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BRUISING OF PACIFIC NORTHWEST APPLES DURING SHIPMENT AND
DISTRIBUTION TO RETAIL STORES IN TEXAS

By

Edwin Smith, Senior Horticulturist
T. R. Wright, Associate Plant Pathologist

Division of Handling, Transportation and Storage of Horticultural Crops

Report of a Study made under the Research
and Marketing Act of 1946
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BRUISING OF PACIFIC NORTHWEST APPLES DURING SHIPMENT AND DISTRIBUTION TO RETAIL STORES IN TEXAS

Studies of the cause and prevention of apple bruises during 1950 - 1951 were designed to supplement those of the previous year. ^{1/} Additional information was desired on (a) the relation of heavy and light packs in wood boxes and fibreboard cartons to apple bruising, (b) the prevention of bruises through the careful handling of wood boxes in carloading, unloading and market distribution, (c) the relation of loading tray-pack cartons lengthwise as against crosswise in refrigerator cars, and (d) the bruising of apples in bulk-filled cartons. Shipping tests were made from points in Washington to Dallas, Texas, a market for which it was possible to secure full carloads of tray-pack cartons and of wood boxes. The tests were designed to show the comparative bruises on apples after delivery to retail stores.

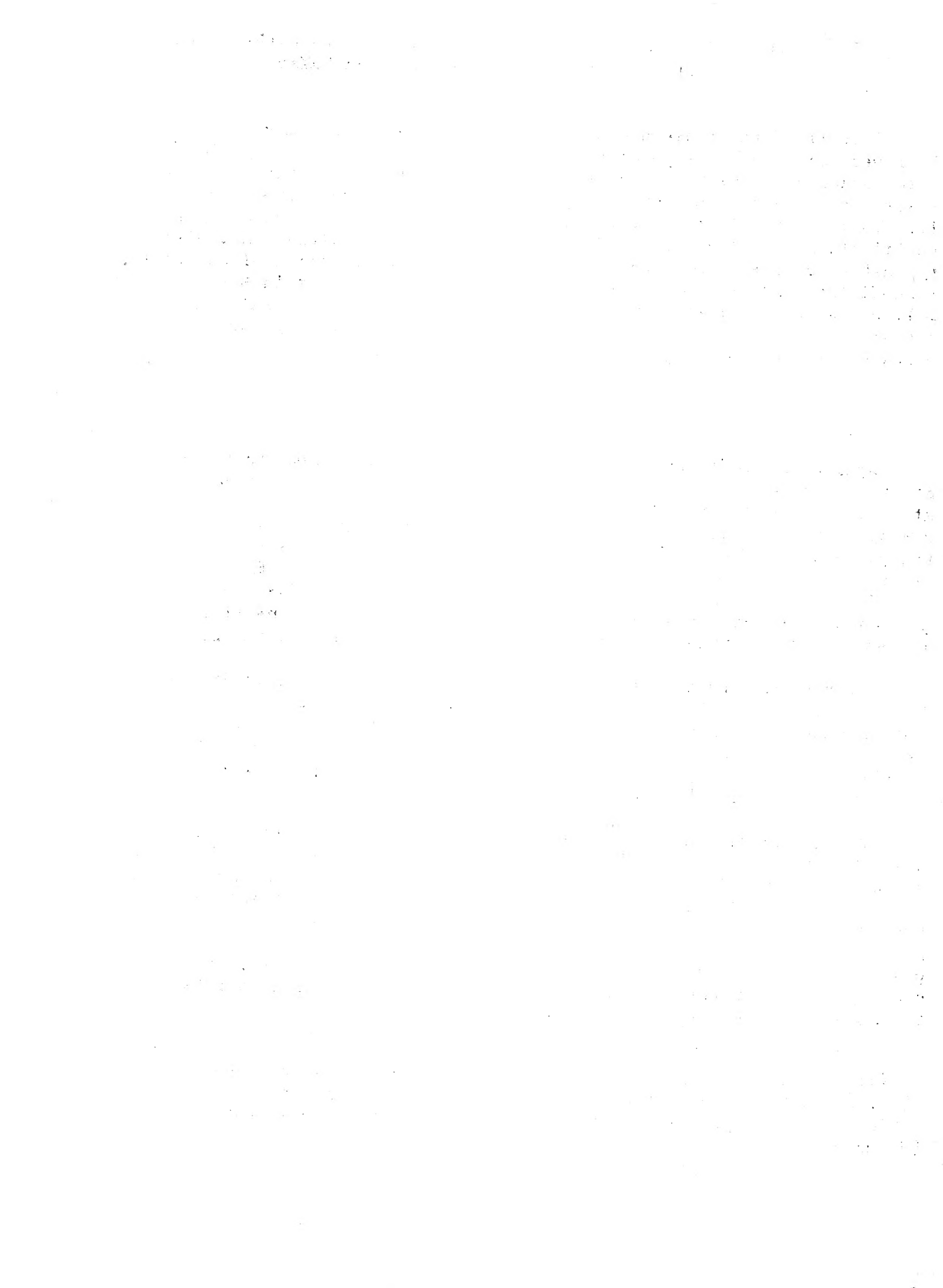
Packaging of Test Apples

Apples of the Richared strain of the Delicious variety from one orchard at Orondo, Washington, were used for the experiments. The apples were picked at a stage of advanced maturity on October 26, 168 days after full bloom, with average firmness (Magness pressure tester) of 15 pounds. Heavy water core was present at fibro-vascular bundles in 80 per cent of the fruits cut. The apples were packed on October 27 from the Combination Extra Fancy-Fancy Grade, 100-size bins, by one individual for each package type. The "heavy" and "light" packs within a package type were secured by adjustment of the sizing equipment whereby slightly larger or smaller apples were dropped into the 100-size bins.

Characteristics of the wood box packages were as follows: inside dimensions, 11-3/4 by 10-3/4 by 18 inches (oversize); protective materials, oiled wraps, indent paper tier pads and 4-way corrugated pad box liners; approximate gross weights, heavy pack, 50 pounds, light pack, 48 pounds; net weights, heavy pack, 40-3/4 pounds, light pack, 38-3/4 pounds; bulge, heavy pack, 1-1/4 to 2 inches, light pack, 1 to 1-1/4 inches.

Characteristics of the tray-pack fibreboard cartons were as follows: inside dimensions 12-1/8 by 11-3/4 by 19-3/4 inches; corrugated fibreboard cartons made up with collar inside single piece construction for top and bottom closure, bottom stapled, top fastened with gummed tape; protective material, Kys-type trays with indent paper top pads; approximate gross weight, heavy pack 48-1/2 pounds, light pack, 45-3/4 pounds; net weights, 43-3/4 and 41 pounds. In the heavy packs the apples caused a slight bulge of the lids when closed whereas in the light packs there was from 1/2 to 1 inch between fruit in the top tray and the closed lid.

^{1/} Smith, E., McCombs, C. L., Wright, T. R., Reubelt, V. A., and Radspinner, W.A. 1950. Bruising of Pacific Northwest apples during shipment and market distribution. U. S. Dept. Agr. H. T. & S. Office Report No. 229, 20 pp. illus. (Processed)



The fibreboard cartons were filled with apples without the use of trays, to exemplify the bulk-filled cartons shipped to a limited extent for consumer-packaging at destination. The average gross weight of these cartons was 51 pounds, and the net weight of fruit was from 47 to 48 pounds.

The test packages were taken to the Wenatchee laboratory immediately after packing and stored at 31° F. until the time of the shipping tests in March.

Evaluation of Bruises

Methods of bruise evaluation were similar to those of the previous season. ^{1/} Any bruise having a single dimension between 1/2- and 3/4-inch was recorded as "slight", those measuring 3/4-inch or more were classified as "severe" and any fruit having a minimum of 3 slight bruises or 1 severe and 1 slight bruise was recorded as "multi-bruised". A record was also kept of bruises having a dimension over 1 inch.

An evaluation of bruises after packing and storage was made with apples in the tray-pack cartons, as these could be examined without causing additional bruises in package closure. This was not possible with apples in wood boxes, so determinations were made from apples in 6 random sample packages taken from each of the heavy and light pack lots. Boxes so opened were not subsequently used for shipping tests. A summary of bruises found soon after packing at Wenatchee is given in table 1. It is to be observed that before shipment the apples packed in cartons had more bruises than the apples in wood boxes.

Methods of Shipment and Handling

Market and transportation difficulties made it necessary to place all of the wood box test packages in a single shipment from Naches, Washington, March 15, with arrival in Dallas, Texas, March 22, 1951, rather than in three successive shipments as originally scheduled. In this shipment 12 boxes were loaded in the bottom and 12 in the top layers of the carload, equitably divided between head and rear ends of the car. Half (6) of those in each layer consisted of heavy packs and half (6) of light packs. Half of the boxes of each type of pack were carefully handled and half were handled in regular manner. At destination the test boxes were unloaded at a produce warehouse and delivered to 3 retail stores where the bruises were counted as the apples were ready to be placed on sale.

^{1/} See citation 1 on page 1.

Three replicate lots of fibreboard cartons were shipped in 2 cars. In a car loaded at Tonasket, Washington, March 19, which arrived at Dallas, March 29, 2 heavy and 2 light tray-pack, and 2 bulk-filled cartons, were loaded lengthwise in the top and bottom layers of the load in the head end of the car and 2 cartons each of heavy and light tray-packs were loaded cross-wise in the top and bottom layers at the rear end of the car. These packages were delivered to 2 retail stores in Dallas. The other car was loaded in Wenatchee, Washington, March 19, and arrived at Dallas April 2. In this shipment 2 heavy and 2 light tray-pack and 1 bulk-filled cartons were loaded in the top and bottom layers at the rear end of the car. Because of the nature of the load it was not possible to load any of the packages cross-wise in the second car. Half (4) of the tray-pack cartons in this shipment were delivered to a Dallas retail store where bruises were counted, the balance of the cartons were not taken beyond the produce warehouse.

The apples used in these tests were extremely susceptible to bruising because of their advanced stage of ripeness when shipped. The fruit was picked at an advanced stage of maturity and was stored about 2 months longer than anticipated. The firmness of comparable lots on March 14 ranged from 9.0 to 14.0 pounds, with an average of 11.5 pounds. The apples were ripe, but not mealy or stale, and had a generally crisp texture and a mild flavor. Upon delivery to the retail stores in Texas a variable number of specimens showed tissue breakdown following water core but otherwise the fruit was not over-ripe to a degree that made it unacceptable to the consumer. Loss from fungous decays was negligible, there being an average 0.5 percent in tray-pack cartons and 0.6 percent in boxes.

Relation of Heavy and Light Packs to Bruising

Studies by the Washington State Department of Agriculture 1/ and by the Washington State Apple Commission 2/ did not show consistent relations between the weight of pack and bruises when the apples were examined at point of shipment. In our preliminary studies of 1950 3/ less bruising was found in the light packs than in the heavy packs when examinations were made after shipment and delivery to retail stores in the vicinity of New York, New York. An evaluation of bruises after the packages have been handled during shipment and in terminal market distribution is more pertinent to the problem than examinations made in the shipping area. Consequently these additional tests were made with heavy and light packs in wood boxes and tray-pack cartons.

The heavy pack cartons had 11 more severe bruises per hundred fruits than the light pack, and the heavy pack boxes had 14 more severe bruises than the light pack. (table 2)

1/ Rich, A. C.
1939. Fruit injuries resulting from improper packing. Wash. State Hort. Assn. Proc. 35: 148-151.

2/ Research Dept.
1949. Causes of bruises in packing apples. Wash. State Apple Com. 1949 Report. 13 pp. (Processed)

3/ See citation 1 on page 1.

The results of two season's studies show quite conclusively that Delicious apples packed in boxes with corrugated pads and tier pads had suffered fewer bruises by the time they were delivered to the retail stores when the net weight of fruit was less rather than over 40 pounds.

The greater number of severe bruises in the heavy tray-pack cartons was partially caused by pressure of the slightly oversize or misplaced apples, through the pulp trays against fruits in the tray above. It appears that this type of package may be well-filled, but not over-filled, with minimum risk of fruit injury if the apples are of uniform size and well placed in the trays.

Prevention of Bruises through Careful Handling

It was shown in 1950 that as much bruising was caused in loading cars with apples packed in wood boxes as was caused during rail movement from Wenatchee, Washington, to New York, New York. In the 1951 experiments an endeavor was made to determine how much bruising would be avoided if the boxes were not thrown into place during car loading, unloading, and distribution to retail stores. Boxes with both heavy and light packs were used for the experiment. Twelve boxes were handled in the regular commercial manner. By careful supervision, a like number were handled so that at no point was a box "slapped down" with force, either on car floors during loading, on pallets at the Dallas produce warehouse, or on truck beds and store floors during delivery to the Dallas retail stores. Half of the boxes were shipped in the top and half in the bottom layers of the car load. Pallets and electric transporters were used for handling the boxes from the car to the warehouse. Since the boxes remained on the pallets until orders were made up for store delivery, and a conveyor belt was used from delivery truck to retail store for 1/3 of the test packages, better than normal facilities were provided for "regular" handling.

Fruit in the boxes that received regular commercial handling showed almost twice as many severe bruises per 100 fruits (table 3) and they had over twice as many bruises larger than 1 inch as the fruit in the boxes that were handled carefully. It is to be emphasized that the apples undergoing regular handling were afforded greater protection against bruising than occurs under average conditions since the boxes were lined with 4-way corrugated pads and apples were separated by indent paper tier-pads. Prior to the time of shipment all boxes were protected against heavy impacts that frequently occur in cold storage warehousing.

A casual observation of the handling of boxed apples during commercial warehousing, car loading, and market distribution, furnishes conclusive evidence as to the frequency of forceful impacts. These studies show that there are great opportunities to reduce apple bruising through better supervision of package handling.

Comparison of Bruises of Fruit in Cartons Loaded Lengthwise and Crosswise of Refrigerator Cars

This phase of the experiment was limited to 8 packages for each type of loading in a single shipment. The results given in table 4 do not show wide differences. Where cartons are not loaded tightly and slack is taken up in transit there would be an opportunity for stacks of cartons loaded crosswise to rock back and forth during sudden starts and stops of the train with consequent injury to apples, especially in the top cartons. As the cartons in this experiment were in a tight load the data may not be conclusive. On the grounds of past observations it is suggested that lengthwise loading is to be preferred and where it is necessary that some of the cartons be loaded crosswise the load should be very tight permitting only a minimum of slack from car thrusts.

Comparative Protection by Wood Boxes and Tray-pack Cartons

A direct comparison could not be made in 1949-50 between bruises on apples packed in wood boxes and those in tray-pack cartons after delivery to retail stores because of differences in handling the two types of packages during the loading of cars. Consequently, during 1950-51 half of the wood boxes and all of the cartons were subjected to regular commercial handling. A greater number of bruises was found in the Dallas retail stores on apples packed in boxes than in cartons (table 5). Differences were most pronounced in the severe bruises, of which there were 17.5 more per hundred fruits in the boxes than in the cartons. An examination of the apples in Wenatchee showed that, under the conditions of these experiments, there were more bruises incident to packing and storage in the cartons than in the boxes (table 1). It seems apparent therefor, that the tray-pack cartons afforded comparatively greater protection during shipment and transportation than did boxes.

When boxes were handled carefully (table 3) less bruising resulted than in cartons receiving regular commercial handling (table 5). There is considerable evidence to show that when packed in boxes with 4-way corrugated pads and indent paper tier-pads, apples may have as good protection against bruising as those in tray-pack cartons, but that more bruising occurs because the boxes are handled more roughly than cartons. An examination of data in table 5 shows that when loaded in the top layer of a car the average bruising in boxes was little different from that in tray-pack cartons, whereas, apples in boxes loaded in the bottom layer of the car had many more bruises than in cartons. The boxes loaded on the floor of the car usually receive a forceful impact during the loading operation whereas boxes in the top layer are more or less shoved into place.

Bruises on apples in the layer against the side of a box resting on the car floor-racks, referred to in this report as the bottom layer of a box in the bottom layer of a carload, have been ascribed to vibration during transit.^{1/}

^{1/} Rose, D. H., and Lutz, J. W.

1933. Bruising and freezing of apples in storage and transit.

U. S. Dept. of Agr. Tech. Bul. No. 370, 14 pp. illus.

An analysis of the data on bruises found in the bottom and top layers of boxes, which in these studies were lined with 4-way corrugated pads, indicates that the impact of dropping boxes, rather than transit vibration, was responsible for the excessive bruising in the layer of apples nearest the car floor. In table 6, it will be noted that there were 34.2 more severe bruises per 100 fruits in the bottom layers of the bottom boxes than in comparable layers of the top boxes when the boxes received regular commercial handling; but in boxes handled without forceful impact (careful handling) bottom layer bruising was very nearly the same whether the boxes were carried on the floor or in the top layer of the carload. More bruises were found on apples at the bottom of packages than at the top, but it is noteworthy that generally there were fewer bruises in the bottom layers of boxes carefully handled than in the top layers of boxes receiving regular commercial handling, regardless of the positions of the boxes in the carloads.

Bruises on Apples in Bulk-filled Cartons

Of the 6 bulk-filled cartons used in the shipping tests only 4 were delivered to the retail stores and owing to the ripeness of the fruit when shipped the bruises were too numerous for evaluation in the regular manner, there being an average of 92.9 bruises larger than 1 inch per hundred apples and 46.9 percent of apples had these over-sized bruises. Of bruises 3/4-inch and larger there were 255 per hundred fruits and the fruit as a whole was so badly damaged that 48.3 percent was discarded as unsalable.

In the 51.7 percent that was sorted out as salable, there were certain fruits of sufficient firmness to have withstood bulk-carton shipping well. The damage done to apples in bulk-cartons placed at the top of the load was more severe than in cartons placed on the floor.

The deduction is made that only apples that are quite firm can be shipped with any degree of satisfaction in cartons as large as these without protective packing materials. It is suggested that the less firm the apples, the smaller the package should be or the more important it is that trays or other protective materials be used in the cartons.

CONCLUSIONS AND SUMMARY

Richard Delicious apples picked and packed when at an advanced stage of maturity, were stored until ripe in March, then shipped in carlots to Dallas, Texas, and distributed to retail stores where an evaluation of the amount of bruising was made.

A heavy pack (40-3/4 lbs. net weight of apples) in wood boxes, lined with 4-way corrugated paper pads and having indent-paper tierpads separating layers of paper-wrapped apples, resulted in an average of 14 more severe bruises (3/4-inch and larger) per hundred fruits than a light pack (38-3/4 lbs. net weight of apples).

A heavy pack (43-3/4 lbs. net weight of apples) in tray-pack cartons had an average of 11 more severe bruises per hundred fruits than a light pack (41 lbs. net weight of apples). Size variation and poor placement of apples accounted for many severe bruises in the tray-pack cartons having heavy net weights.

From two years studies it is concluded that with boxes having pads and tier separators there will be more damage done in transit and distribution when the pack is heavy than when it is light.

Apples in boxes receiving regular commercial handling between shipping point cold storage and the Dallas retail stores had about twice as many severe bruises, as apples in boxes handled with care. There were 34.2 more severe bruises per hundred fruits in the bottom layer apples of the boxes against the car floor racks than in the bottom of boxes in the top layer of the load, both of which received regular commercial handling in loading. Where boxes were not thrown into position in carloading nor otherwise handled with impact, the amount of severe bruising in the bottom layers of boxes was not greatly different from other parts of the load. This indicates that excessive bruising in the bottom layer was caused by the heavy impacts of boxes during loading.

The bruising of apples in tray-pack cartons loaded cross-wise of the car was not markedly different from those loaded lengthwise. As the packages had little shifting in transit the conclusion that crosswise loading of cartons is as satisfactory as lengthwise in tight loads. It seems preferable that cartons be loaded lengthwise of the car, but where it is necessary to do cross-wise loading strict attention should be given to tight loading to avoid slackness and the rocking of the stacks.

A greater number of bruises was found on apples in wood boxes having 4-ply corrugated paper pads with indent paper tier pads than in tray-pack cartons when both received regular commercial handling between shipping point and Dallas retail stores. It is suggested that this difference in favor of the tray-pack carton may be due to the greater tendency to throw boxes about.

Shipping Delicious apples in bulk-filled cartons after they had been stored until late March and were ripe resulted in a loss of 48.3 percent of the apples on account of excessive bruising. Apples remaining in a salable condition after delivery to the retail stores were the firmer fruits that withstood pressures without excessive bruising. It is concluded that apples shipped loose in cartons that carry from 47 to 48 pounds of fruit should be quite firm or hard when shipped.

ACKNOWLEDGEMENTS

Appreciation is expressed to the Auvil Fruit Company, Orondo, Washington for valuable assistance in selecting and packing the test fruit; to the Easwest Produce Company, Yakima and Wenatchee, Washington for accommodating the test packages in carlot shipments; and to the Safeway Stores, Inc., Dallas, Texas for arrangements whereby the fruit was distributed to and inspected in retail stores.

Table 1. Bruises found on apples after packing
Wenatchee, Wash., November, 1950.

Package	Apples examined	Bruised percent	Multi- bruised percent	Bruises per 100 fruits		
				slight	severe	total
Box, heavy	600	43.7	7.3	48.7	11.6	60.8
" light	600	49.0	9.7	59.3	9.0	68.3
" average		46.3	8.5	54.0	10.3	64.3
Carton, heavy	1200	54.8	13.9	76.5	14.2	90.7
" light	1200	57.0	11.7	79.9	10.3	90.2
" average		55.9	12.8	78.2	12.2	90.4

Table 2. Comparison of bruises on apples in heavy and
light packs, Dallas, Texas, 1951

Package	Apples examined	Bruised percent	Multi- bruised percent	Bruises per 100 fruits			
				slight	severe	total	over 1/ 1 inch
Cartons <u>2/</u>							
Heavy	1200	87.2	48.2	168.2	57.7	225.9	6.0(5.4)
Light	1200	83.6	41.9	163.2	46.5	209.7	4.3(4.0)
Boxes <u>3/</u>							
Heavy	1200	85.7	43.2	154.0	60.2	214.2	7.9(7.3)
Light	1200	77.8	34.9	135.4	45.9	181.3	4.7(4.1)

1/ Figures in brackets denote percent apples with bruises larger than 1 inch.

2/ All cartons received regular handling, two of each weight not going beyond Dallas produce warehouse.

3/ Includes boxes receiving both careful and regular handling, which had been packed with corrugated 4-way pads and indent paper tier-pads.

Table 3. Bruises resulting from the regular and careful handling of wood boxes during carloading, unloading and distribution to Dallas, Texas retail stores, 1951.

Handling	Apples examined	Bruised percent	Multi-bruised percent	Bruises per 100 fruits			
				slight	severe	total	over <u>1</u> / 1 inch
Regular	1200	89.0	49.5	171.4	70.3	241.7	8.7(7.7)
Careful	1200	74.5	28.7	118.0	35.9	153.9	3.9(3.7)

1/ Figures in brackets denote percent apples with bruises larger than 1 inch.

Table 4. Comparison of bruises in cartons loaded lengthwise and crosswise of refrigerator cars. 1/

Loaded	Apples examined	Bruised percent	Multi-bruised percent	Bruises per 100 fruits			
				slight	severe	total	over <u>2</u> / 1 inch
Lengthwise †	800	88.8	49.1	169.1	59.9	229.0	7.4(6.4)
Crosswise	800	88.0	49.6	179.7	59.3	239.0	4.9(4.6)

1/ Bruises counted after delivery to retail stores in Dallas, Texas, 1951.

2/ Figures in brackets denote percent apples with bruises larger than 1 inch.

Table 5. Comparison of average bruises in wood boxes and tray-pack cartons after delivery to retail stores in Dallas, Texas, 1951.

Package ^{1/}	Apples examined	Bruised percent	Multi-bruised percent	Bruises per 100 fruits			
				slight	severe	total	over ^{2/} 1 inch
Cartons - Average	1200	85.6	45.5	162.5	52.7	215.2	6.2(5.5)
top of load	600	85.7	46.0	167.3	53.3	220.6	7.0(6.7)
Bottom of load	600	85.6	45.0	157.7	52.2	209.8	5.5(4.3)
Boxes - Average	1200	89.0	49.5	171.4	70.2	241.6	8.7(7.7)
top of load	600	87.7	45.8	174.3	57.5	231.8	5.2(4.7)
Bottom of load	600	90.3	53.2	168.5	83.0	251.5	12.2(10.7)

^{1/} Data from packages loaded lengthwise in cars and receiving regular commercial handling.

^{2/} Figures in brackets denote percent of apples with bruises larger than 1 inch.

Table 6. Relation of bruises to position of apples in packages and to position of packages in car load after delivery to retail stores in Dallas, Texas, 1951

Package	Handling	position		Apples examined ^{2/}	Bruised percent	Multi-bruised percent	Bruises per 100 fruits			
		in package ^{1/}	in carload				slight	severe	total	
Carton	Regular	top	top	200	82.0	43.5	182.0	38.5	220.5	4.5(4.5)
"	"	bottom	top	200	89.5	54.5	160.5	82.5	243.0	17.0(16.0)
"	"	top	bottom	200	81.5	39.5	158.0	33.5	188.5	3.0(3.0)
"	"	bottom	bottom	200	89.5	58.0	155.0	78.5	233.5	11.5(10.5)
Box	Regular	top	top	120	88.3	40.8	168.3	50.0	218.3	6.6(5.8)
"	"	bottom	top	120	84.2	47.5	138.3	80.8	219.1	4.2(4.2)
"	"	top	bottom	120	87.5	39.2	149.2	54.1	203.3	5.5(5.5)
"	"	bottom	bottom	120	92.5	57.5	159.2	115.0	274.2	24.0(20.8)
Box	Careful	top	top	120	74.2	30.8	123.3	36.7	160.0	5.8(5.0)
"	"	bottom	top	120	72.5	29.2	95.8	45.8	141.7	3.3(2.5)
"	"	top	bottom	120	75.0	22.5	121.7	25.8	147.5	2.5(2.5)
"	"	bottom	bottom	120	72.5	25.0	99.2	49.2	148.4	9.2(8.3)

^{1/} Top and bottom layers as stacked in car or warehouse

^{2/} Twenty fruits from each layer in a package

^{3/} Figures in brackets denote percent apples with bruises larger than 1 inch

