	29	25	38
0-14	66	99	85	107	L-4	32	40	34	28
0-15	64	79	86	105	L-5	23	26	21	25
0-16	45	83	67	95	L-6	28	32	29	31
0-17	51	73	56	91	L-7	14	18	18	28
0-18	76	98	55	66	L-8	21	19	38	41
0-19	60	110	25 (no pad)	86	L-9	22	28	30	31
0-20	48	98	86	120	<i>Grapefruit</i>				
0-21	62	99	57	92	G-1	28	29	23	42
0-22	51	83	53	63	G-2	30	33	31	16
0-23	—	—	47	55	G-3	—	—	41	51
0-24	—	—	40	93	G-4	36	57	71	72
0-25	60	57	62	95	G-5	55	70	76	83
0-26	36	89	81	75	G-6	64	77	79	74
0-27	36	49	121	109					

## CAUTION

If pesticides are handled or applied improperly, they may be injurious to humans, domestic animals, desirable plants, and pollinating insects, fish, or other wildlife, and may contaminate water supplies. Use pesticides only when needed and handle them with care. Follow the directions and heed all precautions on the container label.



Use Pesticides Safely  
FOLLOW THE LABEL  
U.S. DEPARTMENT OF AGRICULTURE