FILM OVERWRAPPING OF APPLE TRAYS INCREASES HANDLING EFFICIENCY

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SUMMARY

Overwrapping standard apple trays with a polyethylene shrink film (1) better protected the apples from mechanical injury during retail display; (2) reduced weight loss; (3) improved cooling (polyethylene film box liner was eliminated); and (4) reduced labor time and skill requirements. Less labor was required both at the packinghouse and at the retail store.

Labor requirements to pack a box of apples were about 27 percent less at the packinghouse, and labor requirements to build and rotate displays at retail were about 50 percent less for the film-wrapped tray packs than for conventional tray packs.

The weight loss from Golden Delicious apples packed in the standard pack was about 3 percent, compared with less than 1 percent for Goldens packed in the film-wrapped trays.

The half-cooling time for Goldens in the film-wrapped trays averaged about 18 hours less than those in the standard pack with its film box liner.

At retail stores, 19 percent of the apples displayed in film-wrapped trays had bruises (one-half inch or larger), compared with 29 percent of those displayed in bulk with or without trays. These differences emphasize further the value of film-wrapped trays of apples over conventional methods of bulk displaying apples.

INTRODUCTION

The 1974 U.S. marketing bill,[2] including costs of processing, distributing, and transporting domestic farm foods, totaled $92 billion, an increase of 12 percent over 1973. The three largest components of the food marketing bill are labor (46 percent), packaging (12 percent), and transportation (7 percent).

Ceponis and Butterfield [3] found that mechanical injuries (cuts and bruises) are the leading type of loss in apples at retail. The Golden Delicious apple, because of its soft flesh, is more easily cut and bruised than most of the red apple varieties.

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[2] U.S. DEPARTMENT OF AGRICULTURE, ECONOMIC RESEARCH SERVICE. MARKETING AND TRANSPORTATION SITUATION. MTS-198, 41 pp. 1975.

[3] CEPONIS, M. J., and J. E. BUTTERFIELD, THE NATURE AND EXTENT OF RETAIL AND CONSUMER LOSSES IN APPLES, ORANGES, LETTUCE, PEACHES, STRAWBERRIES, AND POTATOES MARKETED IN GREATER NEW YORK. U.S. Dept. Agr. Mkt. Res. Rpt. 966, 23 pp. 1973.

Comments about Golden Delicious apples from the trade and Washington State Apple Commission fieldmen give some insight into this problem:

1. "When Goldens are displayed in retail stores the change in temperature brings out the bruises and discoloration and shrinkage becomes a major problem."

2. "As the apple marketing season progressed, bruising developed in many lots, primarily in those lots packed in the standard tray pack container."

3. "At times, boxes of apples were dumped onto the display tables causing bruising, and bruising also occurs due to customer sorting."

4. "For the most part, bruising occurs at retail level—the major source of trouble is in removing the paper wraps. Fast handling of the apples (most supermarkets operate with a one-man produce crew or perhaps one and one-half men) to remove the paper wraps results in rough handling and bruising."

To reduce retail losses, the Washington State Apple Commission has for many years encouraged retailers to display apples in the shipping tray in which they are packed and shipped.

The objective of this study was to adapt the conventional standard apple tray to a retail display unit by overwrapping it with film at the packinghouse. Hopefully, this display unit would (1) encourage retailers to display apples in the shipping tray; (2) reduce labor requirements; (3) reduce the level of mechanical injury; (4) maintain or improve apple quality; (5) allow the retailer the option of displaying the apples in bulk or as a consumer package; and (6) would not adversely affect the internal quality, such as browning from carbon dioxide (CO_2) injury.

Changes have occurred in the commercial tray packing of Golden Delicious apples during the course of this study. In addition to the standard full-paper wrap (each apple individually hand wrapped in a tissue paper), many packers and shippers are using a tray pack without any paper wrap around the apples. This "naked" tray pack has cushion pads between each layer as well as a pad on top and is referred to in this report as a "pad pack." Both packagings—the full wrap and the naked with layer pads—commonly used tray packs for Golden Delicious apples, are enclosed in a polyethylene film box liner.

PROCEDURE

Our research involved four experiments: (1) A small-scale, four-store retail experiment, using a limited number of experimentally packed test boxes; (2) a long-distance rail transit test; (3) a 10-store retail experiment using larger numbers of test boxes that had been commercially packed; and (4) a laboratory experiment to simulate the environment during storage, transit, and retail display.

Golden Delicious apples were used in all four experiments. A 1.25-mil polyethylene film was used to wrap individual layers of trays. This film was subsequently removed from the top one or two layers of trays when they were put on display at retail.

Experiment 1—February and April 1974

This test included 84 apple boxes of sizes 88 and 100 apples. These test boxes were packaged by hand, and no time study of labor requirements was conducted. Retail studies were conducted in four stores in the Los Angeles, Calif., area at two different time periods—one week in February (apple size 88) and one week in April (apple size 100). The test boxes of apples were shipped from the Yakima Valley by truck on Saturday, arrived at the terminal warehouse on Monday, and were delivered to the four stores on Tuesday. The tests were completed by the following Saturday. A table display was arranged in each store and each display was split between a typical bulk display from the standard test boxes and the tray display from the experimental film-wrapped tray pack test boxes. Each half of the split display contained the same number of apples for sale at the same price (fig. 1). Bruising, cullage, and sales records were kept for each display. Time studies were made to determine the labor required to build the displays.

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FIGURE 1.—Split display: Typical bulk display on the left; experimental film-wrapped trays with film removed on top layer on the right.

Experiment 2—May 1974

Twelve test boxes of apples (size 113) were packed by hand and shipped via rail from Yakima, Wash., to Landover, Md. The six standard and six experimental film-wrapped tray packs were placed in the top, middle, and bottom layers of the load. An ARS packaging research scientist examined the 12 boxes of apples in Landover and recorded the amount of bruising and severity of bruising by type of pack.

Experiment 3—January 1975

This test involved a full truckload of Golden and Red Delicious apples shipped from Hood River, Oreg., to Houston, Tex. The Golden Delicious apples (size 125) required to compare film-wrapped trays and standard tray packs were trucked to the Hood River packinghouse from a Yakima, Wash., packinghouse. These apples were repacked on a pilot packing line that included an automatic film-overwrapping machine. Time studies of labor required to pack a box of apples were conducted on this pilot packing line as well as on the conventional packing lines. In all, 200 boxes of experimental film-wrapped trays and 200 standard tray packs of Goldens were packed for this test.

Ten retail stores in the Houston, Tex., market area provided table displays similar to those in the Los Angeles tests (fig. 2). However, in this market area the type of bulk display consisted of naked apples in trays stacked several layers high. As in the Los Angeles tests, bruising, cullage, and sales records were kept by type of display. Time studies were made to determine labor requirements to build and change the two types of displays during the sales period.

Experiment 4—April and May 1975

Because of the difficulty of keeping complete control of the previous tests under commercial conditions, we conducted a laboratory test to more accurately evaluate the film-wrapped trays with respect to (1) cooling, (2) temperatures during transit and at retail, (3) ripening, and (4) other internal measures of quality.

For this laboratory simulation test, 39 boxes of comparable apples (size 125) were packed as follows: (1) 13 standard tray packs, each apple paper wrapped, each pack in a polyethylene film box liner; (2) 13 standard tray packs with macerated

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FIGURE 2.—Bulk apple display in trays (left) and film-overwrapped display (right).

newsprint pads (pad packs) between each layer, no paper wraps, and each pack in a polyethylene film box liner; and (3) 13 experimental film-wrapped tray packs, without film box liners, and each apple naked.

The test consisted of three parts: (1) A cool-down period in a coldroom set at 0° C (32° F); (2) a simulated transit period in a coldroom set at 4° C (40° F); and (3) a simulated retail period in a cold-room set at about 21° C (70° F). In the latter, the apples were placed on tables to simulate a retail display. Two boxes of each of the three packs were kept at a constant 0° C (32° F) to determine the market quality of apples held under optimum conditions.

Temperatures of apples located on each end of the top, middle, and bottom layers of each box were recorded from two boxes of each of the types of tray packs during the simulated storage, transit, and retail periods. Also, ambient air temperatures around the boxes were recorded. Pressure tests of representative apples from each of the three types of packs were made periodically during the test period. The individual layers of apple trays were weighed before and after the retail portion of this test. Average CO_2 levels were measured inside the film-wrapped trays. Soluble solids and acidity, as malic acid equivalents, were measured from representative samples of all apples tested.

Estimated Costs of Packaging Materials—1976

The estimated costs of packaging materials for early 1976 are as follows: (1) Shipping container, 53 cents; (2) five shipping trays, 28 cents; (3) polyethylene film box liner, 5 cents; (4) five non-printed polyethylene shrink film wraps, 10 cents; (5) 100 tissue paper wraps, 14 cents; and (6) one macerated newsprint top pad, 4 cents. Four layer pads for the pad pack cost about 13 cents for the thin, macerated newsprint layer pads or about 9 cents for the polypropylene foam layer pads.

Thus, cost of packaging materials for a standard full-wrap tray pack would be about $1.04 per box. These materials for a pad pack without any paper wraps but with the addition of four layer pads would cost about $1.03 or 99 cents per box, depending on the type of pad used. For the ex-

perimental film-wrapped tray pack, the cost of packaging materials is estimated at 95 cents per box. This cost reflects the elimination of the paper wraps and the film box liner.

RESULTS

Experiment 1

There were more bruising and cullage (unsalable apples) and fewer sales of apples from the bulk display (standard tray pack test boxes) than from the film-wrapped trays of apples (table 1).

TABLE 1.—*Bruising, cullage, and sales of Golden Delicious apples in split displays at retail stores in Los Angeles, Calif., during 2 test periods—February and April 1974* [1]

Type of display, test period, and apple size	Bruising (over ½ inch in diameter)	Cullage (unsalable)	Sales
	Percent	*Percent*	*Number of boxes*
Film-wrapped tray display:			
February (size 88)	16.2	3.1	5.0
April (size 100).....	5.0	1.9	2.6
Bulk display:			
February (size 88)	30.0	20.1	2.5
April (size 100).....	7.5	6.9	2.0

[1] Statistical analysis using a T-test showed the following: (1) Bruising differences were not statistically significant; (2) cullage differences between types of displays within test periods were statistically significant at the 5-percent level; and (3) sales differences between types of displays within test periods were statistically significant at the 5-percent level.

With the displays side by side and with more sorted-out bruised apples accumulating on top of the bulk display, customers preferred to buy apples from the film-wrapped display. During the first test period, about twice as many apples were sold from the tray displays (5 boxes) than from the bulk displays (2.5 boxes) in the four stores. During the second test period, about 30 percent more apples were sold from the tray displays (2.6 boxes) than from the bulk displays (2.0 boxes).

The higher levels of bruising in the bulk displays were due to the additional handling these apples received when removed from the box to build the display, when the display was built, and when the apples were handled during customer sorting. In contrast, the apples in the film-wrapped trays were easy to remove from the box a layer at a time and were easily built into displays with no fear of dropping. Also, in this test, customers for the most part did not disturb the lower layers of displayed apples that were kept wrapped in film and selected their fruit from the upper layers, which had the film removed. Thus, over a week's period of display, apples on the film-wrapped tray displays received less handling than those in bulk displays.

Labor required to build the bulk-type display was 6.5 man-minutes, and to build the film-wrapped tray display 3.4 man-minutes were required—almost a 50-percent savings in labor. This savings in labor for the film-wrapped tray display is due to the ease and security of lifting the film-wrapped trays out of the box and placing them on the display table.

Experiment 2

Bruising of apples in the long-distance rail transit test was as follows:

Test box	*Percent bruise injury* [1]
Standard tray pack	12.9
Film-wrapped tray pack	13.0
Average level.....	12.0

[1] Total of bruises ¼ to ½, ½ to 1, and over 1 inch in diameter.

No significant difference was found in the degree or level of bruising of the apples in the two types of packs. Layer location of the boxes had no affect on bruising in this test. The elimination of individual paper wraps and the box liner had little effect on the amount of bruising that occurred during transit.

Experiment 3

Table 2 shows the reduced labor required to pack a box of film-wrapped trays in contrast to conventional packing methods. Depending on the type of standard tray pack (full paper wrap or top

TABLE 2.—*Estimated labor required to pack 1 box of Golden Delicious apples, 5-layer sizes* [1]

Type of pack	Man-minutes
Standard tray pack:	
Typical apple packing line, full paper wrap [2]	3.50
Typical apple packing line, top layer paper wrap [3]	2.60
Automatic tray filling line, top layer paper wrap [4]	2.19
Experimental film-wrapped tray pack:	
Automatic tray filling line, film-wrapped trays (no paper wrap) [5]	1.60

[1] Does not include labor for similar operations on the different packing lines. Includes 15 percent allowance for personal time and fatigue.

[2] Time required to place empty box on stand, insert liner, place and pack 5 layers of paper-wrapped apples, insert pads, close liner, close box, stamp size and packer's number on cover, and place finished box on conveyor belt.

[3] Time required to place empty box on stand, insert liner, place and pack 5 layers of apples with only top layer paper wrapped, place packer's number on cover, and place finished box on conveyor belt.

[4] Time required to place empty trays on line, orient apples in trays, and pack 5 layers of apples with only top layer paper wrapped.

[5] Time required to place empty trays on line, orient apples in trays, place film-wrapped trays of apples in box, and monitor film wrap and heat machine.

layer only paper wrapped), as much as 2 man-minutes could be saved per box of apples by packing the film-wrapped trays. In addition to reducing overall labor requirements, the laborers needed to pack film-wrapped trays require less skill than laborers needed to pack a standard tray pack. However, to get maximum savings in labor, the packinghouse operator would have to change over to a presort and presizing operation.

Figures 3 and 4 show the arrangement of workers and equipment for a typical packing line and the pilot packing line used to wrap and pack the film-wrapped trays. Figures 5 and 6 show the trays of apples going into the automatic film-wrapping machine and the one worker required to place the wrapped trays into the box.

At the retail level there were further labor savings. Less labor was required to construct and change apple displays of film-wrapped trays than was required for standard bulk tray displays (table 3).

In the Houston, Tex., market area, a typical bulk display showed apples packed in apple shipping trays without paper wraps. Thus, in this area, the film-wrapped trays competed against the standard type of tray display in the test stores (fig. 2).

It took about 14 man-minutes to construct an apple display of film-wrapped trays compared with about 32 man-minutes to display the same number of apples from the standard tray pack boxes (table 3). The film-wrapped trays of apples also required less labor when the displays were rotated or changed (14 man-minutes) then when the standard displays were changed (24 man-minutes).

The chief reason for the reduction in labor was the ease and, therefore, the speed with which the film-wrapped trays could be removed from the box and placed on the table without spilling the apples. However, the produce clerk spent more time policing the film-wrapped tray displays to keep a full appearance than he did with the standard tray displays.

As in experiments 1 and 2, apple bruising on retail display was less for those apples in the film-wrapped trays than for those from the standard tray pack (table 4). When the apples were examined just after transit, little difference in bruising was found between the standard and experimental packs. On display, the significant difference was at the 5-percent level (½ to ¾-inch bruises) and 10 percent level (over ¾-inch bruises). Even though the difference was greater in the second inspection period, the treatment by time interaction was not significant.

Experiment 4

The half-cooling times of the apples in the tray packs tested are shown in table 5. The apples in the film-wrapped trays showed a significantly shorter half-cooling time (96.5 hours) than those in the standard tray packs (114.5 hours). The main reason for this faster cooling is the elimination of the film box liner, which restricts circulation of air through ventilation holes and handholds in the box. No significant difference in cooling time was found among layers within these tray packs.

In the "transit" holding room (4° C or 40° F) the apples maintained a constant stabilized temperature due to the good air circulation in the room. There was little difference in apple temperature due to the type of test package.

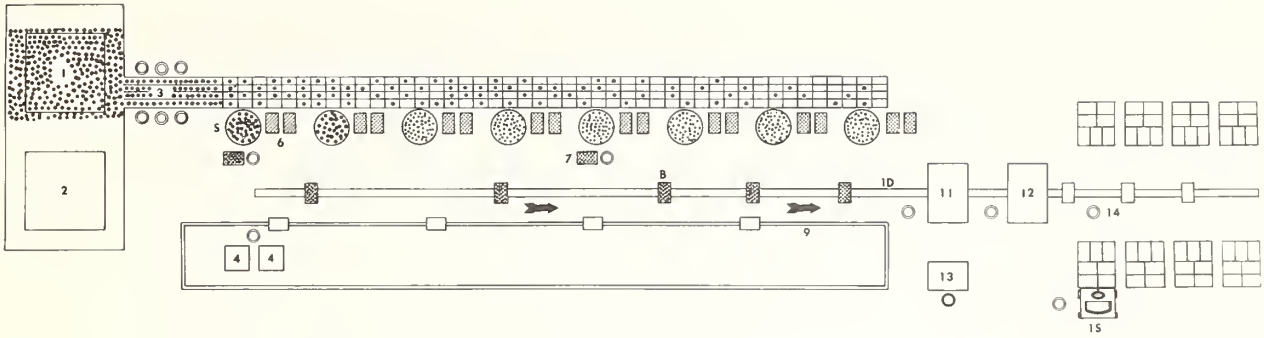


FIGURE 3.—Typical packing line. Tubs or tables and workers shown on only one side of line.

TABLE 3.—*Estimated labor required to construct and change apple displays in retail stores in Houston, Tex., January 1975* [1]

Item	Standard tray display using paper-wrapped apples	Tray display with experimental film overwrapped trays
	Man-minutes	*Man-minutes*
Construct display:		
Total time for full display	32.30	13.70
Per tray	.65	.23
Change display:		
Total time for full display	24.12	14.04
Per tray	.60	.36
Per tray element:		
Remove from box, set on table, and adjust	.57	.14
Remove film wrap	—	.28

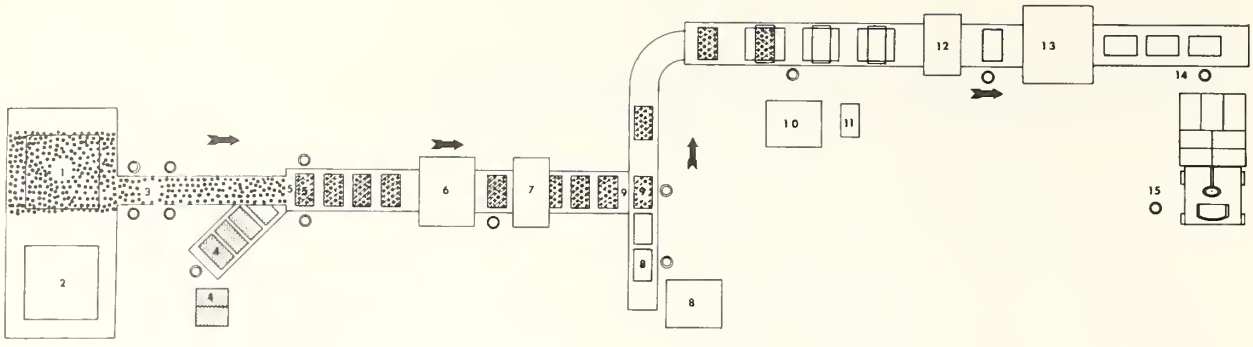
[1] Data taken from time studies conducted in 3 different stores. Times adjusted by 15 percent for personal time and fatigue. Man-minutes reflect only direct labor operations.

In the "retail" holding room in which the layers of apples were out of the boxes and on the table, the small (less than ½°C) temperature differences of apples in the types of test trays were not significant. Apple temperatures in the film-wrapped trays were slightly higher (21.4° to 21.5° C) than the non-film wrapped trays (20.7° to 21.1° C).

Examination showed no significant difference in pressure tests of the apples packed in the experimental and standard tray packs. Moisture loss from apples (table 6) in the film-wrapped trays was significantly lower (0.57 percent) than from apples in the trays without a film overwrap (3 percent). The higher moisture retention and slightly higher temperatures of the film-wrapped apples were not correlated with decay in this laboratory test.

The atmosphere within the film-wrapped trays contained about 4 percent CO_2, but no damage was found as a result of this CO_2 level in any of the 1,070 apples cut open for sampling.

Apples packed in the standard or experimental tray packs did not differ in soluble solids content or acidity.



- WORKERS
1 FLOATING APPLES FROM BIN
2 EMPTY BIN
3 SORTING APPLES
4 TRAY SUPPLY & PLACING ON CONVEYOR
5 FILLING TRAYS WITH APPLES
6 TRAY FILM OVERWRAP
7 HEAT TUNNEL
8 INNER CARTON, SETUP & SUPPLY
9 PLACEMENT OF TRAYS OF APPLES INTO CARTONS
10 SUPPLY & PLACEMENT OF TOP COVER & PAD
11 TOP PAD SUPPLY
12 WEIGHING & MARKING
13 GLUE SEALING MACHINE
14 PALLETIZED CARTONS OF APPLES
15 FORKLIFT TO MOVE FRUIT TO STORAGE
ALSO SUPPLY BINS OF APPLES & PACKING MATERIALS

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FIGURE 4.—Pilot packing line for film wrapping and packing apples in trays.

TABLE 4.—*Bruising of extra fancy, Golden Delicious apples (size 125) displayed in 10 retail stores in Houston, Tex., January 24-31, 1975*

Examination time [1] and severity of bruise	Standard full paper-wrap tray pack	Experimental film-wrapped tray pack
	Average percent	*Average percent*
Arrival:		
½- to ¾-inch diameter	12.0	12.5
Over ¾-inch diameter	0	0
First inspection on display:		
½- to ¾-inch diameter	33.1	25.5
Over ¾-inch diameter	6.3	3.9
Second inspection on display:		
½- to ¾-inch diameter	51.7	40.6
Over ¾-inch diameter	6.1	1.7
Average of two inspections:		
½- to ¾-inch diameter	42.4	33.0
Over ¾-inch diameter	6.2	2.8

[1] Sampled 20 apples from each type of display in each store for each inspection period: First inspection; standard pack, 160 apples; experimental pack, 180 apples. Second inspection; standard pack, 180 apples; experimental pack, 180 apples.

TABLE 5.—*Comparison of the average half-cooling time (Z) of film-wrapped tray pack, and wrapped-fruit tray pack apples*

Packaging treatment	*Average half-cooling time (Z)* [1]	
	Hours	
Film-wrapped tray pack	96.5	c
Standard tray packs	[2]114.5	b
Inboard end of container trays [3]	136.1	a
Outboard end of container trays [4]	81.0	b
Top tray of container	103.5	a
Middle tray of container	114.1	a
Bottom tray of container	108.0	a

[1] Means within each factor not followed by the same letter are significantly different at the 5-percent level by Duncan's multiple range test.

[2] Average of pad tray pack and wrapped-fruit tray pack.

[3] Inboard end of tray was monitored by a sensor in the fruit on the tray closest to the center of the palletized unit.

[4] Outboard end of tray was monitored by a sensor in fruit on the tray closest to the perimeter of the palletized unit.

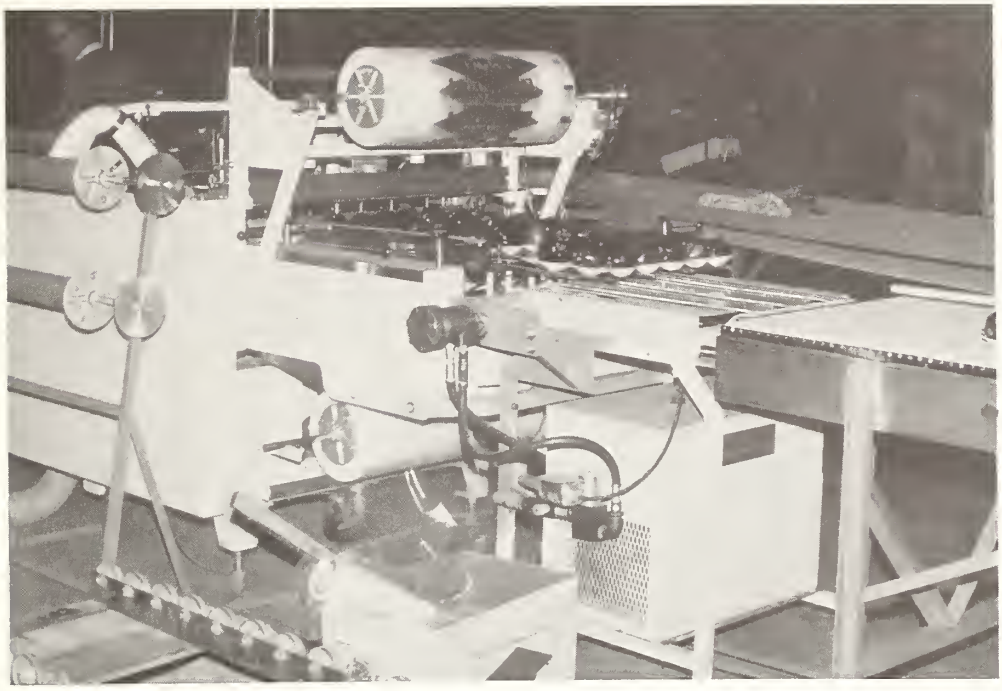

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FIGURE 5.—Automatic overwrapping machine. Trays of apples are moving into position to be overwrapped with shrink film.

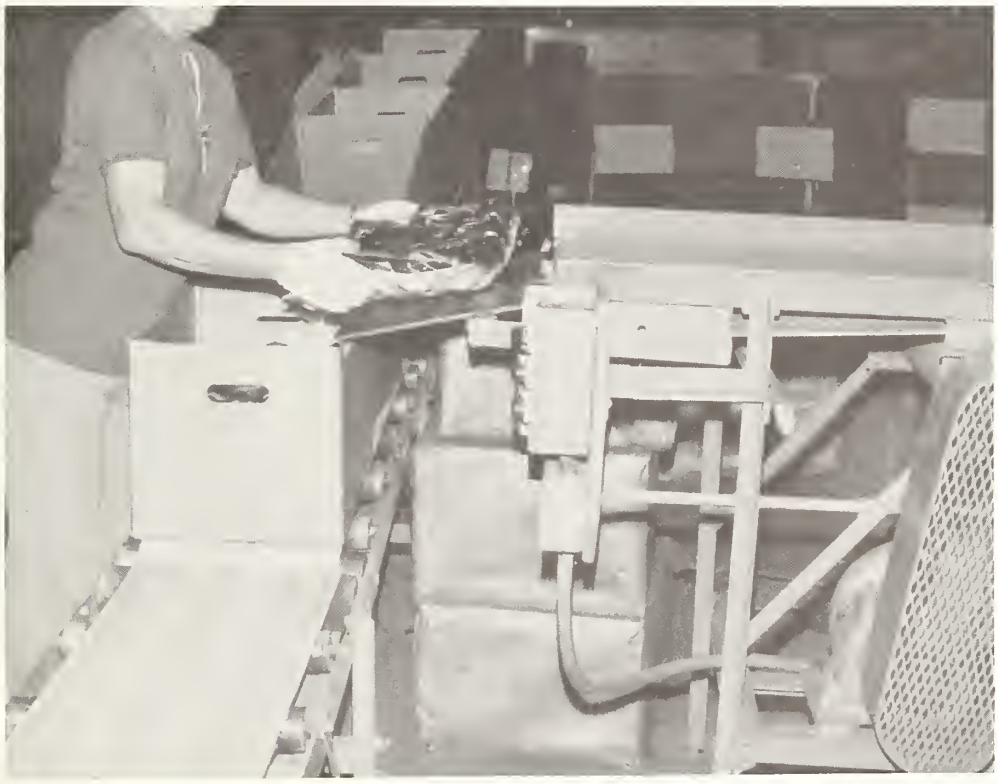

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FIGURE 6—Placing trays in box. Only one worker is required to place the packed film-wrapped trays into the bottom of the box. The lid is placed over the bottom at a point later in the packing line.

TABLE 6.—*Percentage of weight loss and decay of fruit during simulated retail display at 21° C (70° F)*

Type of tray pack	Weight loss				
	0° C room check		21° C room		Decay
Standard:					
Pad	1.27	a[1]	3.08	a[1]	1.24
Wrapped fruit	1.24	a	3.24	a	.57
Film-wrapped	.12	b	.57	b	.48

[1] Means within each factor not followed by the same letter are significantly different at the 5-percent level by Duncan's multiple range test.

CONCLUSIONS AND DISCUSSION

Application of a polyethylene shrink-film overwrap on the Golden Delicious apple shipping tray at the packinghouse should: (1) Encourage retailers to display apples in the tray because it reduces labor costs and the skill needed to build and rotate displays and reduces the amount of bruising and cullage that occurs during the retail sales period; (2) reduce labor requirements and skill needed to pack presized and presorted fruit, especially in packing lines with a semiautomatic tray filler and an automatic film-overwrapping machine; and (3) improve apple quality because of faster cooling, reduced moisture loss, and the absence of any adverse affects on internal quality or decay.

Using the complete film-wrapped tray as a consumer package does not seem very practical because (1) the tray is too big for the shopping bag and for carrying out of the store, and (2) the sale price of this large unit may be too high for most consumers. However, further research into new tray designs may show that trays can be subdivided into a size, count, and weight that would appeal to shoppers.

Research should also develop a way of unitizing these individual film-wrapped trays of apples into larger more economical shipping containers. Such shipping containers could be reusable, further reducing the costs of packaging and handling.

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