AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

g84Mr
3

U. S. DEPT. OF AGRICULTURE
LIBRARY
MAY 18 1982
CURRENT SERIAL RECORDS

Prepackaging Medium-Size Apples in Shrinkable Films at Shipping Point

7a

Marketing Research Report No. 534

5b

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Transportation and Facilities Research Division

PREFACE

Packaging of apples and various other fruits and vegetables in packages for consumers at shipping point is increasing. New materials and new methods are continually being developed. This study was made to help develop and evaluate the new materials as well as methods of applying them. It is part of a continuing program of research aimed at improving marketing efficiency of farm products.

ACKNOWLEDGMENTS

The cooperation of many persons and organizations made this study possible. Individual shippers, receivers, and material manufacturers and suppliers made valuable contributions toward this research. This study was conducted under the supervision of Donald R. Stokes, agricultural economist, of the Transportation and Facilities Research Division, Agricultural Marketing Service. Peter G. Chapogas, in charge of the Division's field station at Fresno, Calif., conducted much of the early research which led to the development of the packages described in this report.

Washington, D. C. April 1962

CONTENTS

	Page
Summary	5
Introduction	7
Temperatures of apples during film-shrinking operation	8
Description of packages and shipping containers	9
Experimental packages	9
Heat-shrinkable films	9
Consumer trays	11
Master containers	13
Conventional tray packs	15
Costs and labor requirements for packing apples	16
Costs of materials and containers	18
Labor requirements and costs	20
Combined costs for materials and direct labor	22
Transportation costs	22
Evaluations at terminal markets	23
Bruising of apples	23
Appearance of packages at terminal markets	26
Appearance of packages at retail stores	27
Discussion	27

SUMMARY

Washington State Red Delicious and Winesap apples packaged in consumer units at shipping point arrived in eastern terminal markets with very little bruising and were well received by chainstore buyers, who were willing to pay a reasonable premium for them.

Since 1956 a number of experimental packages for medium to large size apples have been developed and evaluated. During the 1959-60 and 1960-61 marketing seasons, researchers developed a less expensive package, with a high degree of product visibility and the ability to immobilize the apples by use of heat-shrinkable films. This report concerns itself mostly with this latest development. The costs of packing apples were studied. Test shipments were initiated to evaluate the condition of the apples and packages upon arrival at terminal markets. The appearance and condition of the packages also were evaluated in stores.

Prepackaging apples costs more than packing them in the conventional tray pack. The cost of materials and direct labor to pack apples sized 88 to 138 in the shrinkable-film packages ranged from 2.2 to 2.4 cents per pound, depending on the type of film used. Comparable costs were 1.7 cents per pound for the conventional tray pack. Most of this extra cost is for the additional packaging materials required for the consumer units.

In eight shipments, prepackaged Red Delicious apples sustained but 2.7 percent slight bruising and no damage by bruising or serious bruising; prepackaged Winesaps sustained 3.5 percent slight bruising and no damage by bruising or serious bruising.

Most of the bruising found in the packages was on the upper parts of the apples, visible to the consumers. Various cushioning materials were tested as between-layer pads, but none performed substantially better than the double-faced corrugated board, and all were more expensive.

The master container with double-faced corrugated pads between layers did not adequately protect prepackaged Golden Delicious apples from bruising during transit. The development of cell-type master containers, in which each consumer package was held securely in an individual compartment by separators that prevented the upper layers from pressing on the layers below, substantially reduced bruising of the Golden Delicious, as well as of the Red Delicious and Winesap varieties.

A larger master container for prepackaged apples would permit savings in handling, because more packages could be packed into one box. Such a box was developed late in the 1960-61 season. It held 24 consumer packages with an approximate net weight of 60 pounds.

Presizing apples before they are withdrawn from storage should speed the prepackaging operation, and the use of machinery to wrap the shrinkable film around the tray should bring additional cost reductions. Researchers think that a package such as described in this study eventually may be packed at approximately the same cost as the conventional tray packs.

Acceptance of the consumer packages wrapped in shrinkable film was very favorable. Consumers and store personnel, as well as the wholesale buyers, reacted favorably even though the package at retail was less attractive than when it was packed at the shipping point. Because of handling, the film wraps tested tend to loosen and wrinkle, and thus make a less attractive package.

A continuing demand from retail organizations for prepackaged produce is encouraging apple shippers to continue experimenting with consumer packaging at point of production.

PREPACKAGING MEDIUM-SIZE APPLES IN SHRINKABLE FILMS AT SHIPPING POINT

By James B. Fountain, agricultural economist
Transportation and Facilities Research Division
Agricultural Marketing Service

INTRODUCTION

The most widely used consumer package for apples in the United States is the polyethylene film bag. The use of film bags for packaging apples at point of production was developed by the United States Department of Agriculture under an earlier research project. 1/ From 35 to 45 percent of our apples are sold at retail in these bags, but medium to large size apples do not fit well into 3- to 5-pound bags, the most salable size range. Furthermore, bags do not adequately protect these apples from bruising.

Most retailers prefer to sell packaged produce rather than bulk produce. A good package reduces deterioration caused by customer handling, extends shelf life, lowers the store's handling costs, and enhances the appearance of the product.

Various segments of the apple industry and researchers of the Agricultural Marketing Service began studies in 1956 to develop and evaluate rigid packages for better protection of the larger apples. The packages included cell cartons, window cartons, shipping trays that could be cut into three equal parts and overwrapped with film at the retail store, and molded pulpboard trays, usually holding 6 or 8 apples, overwrapped with various films at the shipping point.

Laboratory tests and studies on the condition of the apples on arrival at the terminal market indicated that the film-wrapped pulpboard tray reduced bruising below that in the conventional apple packs. However, with the films that were then available, a tight pack was not attainable, and movement of the apples within the package caused bruising. Too, film and tray materials were costly and the labor for a complete overwrap was high.

During the 1959-60 apple marketing season an irradiated polyethylene film that shrinks both lengthwise and crosswise when heat is applied was introduced. This film immobilized the apples within the tray and had promise of reducing bruising and costs of materials and labor. Since the use of a heat-shrinkable film wrap for apples was completely new, methods of application had to be developed. The film manufacturers cooperated in the work. Preliminary studies of other types of shrinkable film also were made.

1/ Carlsen, Earl W., and Stokes, Donald R. Prepackaging Apples at Point of Production. U. S. Dept. Agr. Inform. Bul. 29, 52 pp., illus. January 1951.

An experimental prepackaging line was set up in a Yakima, Wash., apple packing plant and introductory shipments of sample shrinkable-film packages were sent to potential buyers in December 1959. Soon after, commercial trial shipments were made as receivers who liked the package sent in orders.

During the 1959-60 and 1960-61 marketing seasons, researchers (1) developed equipment and methods to wrap trays of apples in new shrinkable films and to seal the film and shrink it to form a tight, attractive package; (2) conducted studies in six plants to determine materials and direct labor costs of packaging; (3) originated test shipments; (4) examined the arrival condition of the packaged apples in terminal markets; and (5) determined trade reaction at terminal markets and in retail stores.

The 1959-60 research indicated that because of the excellent strength of the shrink-film and its ability to immobilize the apples, a shallower and less expensive pulpboard tray could be used. When the new shallower trays became available in large enough quantities, they were immediately put into use.

Direct labor was reduced by the introduction of the heat-shrinkable film. The previous film wraps required the packing-line worker to completely overwrap the package, tucking the ends of the film under the package and sealing the film on a hotplate. The application of the shrinkable film only required the worker to whip the film around the package in a loose-fitting sleeve wrap; the heat sealing and shrinking were done automatically.

The 1959-60 and 1960-61 research also included preliminary investigations of other types of shrinkable films, redesigning the pulpboard trays so that they would function better under varying conditions, and redesigning the master container to (1) reduce bruising of the soft-fleshed Golden Delicious variety, (2) pack more than one size of package in the same size of master container, and (3) reduce per unit cost by use of a larger master container.

Different methods of packaging were developed to speed the operation. A semiautomatic wrapping machine was tried out, which may reduce labor costs and the amount of film required per package.

TEMPERATURES OF APPLES DURING FILM-SHRINKING OPERATION

Tests were conducted to determine if the application of heat to shrink the film around the new packages would have any adverse effects on the apples. 2/

The apples used were the standard Delicious variety. They had a temperature of 36° to 41° F. before packaging. The heat tunnel thermometer registered 300°. Thermocouples were placed just under the skin on the top and bottom of the apples. The packages were wrapped and then allowed to pass over

2/ The tests were conducted by H. Schomer and G. Patchen, Agricultural Marketing Service, United States Department of Agriculture, Wenatchee, Wash.

the hotplate and through the heat tunnel. In tests of two different types of packages the temperatures on the top of the apples ranged from 45° to 47.5° and on the bottom from 41° to 41.5°.

Next, the thermocouples were placed on top of the apples, just under the point of contact with the film. The highest reading while the package was in the tunnel was 83.5° F., which dropped to 68° shortly after the package emerged. This relatively high temperature (83.5°) indicated that it was the film which heated, and the quick drop to 68° showed that the heat was quickly dissipated. No damage from heat was noted on the apples.

DESCRIPTION OF PACKAGES AND SHIPPING CONTAINERS

Experimental Packages

Heat-Shrinkable Films

Three types of biaxially oriented heat-shrinkable films were evaluated: (1) An irradiated polyethylene, (2) cast polyvinyl chloride, and (3) polystyrene. These films shrink in both length and width when heat is applied.

Limited tests were made with other heat-shrinkable films. These were a polyester film and a polypropylene film. The polyester films are quite expensive, and the polypropylene film requires higher temperature in the shrinking operations. Equipment to fully test polypropylene film was not available at the time of this study.

Each of the three films evaluated had certain advantages and disadvantages. The manufacturers are doing research to eliminate or reduce the disadvantages of their film as it applies to the apple package. More efficient equipment for the wrapping and shrinking operations will help eliminate some of the disadvantages of each film.

Clarity

1. Irradiated polyethylene of 1-mil thickness had good clarity to enhance the natural color of the apples. However, while on retail display at warm temperatures, the film on some packages clouded because of what is believed to be a chemical reaction between the film and the esters given off by the apples. This discoloration of the film marred the appearance of the package. Not all the film on all packages evaluated at retail clouded, but enough clouding occurred to warrant consideration.

2. Polyvinyl chloride of ½-mil thickness had excellent clarity, and the film maintained this clarity throughout the marketing channel.

3. Polystyrene of 1-, 1¼-, and 1½-mil thickness also had excellent clarity. No large commercial shipments were made with polystyrene films in this study. However, observations of packages made up in retail stores indicated the film maintained its clarity.

Wrinkling

Experimentation using carefully controlled application of heat showed that all three films could be shrunk around the apple package with little or no wrinkling. However, in commercial operations using the heat tunnels available, all the films wrinkled, especially where the film touched the apples. The amount of wrinkling at time of packing was not considered objectionable, but it tended to increase as the packages were subjected to handling, particularly at retail.

Tightness of Wrap

1. Irradiated polyethylene shrank tightly around the package, but some looseness developed later. This looseness was due partly to handling, particularly at retail, and partly to distortion of the pulpboard tray as it absorbed moisture.

2. Polyvinyl chloride film also shrank tightly around the package, but did not maintain its tightness of wrap as well as the polyethylene.

3. Polystyrene film maintained its tightness of wrap very well in laboratory tests.

Strength of Film

1. Irradiated polyethylene was very strong and did not tear easily.

2. Polyvinyl chloride was not as strong as the irradiated polyethylene film, but was adequate in strength.

3. Polystyrene film tore easily. Transit-simulating tests indicated that this film would tear during transit. Because of this problem the film was not used for commercial shipments. Four test lots of apples were packaged in it and experimentally shipped from Yakima to Washington, D. C. Over half of the packages were torn on arrival.

Gas Permeability

1. Irradiated polyethylene had low permeability to oxygen and carbon dioxide. Perforating this film was impossible, because it would tear outward from the holes.

2. Polyvinyl chloride film had medium permeability to oxygen and carbon dioxide. This film can be perforated so that a complete overwrap can be used if desired.

3. Polystyrene film was highly permeable to oxygen and carbon dioxide. This film could be used without perforations as a complete overwrap on apples.

Printing

Words or designs can be printed on all three films tested. However, the irradiated polyethylene film required special equipment, and only the manufacturer could do the printing. Local convertors could print on both the polyvinyl chloride and the polystyrene.

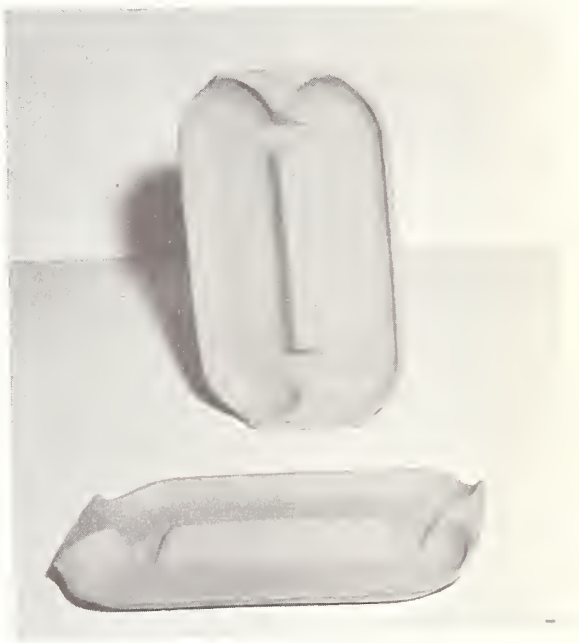
Consumer Trays

The tray available at the time the heat-shrinkable film was introduced was a molded pulpboard tray with raised cones or pyramids to form pockets for the apples (fig. 1). It had been developed by a manufacturer during earlier studies. The sidewalls were 1½ inches high. The tray for six group size 100 apples 3/ measured 9½ by 6½ inches, outside dimensions. The tray for eight group size 125 apples measured 11 3/4 by 5 7/8 inches.

During the study it became apparent that a less expensive, shallower tray would be adequate. One of them had a raised longitudinal divider running down the center of the tray (fig. 2). Eliminating the pockets facilitated group

N-37500

Figure 1.--High-sided pyramid tray for eight apples.



N-37501

Figure 2.--Shallow tray for eight apples with longitudinal divider.

3/ A group size actually includes three sizes of apples--the size which identifies the group, the next size larger, and the next size smaller. Thus, group size 100 apples include size 100 apples, size 88's (the next larger), and size 113's (the next smaller).

sizing of the apples within the tray, because the apples no longer had to be so nearly the same diameter. The shallower tray allowed greater visibility of the apples. The tray sizes used were as follows:

1. Four-unit Delicious or Winesap, sizes 72 to large 80's; size of tray 6 3/4 by 5 5/8 inches. (No commercial tests made with this size of pack.)
2. Six-unit Winesap, group size 100; size of tray 8½ by 5¼ inches.
3. Six-unit Delicious, group size 100 (fig. 3) or eight-unit Winesap, group size 125; size of tray 9½ by 5¼ inches.
4. Eight-unit Delicious, group size 125 (fig. 3), size of tray 11 1/8 by 5¼ inches.

BN-14986

Figure 3.--Sparkling clear polyvinyl chloride film immobilizes these Red Delicious apples and helps reduce bruising in transit.

To reduce or eliminate the distortion of the sidewalls of the tray when it absorbs moisture, a new tray to accommodate group size 100 Delicious or group size 125 Winesap was designed. This tray had a double-folded lip running around the entire tray. It was thought that this lip would hold up better in high humidity. This tray also had the longitudinal divider. The two lengthwise channels were slightly narrower than in the earlier trays. Initial test shipments indicated that these new trays helped maintain a tighter film wrap, and the apples seemed to fit better in the narrower channels.

Master Containers

Master containers were developed to provide a good fit for the six- and eight-unit packages. Because the new shallow trays were more compact than the deep trays, it was possible to pack them in smaller boxes.

The high-sided six-unit trays were packed 15 trays to a box. The master container was a full telescope fiberboard box with inside dimensions of 19 by 15½ by 10½ inches. The packages were packed five per layer (or tier), three layers high. Double-faced corrugated pads were used between layers; no pad was used on top. The eight-unit package was packed in a similar fiberboard box with inside dimensions of 22½ by 11 3/8 by 12 5/8 inches. These packages were packed four per layer and four layers high for a total of 16 packages per box.

The various shallow-tray packages and the full telescope fiberboard master containers used with them were as follows:

1. Trays with six Winesaps were packed five trays per layer, three layers high in boxes with inside dimensions of 18½ by 15 by 10¼ inches. One shipper used these sizes of tray and master container for six size 100 or six size 113 Red Delicious apples.

2. Trays with six Delicious apples were packed four per layer, four layers high in boxes with inside dimensions of 24¼ by 10 1/8 by 13 inches (fig. 4).

BN-14987

Figure 4.--These packaged Delicious apples are ready for shipment. Each box contains four wrapped trays in each of four layers.

3. Trays with eight Winesaps were packed four per layer, four layers high in boxes with inside dimensions of 22½ by 10 1/8 by 12¼ inches.

4. Trays with eight Delicious apples were packed four per layer, four layers high in boxes with inside dimensions of 22 3/4 by 11 3/8 by 12 inches (fig. 4).

Double-faced corrugated pads were placed between layers in all boxes. No top pad was used.

None of the above master containers with corrugated pads between layers protected the softer fleshed Golden Delicious apples from bruising. Various types of cushioning materials were tested but none proved more effective than the corrugated pads. It was then decided to develop a master container with a compartment for each package.

The master container developed for the tray holding six Golden Delicious apples was a full telescope fiberboard box with inside dimensions of 25¼ by 10 1/8 by 13 inches. A "snake" separator, a single length of double-faced corrugated board measuring 75 7/8 by 3 1/8 inches, was used in each layer. When folded inside the box the separator formed four compartments for four packages (fig. 5). A double-faced corrugated pad was placed between the layers.

BN-14988

Figure 5.--Three wrapped trays of Golden Delicious apples have been packed in the top layer of the master container at left. Note separator which forms compartment for each package. In empty compartment at top may be seen corrugated fiberboard pad which forms ceiling for third layer and floor or platform for fourth (top) layer.

The height of the separator was such that the layers above rested on it and did not touch the apples in the layers below. Sixteen packages were packed per box, four per layer, four layers high. A master container of lighter weight can be used with these separators.

Preliminary test shipments of this experimental cell-type container resulted in a substantial improvement in the condition of Golden Delicious apples on arrival. By the time enough new containers became available for a full-scale test, few good quality Goldens were left to pack, so testing was postponed.

In an attempt to reduce the cost of the compartment container, varying thicknesses of chipboard pads were tried in lieu of the corrugated pads. The chipboard pads were not rigid enough and allowed the layers above to press on the layers below, causing bruising even on the hardier Winesaps.

It became evident that by using separators more than one size of apple package could be put in the container; thus inventory requirements would be reduced.

In another attempt to reduce unit costs, a compartmented master container was developed to hold 24 packages instead of 16. It was packed six packages per layer, four layers high. The container was a full telescope fiberboard box with inside dimensions of 20 1/6 by 18 15/16 by 13 1/16 inches. Three upright corrugated strips in each layer formed partitions around six packages. One separator had two notches and measured 18 15/16 by 3 1/8 inches. It supported two single-notch strips each measuring 20 by 3 1/8 inches. Double-faced corrugated pads were used between layers. The theoretical net weight of the pack was 60 pounds. Preliminary test shipments of group size 125 Winesaps reached terminal markets in excellent condition. However, these tests indicated that the separators as designed may fail to give adequate support to the between-layer pads at the corners of the box. Other types of separators will be tested.

Researchers tested three weights of compartmented boxes for 24 packages to determine the minimum strength needed to protect the apples. Even the lightest box performed satisfactorily. The designed bursting strength of its inner case was 200 pounds and of the outer case 175 pounds.

Conventional Tray Packs

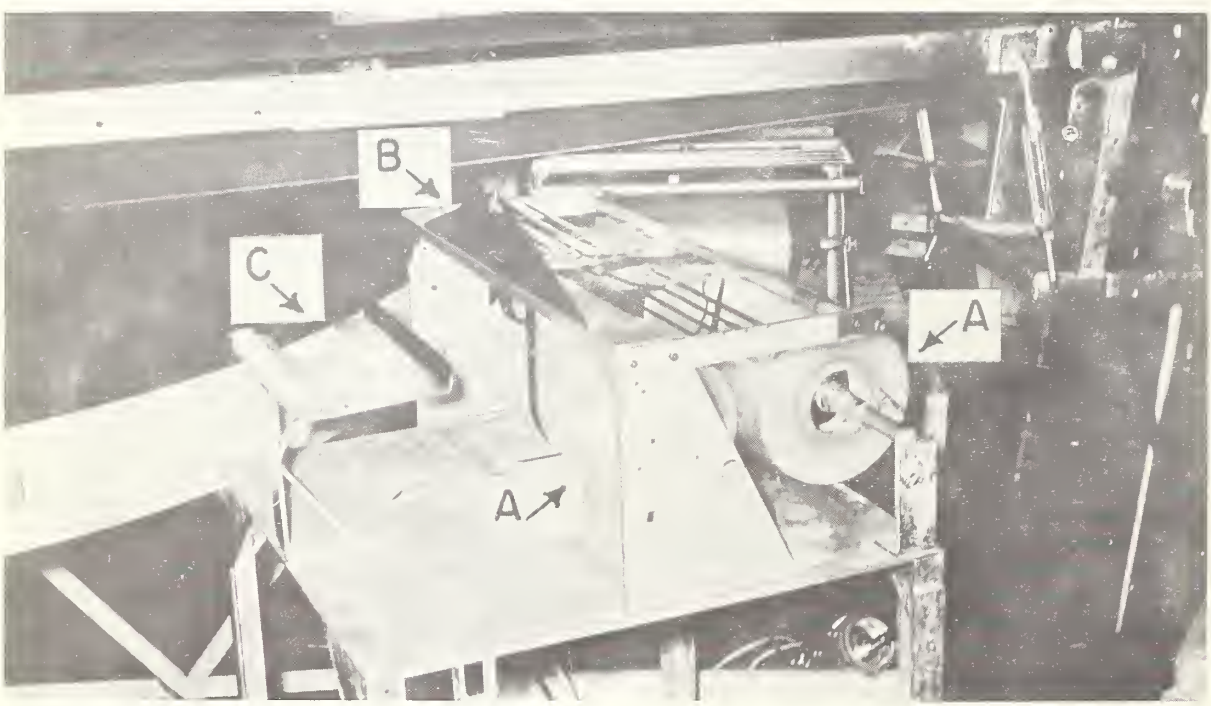
The master container used for the conventional tray pack was a full telescope fiberboard box with inside dimensions of 19 3/4 by 12 by 11 3/4 inches. Molded pulpboard trays with cups, designed to hold the various sizes of apples, were used for each layer in a box. The number of apples per tray and number of trays per box varied with the size of the apples. In this study a complete wrap and pack was evaluated; that is, each apple in the box was wrapped in tissue. Although the method of packing varies in different apple plants, the data in this study apply to the following operations: The fiberboard box was

stitched or stapled, both top and bottom, before the actual packing. The individual packer wrapped and packed the apples in the bottom or inner case and closed the box.

COSTS AND LABOR REQUIREMENTS FOR PACKING APPLES

During the 1959-60 tests two crews filled and wrapped the consumer packages. One crew worked at the tubs, picking out six or eight apples, depending on size, and placing them in the consumer trays. Conveyor belts carried the trays to a station where the other crew wrapped them in film. During 1960-61 the wrapping operation was brought to the tubs so the filling and wrapping could be done by the same worker. Combining the operations allowed greater flexibility in utilizing the workers for either the consumer package or the conventional packs.

Rolls of the shrink-films were inserted in a dispenser. A jig was designed to hold the tray to be wrapped. The film dispenser and jig were mounted on a table, which could be rolled to the tub with apples of the desired size. This table was called the wrapping station (fig. 6). The plants studied used six to twelve of these wrapping stations at a time. Master containers were stapled or stitched and supplied to the crew packing the packages into the box.

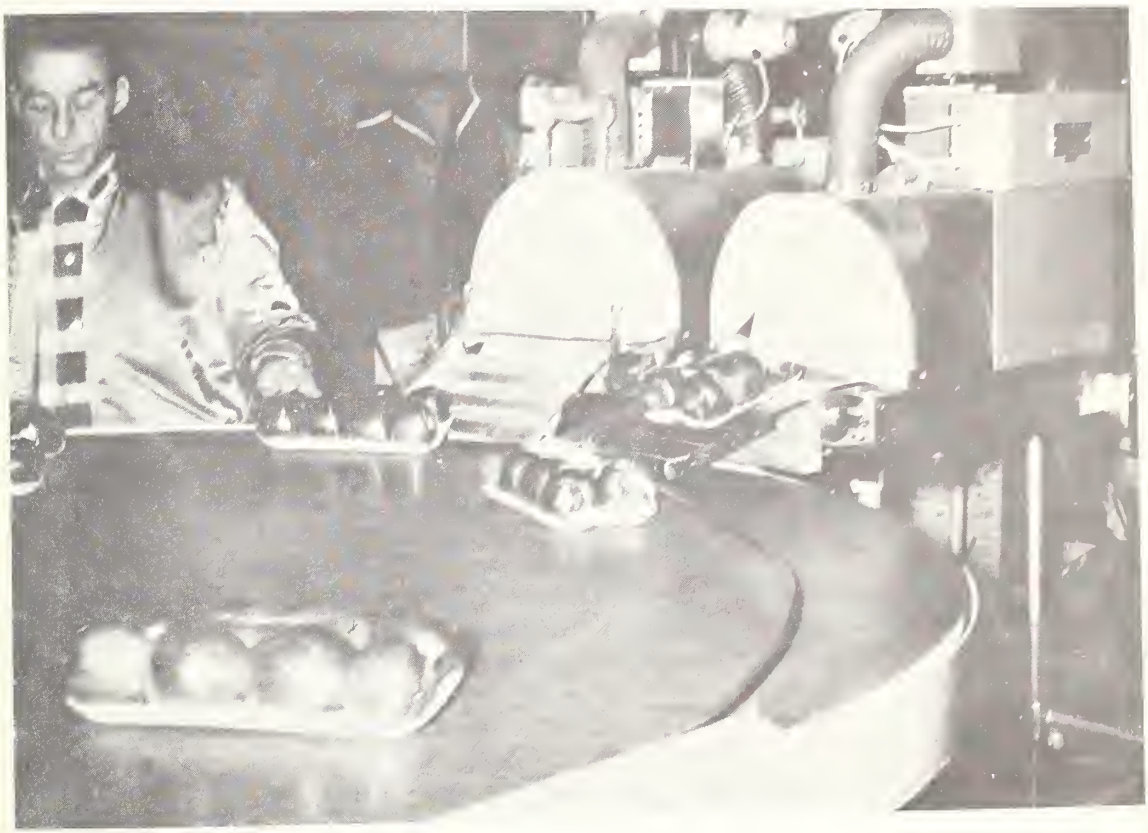


BN-14993-X

Figure 6.--This wrapping station has a dispenser with two rolls of film (A), hot tip cutoff to sever film at desired length (B), and jig on which tray is placed for wrapping (C). One roll of film is for the larger packages and the other for smaller ones.

The operation to package six or eight apples was as follows:

1. Cut the desired length of film and place it on the jig.
2. Place an empty tray on top of the film.
3. Fill the tray with apples.
4. Wrap the filled tray with the film.
5. Remove wrapped tray from the jig and place tray on a belt leading to the hotplate and heat tunnel.
6. Pack wrapped packages in master container (fig. 7).
7. Close master container.



BN-14989

Figure 7.--Revolving table carries trays of apples just emerging from heat tunnels (right) to worker who packs them in master container.

Costs of Materials and Containers

The two films most commonly used by the trade during the 1960-61 season were an irradiated polyethylene and a polyvinyl chloride. The price of the irradiated polyethylene tested was 3.1 cents per 1,000 square inches, 1 mil thick. The price of the polyvinyl chloride tested was 3.4 cents per 1,000 square inches, ½ mil thick. Printing cost was additional.

Widths of the irradiated polyethylene films were 12 inches on the six-unit Winesap package, 13 inches on the six-unit Delicious and eight-unit Winesap packages, and 14.5 inches on the eight-unit Delicious package. The polyvinyl chloride film was a quarter of an inch wider in each instance.

The cost of the molded pulpboard trays used during the 1960-61 season was as follows:

1. Four-unit trays for Winesap and Delicious apples, sizes 72 and 80, $9.52 per thousand; not commercially tested.

2. Six-unit trays for Winesap apples, group size 100, $9.68 per thousand.

3. Six-unit trays for Delicious apples, group size 100, and eight-unit trays for Winesap apples, group size 125, $10.74 per thousand.

4. Eight-unit trays for Delicious apples, group size 125, $13.04 per thousand.

Costs of the experimental packages and their master containers are compared with the cost of the conventional tray pack of tissue-wrapped apples in table 1. The film costs include one-color printing.

Although plain polyvinyl chloride film costs more per unit of surface area than polyethylene, table 1 lists polyvinyl chloride costs below those of polyethylene because it was cheaper to print on the polyvinyl chloride.

The experimental packages in table 1 were included in a number of commercial shipments of Red Delicious and Winesap apples in 1960-61, and the costs are an average of those observed in six packing plants.

The cost of materials required to prepackage and box Red Delcious and Winesap apples was only 0.2 to 0.4 cent a pound higher than the cost of materials for the conventional tray pack.

Table 1.--Costs of containers and packaging materials for standard tray pack of apples and three types of experimental packs of Red Delicious and Winesap apples prepackaged in consumer units, Yakima, 1960-61

Item	Conventional tray pack (42 pounds)	Experimental packs 1/		
		15-6 Winesap Size 100 (38 pounds)	16-6 Delicious Size 100 (40 pounds)	16-8 Delicious Size 125 (40 pounds)
	Cents	Cents	Cents	Cents
Container	31.0	25.5	28.2	27.7
Shipping trays	20.0	---	---	---
Tissue wraps	10.0	---	---	---
Top pad	2.0	---	---	---
Layer pads	---	3.8	5.2	5.4
Unit trays	---	14.5	17.2	20.9
Shrinkable film:				
Polyethylene	---	21.6	25.1	27.2
Polyvinyl chloride	---	16.9	19.1	20.5
Average	---	19.2	22.1	23.8
Total cost: 2/				
Per box	63.0	63.0	72.7	77.8
Per package	---	4.2	4.5	4.9
Per pound	1.5	1.7	1.8	1.9

1/ Experimental packs are identified by two numbers with a hyphen between them; the first is the number of tray packages per master container and the second is the number of apples per package. Apple sizes are group sizes.

2/ Costs of experimental packs based on average film cost, printed in 1 color.

To reduce transit and handling injuries, a more protective pack was developed for the highly perishable Golden Delicious and other soft-fleshed varieties. Each consumer package was isolated from the others by a separator in each layer. The costs of the experimental packages, cushioning materials, and master containers for these experimental packs are compared with those of the conventional tissue-wrapped pack in the cell box in table 2.

Table 2.--Estimated average material costs of the conventional cell pack and the experimental separated pack for prepackaged Golden Delicious apples, Yakima, 1960-61

Item	Conventional cell pack of average size apples (42 pounds)	Experimental packages 1/	
		16-6 separated pack for group size 100 apples (40 pounds)	24-6 separated pack for group size 100 apples (60 pounds)
	Cents	Cents	Cents
Containers	28.0	27.5	33.5
Layer pads 2/	8.2	5.4	7.6
Cell partitions for each apple	32.7	---	---
Separators for consumer packages	---	7.0	11.8
Tissue wraps	10.0	---	---
Polyethylene liner	5.0	4.5	9.0
Consumer trays	---	17.2	25.8
Average cost of polyvinyl chloride and polyethylene film	---	22.1	33.1
Total cost:			
Per box	83.9	83.7	120.8
Per package	---	5.2	5.0
Per pound	2.0	2.1	2.0

1/ Either 16 or 24 consumer packages were packed in the master container; each package held 6 apples, group size 100; and each package was separated from others in the same layer by a strip of corrugated board.

2/ Five pads were used in the conventional pack--three between layers, one on the bottom, one on top. No top or bottom pad was used in experimental packs.

The 60-pound experimental pack with separators cost about the same as the standard cell box on a per-pound basis, and the 40-pound experimental pack was a tenth of a cent higher.

Labor Requirements and Costs

The average labor requirements and the costs to fill and wrap tray packages in film and to pack them in master containers are compared with labor requirements and costs for the conventional tray pack of apples in table 3.

Table 3.--Average labor requirements and costs to pack apples, sizes 88 to 138, in experimental film-wrapped packages and in conventional trays, Yakima, 1960-61 1/

Operation	Labor requirements 2/		Cost 3/	
	Conventional tray pack (42 pounds)	15-6, 16-6 and 16-8 packages (39 pounds)	Conventional tray pack (42 pounds)	15-6, 16-6 and 16-8 packages (39 pounds)
	Man-minutes	Man-minutes	Cents	Cents
Assemble master container	0.28	0.28	0.7	0.7
Position trays, fill and wrap	---	5.42	---	13.6
Tissue-wrap apples, pack, and close box	2.71	---	6.8	---
Pack trays in master container	---	1.50	---	3.8
Close container	---	.16	---	.4
Total:				
Per box	2.99	7.36	7.5	18.5
Per pound	.07	.19	.2	.5

1/ 15 percent has been added for personal time and fatigue.
2/ Average of 2 plants.
3/ At assumed wage of $1.50 per hour.

Packing the film-wrapped packages cost about 0.3 cent more per pound of apples than packing the conventional trays. No difference was noted in labor requirements when different films were used. Labor requirements for dumping, sorting, and sizing are not included because they were the same for either package or tray pack.

At the packing rates observed it would require about 11 one-man filler-wrapper stations to prepackage a carload of apples--830 boxes--in a 7½ hour day. (If the computed labor requirements were duplicated exactly, the 11-station output would be 894 boxes.)

Repeated observations indicated that the output of packages would be much faster if apples of the desired size and grade could be supplied without interruptions. Because of the irregular supply, the workers who performed the combined filling-wrapping operation completed an average of only 2.9 packages per minute. In brief periods of time when the supply of graded and sized apples was ample, some of the more skilled workers filled and wrapped as many as seven trays a minute.

No time studies were made of packing 16 or 24 wrapped trays of apples in the master containers with separators isolating each package, because the quantity of containers available was limited. However, placing the separators would require additional labor. Placing packages in master containers without separators required two workers to handle the output of from six to nine filler-wrapper stations.

Combined Costs for Materials and Direct Labor

Combined costs for materials and direct labor for prepackaging and packing Red Delicious and Winesap apples were from 0.5 to 0.7 cent more per pound than for packing tissue-wrapped apples in the conventional standard tray in 1960-61 (table 4). The amount of the differential depended on the type of film used for the package overwrap. The prepackaging costs were below those of the previous year and work is continuing to reduce them still further.

Table 4.--Cost of material and labor to pack apples in the experimental packages and in the conventional tray pack, Yakima, 1960-61

Item	Conventional tray pack (42 pounds)	Experimental packages, average of size 88 to 138 (39 pounds)	
		Irradiated polyethylene film wraps	Polyvinyl chloride film wraps
	Cents	Cents	Cents
Materials	63.0	74.1	68.3
Direct labor to pack	7.5	18.5	18.5
Total:			
Per box	70.5	92.6	86.8
Per pound	1.7	2.4	2.2
Per package	---	6.0	5.6
Differential per pound 1/	---	+ .7	+ .5

1/ Difference between cost of experimental package and cost of conventional tray pack.

Transportation Costs

Computed transportation charges for conventional tray packs of apples and experimental packs are listed in table 5.

Table 5.--Computed transportation costs of rail shipments of apples from Yakima Valley to New York City in conventional tray packs and in experimental packs at rate of $2.26 per hundredweight, 1960-61

Item	Conventional tray pack	Pack of 15 or 16 packages
Billing weight per box.....pounds.....	46	46
Net weight per box.....pounds.....	42	39
Boxes per car.....number.....	840	830
Gross weight per car.....pounds.....	38,640	38,180
Net weight per car.....pounds.....	35,280	32,370
Cost per car.....dollars.....	873.26	862.87
Cost per pounds of apples.....cents.....	2.48	2.66

Master containers for both the conventional tray and the package packs were billed at 46 pounds per box. The tray pack held 42 pounds of apples and was loaded 840 boxes per car. Master containers used for the packages held from 38 to 40 pounds of apples and averaged about 39 pounds. They were loaded 830 containers per car in mixed shipments which included 16-6 and 16-8 packs (16 packages containing 6 or 8 apples) of Red Delicious, and 15-6 and 16-8 packs of Winesaps. Rail rates from Yakima to New York City were $2.26 per hundredweight, which does not include charges for refrigeration and other protective services.

Table 5 indicates that transportation charges for a shipment of apples in the conventional tray pack were about a fifth of a cent less per pound than for the apples in the packages.

EVALUATIONS AT TERMINAL MARKETS

Eleven test shipments of apples were shipped by rail from Washington State during the 1960-61 season so that experimental materials and containers could be evaluated. Not all test shipments contained the conventional tray pack for comparisons. The apples were inspected upon arrival in eastern markets. Initially, consumer packages were packed 15 or 16 to a box with double-faced corrugated pads between layers. Then, other cushioning materials were evaluated as between-layer pads for the consumer packaged apples. Finally, the newly designed 16-tray consumer pack with sturdy separators isolating each package of extremely perishable Golden Delicious apples was compared with consumer packs with only between-layer pads. The protective capabilities of this 16-tray separated pack and a larger 24-tray separated pack also were observed when used with Winesap apples.

Bruising of Apples

The percentage of bruising found among prepackaged apples in containers with corrugated pads between layers was extremely low. There was no significant difference in bruising by type of shrinkable film used to wrap trays of

the prepackaged apples. Most of the bruises on the prepackaged apples were on the upper parts of the apples.

The low incidence of bruising among the prepackaged apples can be better appreciated when the "very slight" bruises are subtracted. The "very slight" bruises, ¼-inch or less in diameter, do not affect the salability of the apples. "Slight" bruises, ¼ to ½ inch in diameter, are expected by the trade and accepted without question. "Damage by bruising," a flattening of the surface from ½ to 1 inch in diameter, and "serious" bruises, more than 1 inch in diameter, impair salability.

The percentages of bruising in eight test shipments were as follows:

	Percent
Red Delicious, sizes 88 to 138:	
Very slight.....	6.2
Slight.....	2.7
Total bruising	8.9
Winesap, sizes 88 to 138:	
Very slight.....	11.3
Slight.....	3.5
Total bruising	14.8

None of the apples in these eight shipments had damage by bruising or serious bruising.

The ability of the shrinkable films tested to immobilize the apples within the tray was the main reason for the low level of bruising among the prepackaged apples.

Table 6 shows the incidence of bruising found on the prepackaged apples when various types of cushioning materials were used in lieu of the double-faced corrugated pads between layers. The corrugated pads adequately protected Red Delicious and Winesap apples. All other pads tested were more expensive, and with the exception of macerated paper pads, none improved on the corrugated pads.

Table 6.--Condition of consumer packaged Red Delicious and Winesap apples, sizes 88 to 138, by type of layer pad used, on arrival at terminal markets, 1960-61 1/

Variety of apple and type of pad	Amount of bruising				
	Very slight	Slight	Damage	Serious	Total
	Percent	Percent	Percent	Percent	Percent
Red Delicious:					
Corrugated	6.8	2.6	0	0	9.4
Polystyrene foam	8.9	2.1	0	0	11.0
Compressed paper	4.5	3.9	0.4	0.8	9.6
Polyurethane	6.2	4.9	0	.5	11.6
Macerated paper	7.0	2.3	0	0	9.3
Winesap:					
Corrugated	5.1	7.0	0	0	12.1
Wood conversion	5.8	8.2	0	0	14.0
Macerated paper	7.0	0	0	0	7.0

1/ Average of six test shipments.

Table 7 shows that the corrugated and other types of pads did not adequately protect the soft-fleshed Golden Delicious apples. The newly designed master container, with each consumer package isolated from the others by separators that prevented the layers above from touching the layers below, provided excellent protection for the Golden Delicious apples.

It was decided to try the separated boxes with 16 packages containing 8 Winesap apples, group size 125. To reduce costs researchers tested chipboard pads with thicknesses of .020, .030, and .040 inch, and also a separated box holding 24 packages instead of 16.

Table 7 shows that the chipboard pads, regardless of thickness, were not rigid enough to prevent the upper layers from pressing on the apples below. However, when corrugated pads were used between layers and separators in the layers, 16 or 24 packages, each containing 8 Winesap apples, group size 125, could be shipped with minimum bruising in the master containers designed for the larger Golden Delicious apples.

Table 7.--Bruising of group size 100 Golden Delcious and group size 125 Winesap apples, by type of pack at terminal markets, 1960-61 1/

Variety of apples and type of pack	Amount of bruising				
	Very slight	Slight	Damage	Serious	Total
	Percent	Percent	Percent	Percent	Percent
Golden Delicious:					
16-6 with only corrugated pads	18.8	5.7	6.2	1.6	32.3
16-6 with only compressed paper pads	12.2	7.3	6.2	1.4	27.1
16-6 with only macerated paper pads	11.4	10.4	7.3	1.0	30.1
16-6 with corrugated pads and unit separators	5.9	.3	.3	0	6.5
Winesap:					
16-8 with only corrugated pads	12.5	3.6	.1	0	16.2
16-8 with corrugated pads and unit separators	2.9	1.9	.2	0	5.0
16-8 with chipboard pads and unit separators 2/	10.9	5.2	0	0	16.1
24-8 with corrugated pads and unit separators	2.9	1.3	0	0	4.2

1/ One test shipment of each variety.
2/ Average bruising with pads .020, .030, and .040 of an inch thick.

Appearance of Packages at Terminal Markets

The prepackaged apples wrapped in the irradiated polyethylene film or in polyvinyl chloride film were well received by buyers. The packages arrived with fairly tight wraps and the clear film enhanced the appearance of the apples. Generally, researchers and receivers thought the polyvinyl chloride film was clearer than the polyethylene film.

The polyvinyl chloride film arrived with slightly looser film wraps. This loosening of the film, regardless of film type, begins at time of packing. The heat tunnels used are not efficient enough, especially when production is high, to shrink the film on all packages equally. Therefore, some packages have a looser film wrap than others. The handling of the packages when they are packed into the master container can induce wrinkling and loosening of the film, and this may increase during transit. The molded pulpboard trays may wilt and become distorted when absorbing moisture, and thus cause a loosening

of the film wrap. Research shows that handwrapped packages with carefully controlled shrinking and careful packing may arrive in nearly perfect condition. The polyvinyl chloride film, however, did have a tendency to loosen.

Appearance of Packages at Retail Stores

The apples prepackaged in shrinkable films made very attractive and orderly displays at retail. Produce managers liked the films because they had a relatively high coefficient of friction, which kept the packages from sliding when stacked one upon another. The trade commonly terms such films as "tacky" or as having a "low slip" quality. The shallow trays allowed good visibility, and the clear film enhanced the natural beauty of the apples. Many consumers liked the convenience of picking up six or eight apples at a time.

The further handling from terminal point to retail and during display increased the wrinkling and loosening of the film wraps of both types of film.

The polyvinyl chloride film on packages inspected maintained its excellent clarity while in the retail store. However, researchers noticed a tendency of the irradiated polyethylene film to cloud. Clouding occurred only at retail, with its higher temperatures during display, and did not occur on all packages in all shipments. During the 1959-60 season this clouding occurred late in the season on packages of Winesaps, and during 1960-61 it occurred with early Delicious apples. It usually showed up from 2 to 4 days after the apples were put on display. If the packages were held on display long enough the clouding might become severe, making visibility poor. Earlier research indicated that the clouding is a chemical reaction between the irradiated polyethylene film and the esters given off by the apples and only occurs at relatively high temperatures. The shallow, molded pulpboard trays used during the 1960-61 season did not cause as much loosening of the film wrap as the earlier high-sided trays, because there was less pulpboard to become distorted by the moisture.

DISCUSSION

It cost more to prepackage apples than to pack them into the conventional tray packs at shipping point. However, the material and direct labor costs for the shallow, molded pulpboard trays and heat-shrinkable films were substantially less than for previous packages studied. The fact that the output of individual consumer packages averaged only 2.9 per minute was primarily due to an irregular supply of apples of the proper size and grade at the wrapping stations. Presizing the apples--sizing them before putting them into storage rather than as part of the packing operation after their removal from storage--could substantially increase the rate of packing.

Semiautomatic and automatic equipment for wrapping the packages could substantially reduce the labor cost by increasing the speed of wrapping and reduce material cost by consistently using the proper amount of film for each package.

The additional cost of prepackaging apples at shipping point is offset by decreased costs at retail because of less spoilage and less labor and generally less retail expense in handling the consumer units. As a consequence, chain-stores were willing to pay a premium for prepackaged apples.

Each year there is an increasing demand from retailers for prepacked apples. Many retail stores are beginning to realize how much packaging costs them, and they prefer the packaging to be done at shipping point.

During the 1959-60 Washington apple season, about 40 commercial rail shipments of the shrinkable-film packages were made. Fewer shipments were made during 1960-61, primarily because of the short apple crop and correspondingly higher prices for the conventional packs, particularly for Delicious apples. When prices are good, shippers see little need to experiment. However, there were a considerable number of commercial shipments of prepackaged Winesaps. One cooperating shipper had to turn down orders for prepackaged apples because he could not obtain enough Winesap and Golden Delicious apples to fill the orders.

The perfect combination of film, trays, and master container has not been found. Much headway has been made; new developments in trays and master containers during the latter part of the 1960-61 season show promise in helping to solve the problems. The manufacturers of the various materials are altering their products to improve them. Semiautomatic equipment and presizing of apples will be evaluated as soon as possible to determine their effect on increased production and on lowering labor and material costs. However, the materials for and methods of prepackaging apples, as reported in this study, are such that apple shippers can utilize them now and prepare for the increasing demand for the consumer package.

The shrink-films tested have advantages and disadvantages, and new films are becoming available. Differences in sealing ability, in percentage of shrink, in cost of printing, and other factors all require further evaluation to find the best use for each film.

☆ U.S. GOVERNMENT PRINTING OFFICE : 1962 O - 635066