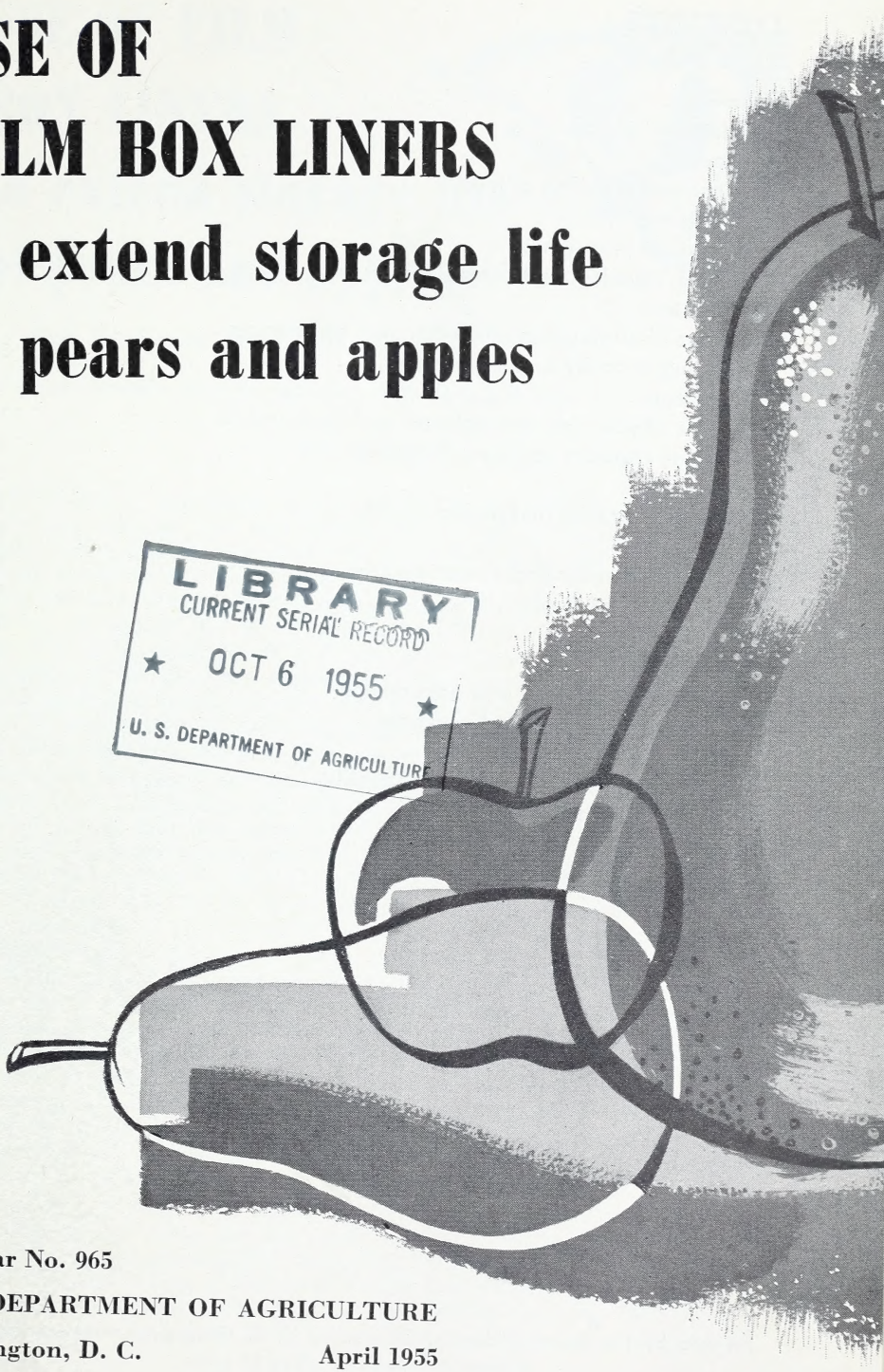
USE OF FILM BOX LINERS to extend storage life of pears and apples



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USE OF FILM BOX LINERS to extend storage life of pears and apples

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SUMMARY

Evidence is presented in this report to demonstrate that the appearance, storage life, and dessert quality of fall and winter pears and Golden Delicious apples can be improved by packing the fruit in certain kinds of sealed film box liners.

Of the films tested, the following may be safely used as sealed liners during storage at 31° F.: Pliofilms 75 FF, 80 and 100 FM1, 80 and 100 HP, cellophane 300 LSAT, and polyethylene 100 and 150. Perforation of the film liner immediately upon removal from cold storage is necessary to avoid injury to the fruit when such films as Pliofilm 75 FF, 80 and 100 HP, and cellophane 300 LSAT are used. The other Pliofilms and polyethylene films are sufficiently permeable to respiratory gases to permit safe handling of the fruit at room temperatures for at least 4 days without perforating the sealed liner. Perforation of all sealed film box liners at shipping point is recommended for packed pears and apples destined for unsupervised handling at retail.

Gas concentrations of 1 to 5 percent CO_2, and of 10 to 18 percent of O_2 were obtained in boxes of pears and apples at 31° F. when various kinds of recommended sealed film box liners were used.

Physiological changes in pears, generally associated with progressive ripening of the fruit in cold storage, were definitely retarded by the use of sealed film liners. The "shelf life" of such fruit when ripened was generally increased several days by this packing procedure. Pears in these sealed films possessed a fresher appearance, a greater freedom from shrivel, and a cold storage life (with normal ripening capacity) of 6 to 8 weeks longer than comparable fruit packed without protection of the sealed film.

Neither the degree of shriveling nor the enhancement of dessert quality in Golden Delicious apples was always reflected by biochemical assay. Visual examination, taste observation, and loss in weight during storage were the best indices of condition, appearance, and dessert quality as related to packaging methods.

Visible shriveling of the fruit occurred when approximately 3 to 5 percent of its original weight was lost during storage. Shrivel was apparent in all Golden Delicious apples packed in both cartons and

wooden boxes without protection of sealed film box liners. Polyethylene film provided the greatest protection against shrivel; paraffined fiberboard liners were ineffective in the prevention of loss in weight of the packed fruit.

The appearance and dessert quality of Golden Delicious apples, especially after prolonged cold storage, were greatly enhanced by packaging in certain sealed films. This fruit had a fresh look, a firm feel to hand pressure, and a delicate, aromatic flavor characteristic of the variety when sampled early in its storage life.

Certain precautions must be taken when pears and apples are packed in sealed film liners. Every effort should be made to use fruit free from surface abrasion and potential fungus infection; it should be washed with an effective fungicide and handled carefully to minimize bruising, as moisture conditions within the sealed package are conducive to the development of decay. Care should be exercised in handling and closing the film box liner.

Commercial use of the sealed film liner for packing pears and Golden Delicious apples has been substantial. Trade acceptance of the packaged fruit has been excellent.

INTRODUCTION

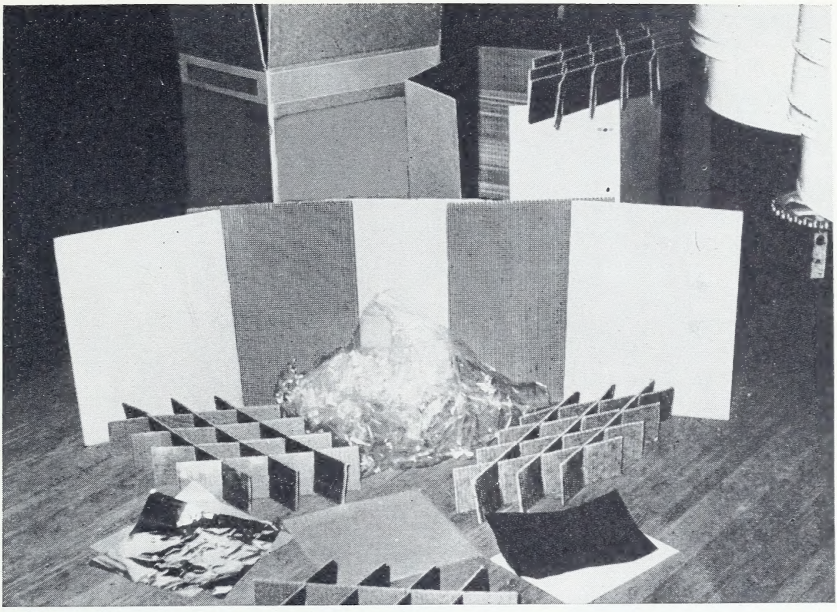
All commercial varieties of fall and winter pears grown in the Pacific Northwest lose their capacity to ripen normally after rather definite periods of storage at 31° F. (*2*).[1] This onset of loss of normal ripening is dependent upon the storage temperature and the maturity of the fruit at harvest. All varieties of pears also lose moisture during extended storage and at relative humidities lower than 90 percent eventually shrivel. The fresh appearance of the fruit is thereby impaired. Methods of packaging pears to extend their storage life and to preserve their appearance and dessert quality are needed to successfully market an increasing tonnage of this fruit.

The Golden Delicious is a variety of apple with skin characteristics that permit relatively large moisture losses and visible shrivel, even during prolonged cold storage at a relative humidity as high as 85 percent. The variety bruises easily, and small surface injuries darken readily and detract greatly from the appearance of the fruit. Notwithstanding these characteristics, the variety possesses an excellent dessert quality, a long storage life, and freedom from most physiological storage disorders. New plantings of this variety in Washington (*8*) during recent years have been 4 to 8 times greater than needed to maintain present tree numbers. An expanding future production of Golden Delicious apples is therefore indicated.

An increasingly larger tonnage of this variety in Washington now receives specialized handling during picking, washing, grading, and packing. Many of the most desirable sizes of fruit are packed in wooden boxes or fiberboard cartons with cupped or cell-type fiberboard separators for the individual apples (figs. 1, 2, 3, 4). Bruising is thereby minimized, but moisture loss and visible shrivel in the fruit during late storage are still very apparent.

This publication presents information developed during the last five years on the packing of pears and apples in various kinds of sealed

[1] Italic numbers in parentheses refer to Literature Cited, p. 28.



N-14451

FIGURE 1.—Showing the component parts of the individual cell-type carton used for packaging Golden Delicious apples.

N-14392

FIGURE 2.—Showing the placement of the plastic liner in the cell-type carton during commercial packing.

N-14452

FIGURE 3.—Showing the fold-over of the plastic liner in a commercial pack of Golden Delicious apples in the cell-type carton prior to sealing. Some colored foil wraps are used to decorate the top layer of fruit.

N-14391

FIGURE 4.—Showing one method of sealing the plastic liner after packing Golden Delicious in the cell-type carton. Film closure can also be made by covered wire twist seal.

plastic films. The influence of these films on the storage condition, ripening capacity, dessert quality, and physiology of the fruit received special attention.

METHODS

Source and Handling of Fruit

Pears and apples of each variety in the tests were picked at optimum maturity from individual trees located in the Wenatchee valley of Washington. The fruit was sorted, composited, and placed in storage at 31° F. on the day of harvest. After 24 to 48 hours of precooling, it was packed in the various experimental sealed films.

Film for pears was used in bag form to fit a special small wooden apple box (8½ x 7¼ x 16 inches I. D.) and as individual fruit wrappers. Approximately 20 pounds of unwrapped fruit was packed in each film-lined box and the film was closed by twist-sealing around a short piece of glass tubing to facilitate withdrawal of air for gas analyses. In the individual stretch-wrapping trials, the heated film was tightly stretched around each pear with a twist seal around the stem. Check lots of pears were packed in oiled wraps in standard wooden pear boxes.

The films for Golden Delicious apples were made into gussetted bag liners to fit either the standard wooden apple box (1948) or the cell-type fiberboard cartons (1951) shown in figures 1, 2, 3, 4. These cartons had either plain or paraffin-waxed corrugated fiberboard liners that strengthened the sides and afforded the fruit added protection against bruising. Film closure in all instances was made by a twist seal as used for pears. The varieties of pears and apples used in this study and information relative to their harvest are given in table 1.

TABLE 1.—*Date of harvest and firmness of pears and apples for specified years*

Variety and year	Date of harvest	Firmness
Pears		
Bartlett:		*Pounds*
1949	Aug. 22	16. 4
1950	Aug. 22	16. 6
1952	Aug. 26	15. 8
Anjou:		
1948	Sept. 21	10. 6
1949	Sept. 31	11. 8
1950	Sept. 13	10. 6
1951	Sept. 17	10. 9
1952	Sept. 22	10. 7
Comice:		
1951	Oct. 3	10. 2
1952	Sept. 25	9. 3
Bosc:		
1952	Sept. 30	11. 8
Apples		
Golden Delicious:		
1948	Oct. 15	15. 5
1951	Oct. 8	15. 3

Films Tested

Pears were packaged in Pliofilms 120P6, 120P4, 75FF, 80 FM1, 100 FM1, 80HP and 100HP; cellophane 300 LSAT; and polyethylene 100 and 150. Golden Delicious apples, in the earlier work of 1948–49, were packaged in cellophanes 450 MSAT, 300 MSAT, 300 LSAT; Pliofilms 120P6, 120P4, and 75FF. In 1951–52 the newer Pliofilms 80 FM1, 80 HP, and 100 HP were used along with polyethylene 150. In most instances these films were used in the form of sealed box liners; when film perforation was tried, four $\frac{1}{16}$ inch openings per liner were made. A fresh supply of the various kinds of film was obtained from the manufacturer each year a particular film was under study.

Analytical Procedures

Carbon dioxide and oxygen in the test packages of pears and apples were determined with a portable Hayes gas analyzer and a Beckman Model D instrument, respectively. Firmness was measured with a Magness-Taylor pressure tester using a $\frac{5}{16}$ inch and $\frac{7}{16}$ inch plunger for pears and apples, respectively, on 3 paired surfaces of 20 fruits. Loss in weight was obtained by weighing the unwrapped fruit before and after treatment. Soluble pectin was determined (as percentage of calcium pectate) in 100 gm. of fresh tissue macerated in a Waring Blender according to unpublished methods of U. S. Department of Agriculture laboratories at Wenatchee, Wash. Respiration values were obtained by absorption of the CO_2 from tared fruits in standard NaOH, precipitation of the carbonate with $BaCl_2$, and titration with 0.3N HCl; they are expressed as milligrams of CO_2 per kilogram of fruit per hour. Aeration during absorption was at the rate of 30 liters per hour of CO_2-free air.

Storage, Ripening, and Dessert Quality

The apples and pears under study were stored at 31° F. and 85 percent relative humidity and ripened at 65° F. in a relative humidity of 85 percent. Visual inspection was made for color change, scald, and core breakdown in pears, and appearance, condition, and storage quality of apples. Measurements of firmness, soluble pectins, and respiration were made on pears and apples and determinations of weight loss were made on apples. Dessert quality (texture and flavor) was judged by a taste panel of 4 people.

BARTLETT PEARS

Storage Physiology, Atmospheres, and Appearance

Many of the data from a study of 10 different kinds of films over a period of 5 years on 4 varieties of pears are condensed; some pertaining to the older types of films are omitted. The primary grouping of the data is by variety.

The soluble pectin content, firmness, and loss in weight are recognized guides for the storage condition of pears. Data in table 2 show

that these indices were favorably influenced when Bartlett pears were packed in sealed films. Soluble pectin formation, loss in weight of the fruit, and softening were retarded by packing in this manner. The longer the interval of storage, the greater was the protection afforded by these films. Weight losses were least in the polyethylene film. The storage condition of the fruit in all of the films was superior to check lots packed in oiled wraps in the standard manner.

Information on the carbon dioxide and oxygen levels encountered in packages of fruit sealed in various films is summarized in table 3.

TABLE 2.—*Influence of different sealed films on certain changes in Bartlett pears at 31° F., by specified days in storage for 1949, 1950, and 1952*

Year, film, and period of storage	Firmness	Soluble pectin	Loss in weight
1949			
Pliofilm (75 FF):	*Pounds*	*Percent*	*Percent*
59 days	15. 0	0. 039	0. 45
99 days	14. 0	. 036	. 71
136 days	13. 1	. 061	. 66
Cellophane (300 LSAT):			
59 days	13. 6	. 036	1. 26
99 days	14. 0	. 037	2. 17
136 days	13. 9	. 060	2. 56
Check standard pack:			
59 days	14. 2	. 080	3. 08
99 days	13. 6	. 091	4. 52
136 days	12. 9	. 110	6. 00
1950			
Pliofilm (80 FM1):			
33 days	16. 6	. 067	. 89
62 days	16. 0	. 066	1. 32
107 days	15. 1	. 089	2. 25
Pliofilm (100 FM1):			
33 days	17. 0	. 062	. 52
62 days	16. 3	. 066	. 86
107 days	15. 3	. 076	1. 34
Polyethylene (150):			
33 days	17. 0	. 062	. 22
62 days	16. 2	. 068	. 32
107 days	15. 9	. 068	. 40
Check standard pack:			
33 days	16. 3	. 067	1. 58
62 days	15. 4	. 066	2. 83
107 days	14. 4	. 141	4. 14
1952			
Polyethylene (100):			
0 days	15. 8	. 046	----------
126 days	13. 3	. 056	----------
160 days	13. 4	. 100	----------
Check standard pack:			
0 days	15. 8	. 046	----------
126 days	12. 0	. 096	----------
160 days	10. 2	. 180	----------

TABLE 3.—*Average percentage concentration of carbon dioxide and oxygen in the atmosphere when Bartlett pears were held in various sealed films*

Film	Gas concentration in sealed films			
	31° F.[1]		65°–70° F.[2]	
	CO_2	O_2	CO_2	O_2
	Percent	*Percent*	*Percent*	*Percent*
Pliofilm—				
75 FF	3. 5	17. 0	10. 0	1. 5
80 FM1	1. 0	16. 0	3. 0	3. 5
100 FM1	2. 0	13. 0	6. 0	2. 0
Cellophane—				
300 LSAT	3. 0	17. 0	13. 0	3. 0
Polyethylene—				
100	2. 5	14. 0	6. 0	2. 0
150	3. 0	17. 0	6. 0	1. 5

[1] During 107 to 160 days of storage.
[2] After 5 days of ripening.

The data are average concentrations obtained from many individual boxes during 3 years of study. The diffusion rate of oxygen and carbon dioxide through all films was sufficiently great at 31° F. to prevent the harmful accumulation of carbon dioxide or the depletion of oxygen. Carbon dioxide accumulated to concentrations of 1 to 3.5 percent and oxygen was lowered to a range of 13 to 17 percent. These concentrations were attained soon after packaging and remained relatively constant as long as the pears were held at 31°.

The respiration of a fruit is a good index of its rate of metabolism. Measurements of this kind were made on Bartlett pears wrapped in oiled paper and sealed in various plastic films. These data are given in figure 5; they show that at 31° F. pears in the sealed films respired at a slower rate than comparable fruit in oiled paper wraps in the standard pack. In other words, the sealed film depressed the general rate of metabolism of the fruit and thereby contributed to a lengthened storage life. The polyethylene film was more efficient in this respect than was the Pliofilm.

Stem shrivel was reduced and the fresh appearance and green color of Bartlett pears in cold storage were markedly preserved by packing the fruit in any of the sealed films shown in table 2. Fruit in oiled wraps when packed in the standard manner usually developed considerable yellow ground color and visible shrivelling in the stem region after prolonged cold storage. Differences in ground color of pears due to packaging methods are shown in figure 6. The preservation of green color, reduction of moisture loss and soluble pectin formation, and a reduced respiration rate indicate that the cold storage life of Bartlett pears was lengthened by packing in any of the sealed films used.

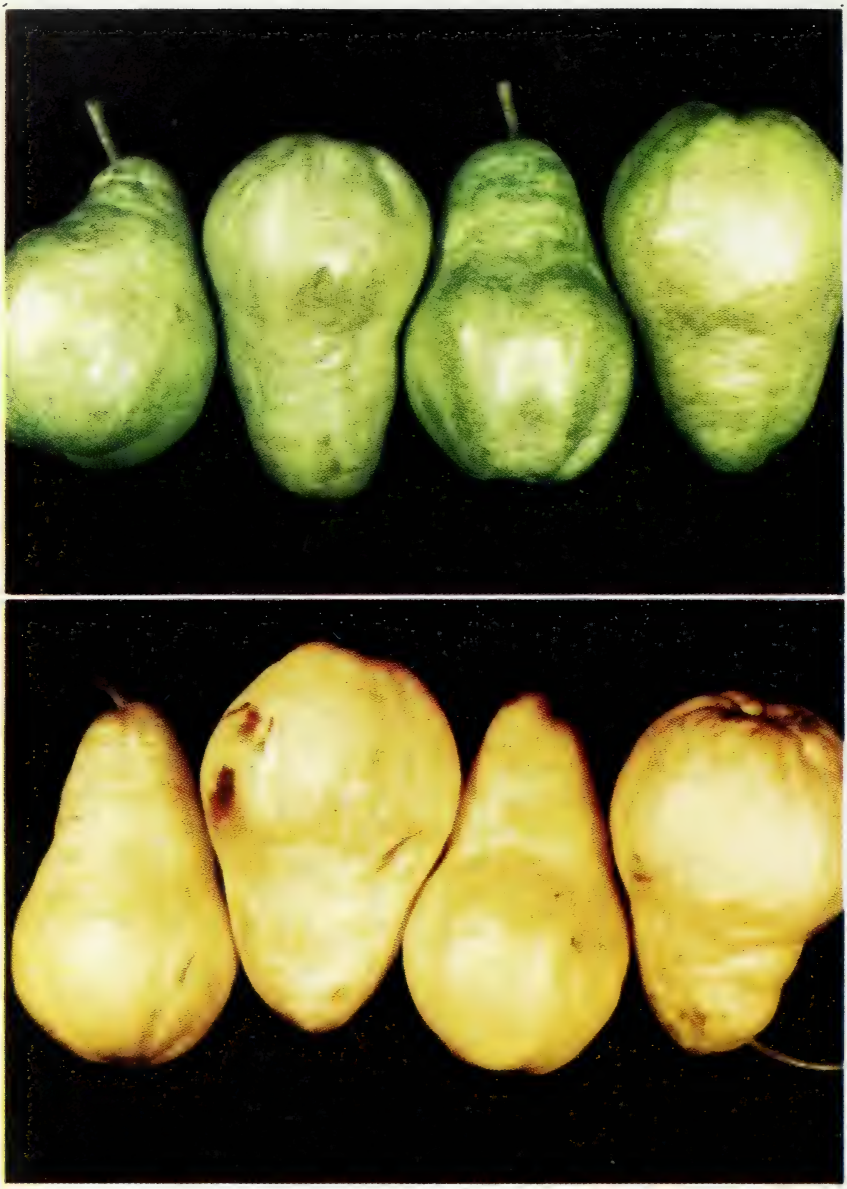


FIGURE 6.—Appearance of Bartlett pears as influenced by packing methods. Top row—oil paper wrapped in standard pack; bottom row—in sealed film (polyethylene 150). Photographed after 107 days at 31° F. and 2 days at 65°.

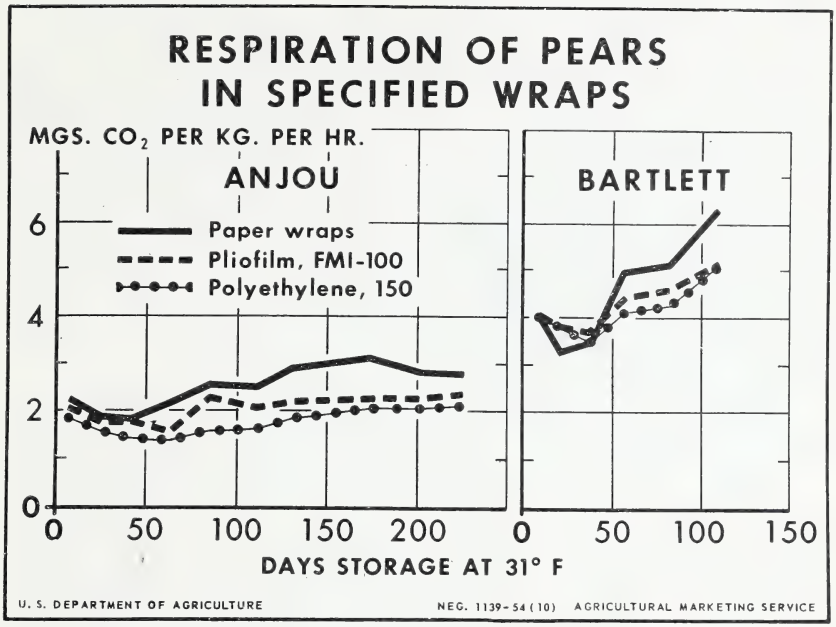


FIGURE 5.—Respiration of pears in sealed film and in paper wraps.

Ripening Capacity and Dessert Quality

Data on the ripening of Bartlett pears at 65° F. in various kinds of sealed film are summarized in table 4. The practice of ripening pears in sealed film is fraught with danger of destruction of flavor and discoloration of tissue as a result of possible injurious accumulation of carbon dioxide and a depletion of oxygen. To establish the length of time that the ripening fruit can be held in the sealed films at 65° without injury to the fruit, seals were broken after various periods of ripening. Carbon dioxide and oxygen concentrations after 5 days of ripening varied from 3 to 13 percent and from 1.5 to 3.5 percent respectively for the different films (table 3). These concentrations of CO_2 and O_2 for the first 4 to 7 days following removal of the pears to the ripening room were not injurious to normal ripening provided the previous period of cold storage was not too long (table 4). Rapid ripening of pears is generally desired at most terminal markets and can be obtained even with film-sealed fruit by immediate perforation of the film. The margin of safety of 4 to 7 days of ripening under seal should provide ample time to handle pears at wholesale and retail without serious danger to dessert quality.

Bartlett pears when packed in the conventional manner usually have a maximum storage life at 31° F. of 70 to 85 days. Data in table 4 show that this period can be considerably extended by packaging in any of the sealed films used. For instance in 1950, pears in the sealed film ripened satisfactorily after 107 days of cold storage, whereas those stored this long in the conventional pack never ripened to acceptable dessert quality, but remained granular in texture, and developed scald and core breakdown before obtaining acceptable dessert quality.

TABLE 4.—*The ripening of Bartlett pears following storage in sealed films for specified days, 1949, 1950, and 1952*

Year, film and period of storage	Period ripened under seal	Period to acquire optimum dessert quality	Additional period of acceptable dessert quality
1949			
Pliofilm (75 FF):	*Days*	*Days*	*Days*
59 days	5	9	4
99 days	5	9	4
136 days	5	7	[1] 2
Cellophane (300 LSAT):			
59 days	5	9	4
99 days	5	9	3
136 days	5	7	[1] 2
Check standard pack:			
59 days	0	5	1
99 days	0	[2] 5	[2] 0
136 days	0	[2] 5	[2] 0
1950			
Pliofilm (80 FM1):			
62 days	4	6	3
	7	8	7
107 days	4	6	2
	7	7	1
Pliofilm (100 FM1):			
62 days	4	7	7
	7	9	3
107 days	4	7	5
	7	7	[1] 0
Polyethylene (150):			
62 days	4	6	3
	7	10	4
107 days	4	6	3
	7	10	4
Check standard pack:			
62 days	0	5	2
107 days	0	[2] 5	[2] 0
1952			
Polyethylene (100):			
126 days	0	5	1
	2	7	2
	5	[1] 9	[1] 0
160 days	0	5	1
	2	7	1
	5	[1] 0	[1] 0
Check standard pack:			
126 days	0	[2] 4	[2] 0
160 days	0	[2] 2	[2] 0

[1] Either a sharp acid taste, abnormal flavor or tissue discoloration due to CO_2 injury.

[2] Showed scald, loss of normal ripening capacity, poor texture and flavor or core breakdown during ripening.

In 1952 the first withdrawal for ripening was made after 126 days of previous cold storage to determine the protective value of sealed polythylene film in prolonging the storage life of Bartlett pears. Fruit in the standard pack was almost full yellow in color, hard, moderately shrivelled, with a trace of pear scald upon removal from 31° F.; those in the sealed films were light green in color, fresh in appearance, and free from pear scald. Pears in the standard pack scalded badly and developed severe core breakdown in 4 days without ever attaining acceptable dessert quality. Those in the sealed film ripened with a juicy texture and a good dessert flavor. The latter lots ripened with fair texture and fair flavor even after 160 days of cold storage but the shelf life of the ripened fruit was short and the dessert quality was distinctly inferior to that of pears ripened after 126 days at 31°.

With an accepted cold storage life of 80 days for Bartlett pears in the standard pack, the sealed film lengthened the storage period by approximately 7 weeks during which the fruit could be withdrawn and ripened with good dessert quality. The shelf-life of the ripened pears (table 4) was usually extended by several days in those lots of fruit which had been packaged in sealed film during prior cold storage.

ANJOU PEARS

Storage Physiology, Atmospheres, and Appearance

Data on the firmness, soluble pectin content, and loss in weight of Anjou pears at different intervals of cold storage when packed in various sealed films and in oiled wraps are shown in table 5. Some experiments were made in 1949 to compare the protection afforded the fruit when a film was folded over the top of the pear pack instead of sealed; tests also included trials of stretch wrapping the fruit in Pliofilm 75 FF.

The sealed films always provided greater protection for the fruit than did either the "fold-over" or stretch wrap. The degree of softening and the percentage of soluble pectin of the fruit at 31° F. in folded film liners and in stretch wraps approached that of the check lot; but these procedures did afford the fruit some protection against loss of moisture. The storage condition of the pears in all of the sealed films, as shown in table 5, was superior to that of the fruit in oiled wraps in the standard pack; soluble pectin formation was approximately one-half, and moisture loss was only a small fraction, of that of the fruit in the standard pack. The polyethylene films afforded the greatest protection against shrivel.

Data on the carbon dioxide and oxygen levels in the atmosphere in the packages are given in table 6. Some of the earlier Pliofilms (120P6 and 120P4) studied in 1948 were nearly impervious to diffusion of the respiratory gases and tissue discoloration and flavor destruction in the Anjou pear resulted from their use. The heavy duty Pliofilm 100 HP also had a low gas transfusion rate and its use as sealed liners may result in injury to flavor of the Anjou pear (see later discussion of dessert quality). These films can be safely used when perforated but then the benefit from controlled atmosphere storage is lost. The 75 FF, 80 and 100 FM1 Pliofilms, 300 LSAT cellophane, and 100 and

TABLE 5.—*Influence of different sealed, fold closed, and stretch wrapped films on certain changes in Anjou pears at 31° F., by specified days in storage, 1949, 1950, and 1952*

Year, film and period of storage	Firmness	Soluble pectin	Loss in weight
1949			
Pliofilm (75FF):	*Pounds*	*Percent*	*Percent*
140 days	11. 2	0. 069	1. 02
189 days	10. 7	. 071	1. 04
189 days [1]	7. 7	. 126	2. 40
189 days [2]	8. 7	. 106	2. 10
Cellophane (300 LSAT):			
140 days	10. 8	. 060	1. 60
189 days	10. 5	. 075	1. 89
189 days [1]	7. 9	. 130	3. 00
Check standard pack:			
140 days	8. 5	. 076	3. 16
189 days	7. 8	. 123	3. 95
1950			
Pliofilm (80 FM1):			
152 days	9. 8	. 073	2. 40
214 days	7. 6	. 100	3. 40
Pliofilm (100 FM1):			
152 days	11. 1	. 069	1. 37
214 days	9. 4	. 100	1. 99
Polyethylene (150):			
152 days	11. 2	. 070	. 16
214 days	9. 7	. 090	. 21
Check standard pack:			
152 days	9. 0	. 075	3. 71
214 days	7. 3	. 160	5. 63
1952			
Polyethylene (100):			
0 days	10. 7	. 091	----------
216 days	8. 6	. 135	. 34
Check standard pack:			
0 days	10. 7	. 091	----------
216 days	6. 3	. 238	5. 94

[1] The bag-formed film liners were folded over top rather than sealed.
[2] Individual fruits were encased in stretch-wrap film.

150 polyethylene films all provided atmospheres with 1 to 3 percent of CO_2 and 14 to 18 percent of O_2 when used at 31° F. as sealed films for Anjou pears. These concentrations of gases were satisfactory, were established early in storage, and remained relatively constant thereafter.

The appearance of Anjou pears at 31° F. in all of the sealed films noted in table 7 was distinctly superior to that of comparable fruit packed in the standard manner. The former were fresh, firm, dark green in color, and free from visible shrivel. Anjou scald as shown in figure 7, was much less pronounced in the late-stored fruit in the stretch-wrapped film than in that in oiled wraps.

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FIGURE 7.—Showing Anjou pears after removal from 31° F. on February 7, 1950, and ripening at 65° for 4 days. Top row—wrapped in plain paper. Bottom row—stretch-wrapped in Pliofilm 75 FF. Note difference in Anjou scald between the two lots.

TABLE 6.—*Average percentage concentration of carbon dioxide in the atmosphere when Anjou pears were held in various sealed films*

Film	Gas concentration in sealed films			
	31° F.[1]		65°–70°	
	CO_2	O_2	CO_2	O_2
	Percent	*Percent*	*Percent*	*Percent*
Pliofilm—				
120 P6	9. 0	10. 0	[2] 16. 0	0. 0
120 P4	6. 0	14. 0	[2] 15. 0	0. 0
75 FF	3. 0	15. 0	[2] 5. 0	4. 0
80 FM1	1. 0	18. 0	[3] 3. 0	6. 0
100 FM1	1. 5	14. 0	[3] 4. 0	6. 0
80 HP	4. 0	12. 0	[3] 15. 0	0. 0
100 HP	4. 0	6. 0	[3] 16. 0	0. 0
Cellophane—				
300 LSAT	1. 0	18. 0	[2] 9. 0	2. 5
Polyethylene—				
100	1. 5	14. 0	[3] 7. 0	1. 0
150	1. 5	17. 0	[4] 8. 0	1. 0

[1] During 189 to 216 days of storage.
[2] After 5 days of ripening.
[3] After 4 days of ripening.
[4] After 7 days of ripening.

TABLE 7.—*The ripening of Anjou pears following storage in sealed film for specified days, 1949–52*

Year, film, and period of cold storage	Period ripened under seal	Period to acquire optimum dessert quality	Additional period of acceptable dessert quality
1949			
Pliofilm (75 FF):	*Days*	*Days*	*Days*
140 days	5	12	4
189 days	5	10	4
Cellophane (300 LSAT):			
140 days	5	12	4
189 days	5	12	4
Check standard pack:			
140 days	0	8	2
189 days	0	[1] 9	[1] 0
1950			
Pliofilm (80 FM1):			
152 days	4	8	4
	7	8	5
214 days	4	7	5
	7	7	5
Pliofilm (100 FM1):			
152 days	4	8	7
	7	9	9
214 days	4	10	3
	7	10	5
Polyethylene (150):			
152 days	4	8	9
	7	10	7
214 days	4	10	5
	7	11	2
Check standard pack:			
152 days	0	8	4
214 days	0	[1] 7	[1] 0
1951			
Pliofilm (80 FM1):			
199 days	0	7	5
	4	9	8
Pliofilm (80 HP):			
199 days	0	7	5
	4	[2] 9	[2] 8
Pliofilm (100 HP):			
199 days	0	7	5
	4	[2] 9	[2] 8
Polyethylene (150):			
199 days	0	7	5
	4	9	8
Check standard pack:			
199 days	0	[1] 10	[1] 0
1952			
Polyethylene (100):			
169 days	2	6	6
	4	7	7
216 days	2	5	4
	4	5	4
Check standard pack:			
169 days	0	[1] 6	[1] 0
216 days	0	[1] 6	[1] 0

[1] Loss of normal ripening, granular texture, shrivel, surface scald, poor dessert.
[2] Distinct lack of true varietal flavor but no tissue injury or flavor suggestive of anaerobic conditions.

Data in figure 5 and table 8 show that the respiratory rate of Anjou pears, while in cold storage and during the first few days of ripening, was significantly lowered by packaging in sealed films. Data in figure 5 were obtained from the fruit while in sealed film; those in table 8 were developed from fruit whose film had been removed 48 hours prior to measurement of respiration and therefore reflect the residual effect of previous packaging methods. The polyethylene film was more effective in lowering respiratory activity than was the Pliofilm. These data, together with those on soluble pectin formation, afford specific evidence that the physiology of both Bartlett and Anjou pears can be favorably influenced by packaging the fruit in sealed films.

TABLE 8.—*Respiration of Anjou pears at 31° and 70° F. as influenced by packaging in sealed polyethylene film*

Date	Storage temperature	Days in storage	Respiration of fruit, CO_2/Kg. per hour		Condition and dessert quality
			Sealed polyethylene (A) [1]	Standard pack (B)	
1953	*Degree F.*	*Number*	*Milligrams*	*Milligrams*	
Mar. 17	31	176	2. 9	3. 8	Both lots of fruit hard, light green.
Apr. 13	31	203	2. 8	3. 7	Both lots hard, (B) more yellow color than (A).
Apr. 14	70	1	21. 8	32. 3	Lot (B) softer and lighter green than lot (A).
Apr. 15	70	2	25. 5	37. 0	Same difference between lots as above.
Apr. 16	70	3	29. 2	36. 2	Both lots softening, considerable pear scald.
Apr. 17	70	4	37. 1	36. 5	Both lots almost eating ripe.
Apr. 18	70	5	35. 0	35. 3	(A) Excellent dessert (B) poor dessert, granular.
Apr. 20	70	7	31. 9	35. 3	(A) Excellent dessert (B) mealy, poor dessert.
Apr. 23	70	10	31. 4	33. 7	(A) Excellent dessert (B) mealy, core breakdown.
Apr. 25	70	12	[2] 35. 8	[3] 40. 0	Blue mold decay in both lots.

[1] Fruit removed from sealed film 48 hours prior to respiration measurements.
[2] Mealy, slight amount of decay.
[3] Mealy, severe internal breakdown, considerable surface decay.

Ripening Capacity and Dessert Quality

Information on the ripening behavior and dessert quality of Anjou pears previously stored in sealed films is presented in table 7. The results from ripening follow a pattern similar to that for the Bartlett variety. All of the sealed films definitely prolonged the normal

storage life of the fruit (period during which it could be removed from 31° F. and ripened with excellent texture and flavor). Anjou pears packed in the standard manner usually fail to ripen with the desired juicy, luscious texture after approximately 175 to 185 days of cold storage (March 15). In 1950 and 1952 (table 7), it was possible to obtain such a dessert quality in film-packed fruit after 214 to 216 days of cold storage (about May 1). In some commercial trials, even this period was lengthened. Fruit in a standard pack after such a long storage period has considerable scald, shrivel, and yellowish-green color at 31° F. and generally develops a mealy texture and core breakdown without attaining prime dessert quality. The use of sealed films increased the storage life of Anjou pears approximately 6 to 8 weeks.

Although it is strongly recommended that all sealed films be opened before placing the fruit at ripening temperature, the data in table 7 show that there is a margin of safety of several days for all of the sealed films except Pliofilm 80 and 100 HP. In these films, varietal flavor was definitely inferior when the fruit was ripened in sealed film for 4 days.

In most instances where direct comparison is possible in table 7, the shelf life of the ripened film-packed pears was several days longer than that of comparable fruit in the standard pack. This is evidence of the residual effect sealed films have on the metabolism of the fruit.

COMICE PEARS

Ripening Capacity and Dessert Quality

Comice pears have a shorter storage life than the Anjou variety: the former usually ripen with an inferior dessert quality after the middle of January. Tests of the packing of Comice pears in sealed film were limited to Pliofilm 80 FM1 and polyethylene 100 and 150.

Comice pears in sealed films of Pliofilm 80 FM1 and in polyethylene 150 were much greener in color and more turgid than comparable fruit in the standard pack when removed from 31° F. on March 19, 1952. Fruit stored without film protection failed to ripen normally, remained hard, scalded badly, and developed 100 percent core breakdown in 8 days at 65°. Comparable lots in both of the above sealed films, when opened immediately upon removal from 31°, ripened normally in 8 days. Such fruit was juicy, free from scald, and of good dessert quality; it maintained an acceptable flavor for 3 additional days at 65°. It was not possible, however, to hold Comice pears at 65° in these sealed films for 4 days in March without destruction of flavor and the appearance of core breakdown.

In 1953, Comice pears in the conventional pack and in sealed polyethylene 100 film were removed from 31° F. on January 6 (106 days) and on March 10 (160 days) and ripened at 65°. Only a few fruits in the standard pack ripened satisfactorily at the first withdrawal; those packaged in the sealed film, opened either immediately or after 2 and 4 days at 65°, developed excellent texture and flavor in 6 days. They were of excellent dessert quality for 5 additional days.

At the second withdrawal (160 days), fruit in the standard pack showed some scald and considerable shrivel upon removal from 31°

F. Because of scald and core breakdown, this fruit was discarded without attainment of an acceptable dessert quality. Comice in sealed polyethylene 100 was free from scald, but only approximately 50 percent ripened normally in 6 days; 28 percent developed core breakdown without the prior attainment of normal ripening, and 22 percent remained hard without the appearance of either scald or core breakdown.

These results indicate the appearance and ripening capacity of Comice pears can be improved by storage in sealed Pliofilm 80 FM1 and polyethylene 100. A cold storage period of 160 days, even with the added protection of the sealed film, is too long to always insure acceptable dessert quality in this variety upon ripening. Probably 4 to 6 weeks' extension of storage life can reasonably be expected by packing Comice pears in the above sealed films.

BOSC PEARS

Ripening Capacity and Dessert Quality

Bosc pears have even a shorter cold storage life than the Comice variety; they usually lose their capacity to ripen normally by the last of December. Information on the packing of this variety in sealed film is limited to the use of polyethylene 100 in the 1952 season.

Bosc pears packed in the standard manner and in sealed polyethylene 100 film were stored at 31° F. for 98 and 161 days before removal for ripening. After 98 days, fruit in the standard pack was considered eating ripe after 8 days at 65° and had a normal flavor, but because of very granular texture, it was of poor dessert quality. Its loss of normal ripening capacity was apparent at that time. Comparable fruit in the sealed film (opened immediately, or after 2 and 4 days at 65°) was eating ripe in 8 days and had a good flavor, juicy texture, and a dessert quality that was greatly preferred to that of the standard pack. The lot opened immediately after removal from cold storage maintained an acceptable dessert quality during 7 additional days at room temperature.

At the second withdrawal for ripening on March 10, 1953, after 161 days at 31° F., fruit in the standard pack had completely lost its capacity to ripen. It remained hard and granular in texture without the attainment of acceptable dessert quality. Bosc pears in the sealed film softened, but developed only a limited juicy texture in 8 days of ripening. While flavor was normal, their dessert quality was inferior to comparable pears ripened in January. These storage and ripening studies indicate that Bosc pears cannot be stored as late as March and still develop good dessert quality, even though they are stored in sealed polyethylene. Probably the storage life can be extended 4 to 6 weeks by packing this variety in sealed polyethelene film.

GOLDEN DELICIOUS APPLES

Earlier Studies

Most of the synthetic films available in 1948 for packing Golden Delicious apples in sealed box liners injured either the dessert quality

or the appearance of the fruit. Data for these earlier studies are summarized in table 9. This information is presented to emphasize the hazards encountered in packing apples in sealed films unadapted for such purpose. Fruit in the MSAT cellophanes and 120P4 and P6 Pliofilms was injured even during storage at 31° F. Because of the low permeability of these films, carbon dioxide concentrations of 15 to 24 percent were present in containers of apples sealed in these films. The fruit in these films was severely injured, was soft, discolored (black), and possessed a foul odor. Cellophane 300 LSAT and Pliofilm 75 FF did not injure the appearance or flavor of fruit in cold storage; flavor of such apples was, however, somewhat impaired when ripened for 7 days with seals intact.

Golden Delicious apples packed in all of the sealed films lost less weight than comparable fruit packed in the standard manner. Prevention of shrivel, however, at the expense of impairment of flavor is not advisable. Data in table 9 show that sealed cellophane 300 LSAT and Pliofilm 75 FF did restrict moisture loss from the fruit during cold storage without injury to its dessert quality. These films should be perforated when the fruit is removed to room temperature. None of the other films in table 9 should be used for Golden Delicious apples at any temperature without perforation.

Later Studies

Storage Physiology and Appearance

In 1951, Pliofilm 80 FM1, 80 HP, 100 HP, and polyethylene 150 were used as sealed box liners for Golden Delicious apples packed in cell-type fiberboard cartons as shown in figures 1, 2, 3, 4. Some lots of fruit were also packed in plain fiberboard cartons without film protection, others in waxed fiberboard, and some in the standard wooden apple box.

Data relative to certain physiological changes and condition of Golden Delicious apples in the various test packages are shown in table 10. The values for firmness and soluble pectin suggest that packaging methods did not influence, to a measurable degree, the softening of the fruit during storage at 31° F. The data indicate that Golden Delicious apples previously held in the various sealed films respired at a lower rate during cold storage than did comparable fruit without film protection. Loss in weight and the degree of shrivel were, however, markedly altered by packaging procedures. Apples in plain and paraffined fiberboard cartons lost about 5 percent moisture, those in the standard pack lost 3.61 percent, and those in sealed polythylene lost the least weight (1.94 percent).

When examined immediately upon removal from cold storage, fruit in the standard wooden apple boxes and in the cell-type cartons with either plain or paraffined corrugated fiberboard liners showed severe shrivel. This fruit had a "punky" feel to hand pressure; turgidity of the flesh tissue was low; it had a tough texture and possessed a strong varietal aromatic flavor usually associated with an advanced degree of ripeness.

TABLE 9.—*Influence of various sealed films on Golden Delicious apples during storage and ripening*

Film [1]	Stored at 31° F. until April 2, 1949				Ripened 7 days at 65° F.[2]			
	Loss in weight	CO_2 in packed box	Firmness	Condition and flavor	Total loss in weight	CO_2 in packed box	Firmness	Condition and flavor
	Percent	*Percent*	*Pounds*		*Percent*	*Percent*	*Pounds*	
Cellophane—								
450 MSAT	1. 21	20. 0	10. 5	Tissue injury—poor	1. 33	18. 0	9. 7	Tissue injury—poor.
300 MSAT	1. 40	15. 0	10. 5	Tissue injury—poor	1. 60	14. 5	9. 4	Tissue injury—poor.
300 LSAT	1. 96	4. 5	10 9	Excellent—normal	3. 02	16. 0	9 7	Tissue injury—impaired.
Pliofilm—								
120 P6	. 64	24. 0		Tissue collapse—poor				
120 P4	. 41	20. 0		Tissue collapse—poor				
75 FF	1. 42	3. 0	10 7	Excellent—normal	3 44	6. 0	9. 6	Excellent—slightly impaired.
Check standard pack	3. 89		10. 4	Shrivel—normal	5. 85		9. 0	Severe shrivel—normal.

[1] Used as gussetted bag liners and sealed around unwrapped fruit packed in standard wooden apple boxes.
[2] With sealed films intact.

TABLE 10.—*Changes in Golden Delicious apples during storage at 31° F. as influenced by type of package, April 1952*

Container, film, and liner [1]	Loss in weight	Soluble pectin	Firmness	Visible shrivel	Respiration of fruit, CO_2 Kg. per hour
Cell carton					
Plain fiberboard:					
Pliofilm—	*Percent*	*Percent*	*Pounds*		*Milligrams*
80 FM1	2. 96	0. 190	10. 8	No	3. 60
80 HP	2. 41		10. 9	No	
100 HP	2. 35	. 190	11. 1	No	3. 43
Polyethylene 150	1. 94	. 168	10. 8	No	3. 44
No film	4. 60	. 168	10. 1	Yes	4. 60
Waxed fiberboard:					
No film	5. 00	. 174	10. 0	Yes	
Check standard pack:					
Plain paper, no film	3. 61	. 168	10. 2	Yes	4. 45

[1] Used as gussetted bag liners and closed around the packed fruit by twist-seal. Corrugated fiberboard inserts to add rigidity and strength to the carton.

Golden Delicious apples in the cell-type cartons protected by the various sealed films indicated in table 10, were similar in texture, flavor, and appearance. The fruit was turgid, firm to hand pressure, and fresh in appearance, had a preferable light greenish-yellow cast to its golden color, and was free from lenticel prominence. None of the fruits were shriveled; all had a crisp, juicy, crunchy texture. They possessed a delicate, slightly acidic aromatic flavor commonly associated with the taste of Golden Delicious apples early in the storage season. All of the plastic films listed in table 10 gave equally good storage protection when used as sealed liners. The appearance, condition, and dessert quality of such fruit was always far superior to comparable fruit held without protection of the sealed film when taken from cold storage in April.

Atmospheres in Sealed Packages

Data relative to the carbon dioxide and oxygen concentrations in the sealed boxes of test fruit are given in table 11. At 31° F., these levels ranged from 2 to 5 percent and from 10 to 15 percent for CO_2 and O_2, respectively. These concentrations were established early in the storage period and remained relatively unchanged thereafter. During ripening of the fruit in sealed film after removal from cold storage, carbon dioxide accumulated and oxygen decreased rapidly. Oxygen was absent in the sealed Pliofilm 100 HP container after 2 days at 65° and only 1.5 percent was present in the polyethylene film after 3 days (table 11). As will be shown later, only Pliofilm 100 HP produced atmospheres injurious to the dessert quality of the fruit. All other types of sealed films gave a margin of safety of at least 4 days in the handling of Golden Delicious apples in sealed film at room temperatures. It is recommended, however, that all films be

perforated during unsupervised handling at room temperature to avoid possible injury to the fruit.

Decay in Sealed Packages

Decay is always a hazard during the prolonged storage of apples. When fruit is packed in any of the sealed films with low moisture transmission rates, the decay problem can be intensified. This is especially true in the packing of apples with an unsuspected orchard infection of perennial canker. The author has observed as high as 16 percent decay in such cases. Only sound fruit washed with an effective fungicide and from orchards of good previous storage history should be packed in sealed liners. In limited commercial experience, the appearance of certain lots of unwashed but wiped Golden Delicious apples packed in sealed film was impaired because of excessive growth of a surface mold (fig. 8). This fungus did not affect the keeping quality or taste of the fruit. Its removal from the surface of the fruit was difficult because of the sticky nature of the fungus. Comparable fruit washed with an effective fungicide and packaged in a similar film presented an excellent appearance after storage.

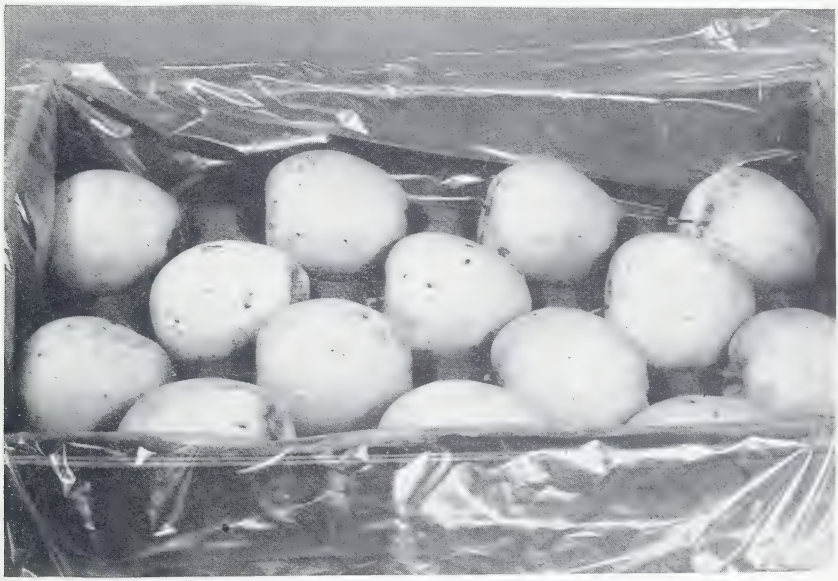

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FIGURE 8.—Showing the impaired appearance and presence of a dark surface mold on unwashed Golden Delicious apples at 31° F. when packed in sealed polyethylene 150.

Ripening Capacity and Dessert Quality

The condition, appearance, and dessert quality of Golden Delicious apples packaged in the films listed in table 10 were studied during ripening at 65° F. To establish the margin of safety in the handling of the fruit in sealed film liners during simulated retail marketing,

TABLE 11.—*Percentage of carbon dioxide and oxygen in cartons in Golden Delicious apples during storage and ripening when packaged in sealed liners of various films, 1951–52*

Film	In storage at 31° F.						185 days at 31° F. and ripened at 65° F. in—							
	71 days		135 days		183 days		1 day		2 days		3 days		4 days	
	CO_2	O_2	CO_2	O_2	CO_2	O_2	CO_2	O_2	CO_2	O_2	CO_2	O_2	CO_2	O_2
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Pliofilm—														
80 FM1	2. 5	14. 0	2. 0	15. 0	2. 0	15. 0	5. 5	10. 0	7. 0	4. 0	7. 0	4. 0	7. 0	4. 0
80 HP	5. 0	13. 0	3. 5	15. 0	3. 2	15. 0	4. 5	13. 0	7. 0	7. 5	7. 6	7. 0	7. 0	7. 0
100 HP	4. 5	10. 0	4. 0	14. 0	3. 4	14. 0	7. 0	10. 0	11. 0	0. 0	11. 0	0. 0	11. 0	0. 0
Polyethylene 150	4. 3	11. 0	4. 0	13. 0	3. 3	13. 0	5. 6	12. 0	7. 0	4. 5	7. 0	1. 5	7. 0	1. 5

seals were broken immediately upon withdrawal from cold storage and after 4 days of ripening.

When examined after 4 days of ripening at 65° F., fruit in film liners opened immediately following storage possessed a crisp, juicy texture and an excellent flavor and was superior in dessert quality to any packed without film liners. All lots of apples were golden in color after 8 days at 65° F. Those in opened film liners were free from visible shrivel, fresh in appearance, juicy, and crisp to yielding in texture. Difference in flavor between the above-mentioned fruit and that packed without film liners was not as great after 8 days as after 4 days of ripening. But fruit without film protection was inferior after 8 days at 65° to that packed in any of the various films chiefly because of the amount of shrivel and toughness of texture.

Respiration rates of Golden Delicious apples at 65° F. immediately following removal from cold storage in various packing media, are given in figure 9. With the exception of the lot previously sealed in Pliofilm 100 HP, respiratory activity of the fruit during ripening was not influenced by previous packaging methods. This fact would indicate that differences in such factors as shrivel, texture, and flavor probably bear little relationship to respiratory intensity of the fruit during ripening at room temperature.

When the packed fruit was ripened for 4 days before the sealed film liners were opened, there were no abnormal odors present when the seals were broken. Fruit in Pliofilms 80 FM1, 80 HP, and polyethylene 150 possessed an excellent texture and flavor; its delicate varietal flavor and crisp texture was similar to that immediately after removal from 31°. Fruit in the Pliofilm 100 HP had an excellent texture but flavor was impaired; it had a slightly anaerobic flat taste. This is not surprising, since, as shown in table 11, this fruit had been devoid of oxygen for 2 days before the sealed carton was opened.

When the above lots of fruit were again examined after 8 days at 65° F., those in all of the film liners except Pliofilm 100 HP had a crisp, juicy texture, an excellent flavor, and a fresh appearance. Comparable fruit packed without film in the cell carton or in the standard wooden apple box showed considerable shrivel; it had a "punky" feel and a dessert quality inferior to the film-packaged lots. The fruit in Pliofilm 100 HP at this time was very mealy in texture and lacked the characteristic taste of the variety. After 2 weeks at 65°, fruit without film liners was badly shriveled, mealy, and definitely lacking in varietal flavor. That stored in all types of sealed film except Pliofilm 100 HP was yielding in texture and still of acceptable dessert quality; it was only slightly shriveled.

The data on fruit ripening show the existence of a margin of safety of at least 4 days in the holding of Golden Delicious apples at room temperature in certain sealed film liners. In order to avoid possible injury to the fruit, perforation of the sealed film is recommended upon withdrawal from cold storage; this is especially urgent when unsupervised handling at retail is likely to occur. Golden Delicious apples can be safely packed and cold stored in sealed liners of Pliofilm 80 FM1 and 80 HP, and in polyethylene 150. The appearance, condition, and dessert quality of fruit destined for long storage will be improved by the use of these films.

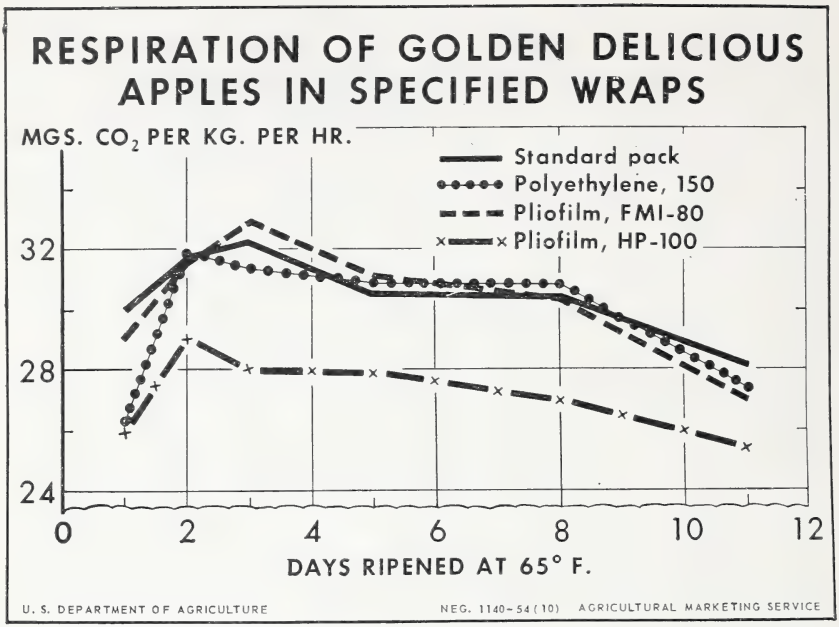

FIGURE 9.—Respiration of Golden Delicious apples at 65° F. following previous storage until April in various kinds of sealed film. The sealed films were broken prior to the measurement of respiratory activity of the fruit.

FILM PERFORATION REQUIREMENTS

As demonstrated in this study, severe injury to the packed fruit can occur even at 31° F. from the use, as box liners, of sealed films that have limited rates of gaseous diffusion. Destruction of flavor and tissue discoloration are produced as a result of CO_2 gas injury or the lack of sufficient oxygen to support the normal respiration of the fruit. Sealed films such as cellophanes 300 and 450 MSAT, and Pliofilms 120P4 and 120P6 should never be used without suitable perforation for pears and apples even at 31° F. Cellophane 300 LSAT and Pliofilm 75 FF and 100 HP may be used with safety as sealed box liners for pears and apples provided the liners are perforated immediately upon removal from cold storage.

The more gas-pervious films such as Pliofilm 80 FM1 and 80 HP, and polyethylene 100- and 150-gage can be used with safety as sealed film box liners for pears and Golden Delicious apples at 31° F., and for limited periods at ripening temperatures. There is a margin of safety of at least 4 days in handling such film-packed fruit even at room temperatures of 65° to 70° F. In order to avoid possible injury to the fruit during uninformed retail handling, it is strongly recommended that the sealed film of all packed fruit be perforated or slit open at shipping point. Nearly maximum protection to the fruit from the use of the sealed liner during previous prolonged storage will already have been attained by this time.

The sealed film box liner will retard the rate of ripening of pears even at room temperature. This fact, intelligently exploited by an informed retailer, can extend his merchandising period of the ripening pears without the need of reserve refrigerated space.

DISCUSSION

Packing pears in sealed plastic films at harvest is suggested for only that part of the crop intended for late storage, and should not be used to interrupt the orderly marketing program of each variety. Only sound fruit washed with an effective fungicide should be packed under film seal. The possibility of the development of decay in pears packed in the standard manner is very real; this possibility is increased with the use of the sealed film. The high relative humidity present in such packages is conducive to a more rapid appearance of decay than in the conventional pack. In only one season, however, was decay a serious factor in the film packaging of the experimental fruit in this study. That instance occurred in Anjou pears with an unusual number of stem punctures carrying an orchard infection of perennial canker (*Neofabraea perennans*).

The condition and appearance of the fruit in cold storage is much improved when packed in sealed film. Moisture loss with evident shrivel is reduced; softening of the fruit, adverse color changes, and the development of pear scald are retarded. The retention of freshness is much more pronounced in all varieties of pears under film seal than in those in the standard pack.

The Pliofilms 75 FF, 80 and 100 FM1, cellophane 300 LSAT, and polyethylene films 100 and 150, all can be safely used for packing pears in sealed box liners. These films will permit the accumulation of from 1 to 3.5 percent carbon dioxide in the atmosphere surrounding the packed fruit at 31° F.; oxygen levels of 13 to 18 percent were ample for the successful cold storage of all the varieties of pears studied.

The accumulation of low concentrations of carbon dioxide in the atmosphere definitely influenced the metabolism of the film-sealed pears in cold storage. Both respiratory activity and soluble pectin formation were retarded. Ulrich and Mimault (*7*) obtained similar results when paraffined pears were ripened. Trout, Hall, and Sykes (*6*) found that higher internal carbon dioxide levels rather than low internal oxygen concentrations were associated with the preservation of condition and the retention of flavor in apples. Extensive research (*1, 3, 4, 5*) has demonstrated that the storage life of pears can be extended by an increase in the carbon dioxide content of the storage air.

Moisture losses in pears can be curtailed by the use of perforated film or by folding the top of the unperforated liner over the packed fruit. In these instances, however, accumulations of effective concentrations of carbon dioxide are not possible and extension of the storage life through a retardation of the metabolism of the fruit is not attained. Therefore, it is very important that the films be sealed to obtain maximum storage protection.

All of the data in this study show that the storage life of Bartlett, Anjou, Comice, and Bosc pears is lengthened when the fruit is packed in certain sealed films during long storage at 31° F. The data also

show that the shelf life of such fruit when ripened is several days longer than when packed in the conventional manner.

Approximately 300,000 boxes of fall and winter pears were commercially packed in sealed film box liners during the 1953 season. Estimates for 1954 indicated that from 750,000 to 1 million boxes of pears in California, Oregon, and Washington would be packed in sealed polyethylene film. Sufficient film in the form of a gussetted bag liner, to fit the standard wooden box and to provide closure with a twist seal, was generally used commercially (fig. 10). Most operators partially exhausted the air from the packed box of pears before applying the twist seal. This was done to protect the film from puncture during the lidding operation; it also removed the "slack" in the pack.

A limited survey indicates that trade acceptance has been favorable. Several terminal market handlers of such fruit have commented on its fresh appearance and the uniformity of excellent color development on ripening. A receiver of several carlot shipments of film-sealed Anjou pears in April commented, "It would be wonderful if all winter pears were packed this way throughout the season, because these look as if they had been picked only yesterday and the ripening and holding ability of these pears is as good or better than it is in January." Shippers generally are proceeding with trial carlots of film-sealed packages of pears and are closely following trade reaction; most of them appear encouraged with their experience to date.

The degree of shriveling and the enhancement of dessert quality in Golden Delicious apples as a result of packing in sealed film box liners were not always reflected in such measurements as firmness (by pressure test), soluble pectin values, and respiratory activity. Visual examination, taste evaluation, and loss in original weight during storage, were the best ways of judging condition, appearance, and dessert quality of the fruit as related to packaging methods.

Visible shriveling of the fruit was evident when it lost approximately 3 to 5 percent of its original weight during storage. Such a condition existed in all Golden Delicious apples in cartons and wooden boxes without film liners. In polyethylene, however, weight losses in the fruit were reduced to about 40 percent of those in cell cartons without film protection. Paraffined fiberboard liners were ineffective in the prevention of fruit shrivel.

The appearance and dessert quality of the fruit, especially after prolonged cold storage, were greatly enhanced by packaging in certain sealed films. This fruit had a fresh look, a firm feel to hand pressure, and a delicate, aromatic flavor characteristic of the Golden Delicious apple when sampled early in storage. A somewhat longer shelf life was also noted as a residual effect of packing this variety of apples in sealed film.

Certain precautions are necessary when Golden Delicious apples are packed in film liners. Every effort should be made to use washed fruit free from surface abrasion and possible orchard infection, as moisture conditions within the sealed package are conducive to the development of decay. Precautions should be taken to assure a perfect seal as even a small perforation or tear in the film will preclude the establishment of the desired accumulation of carbon dioxide. Film closure may be made by twist-seal, by hot iron, and in the cell carton, by a careful overlap fold of the film on the chipboard top pad of the

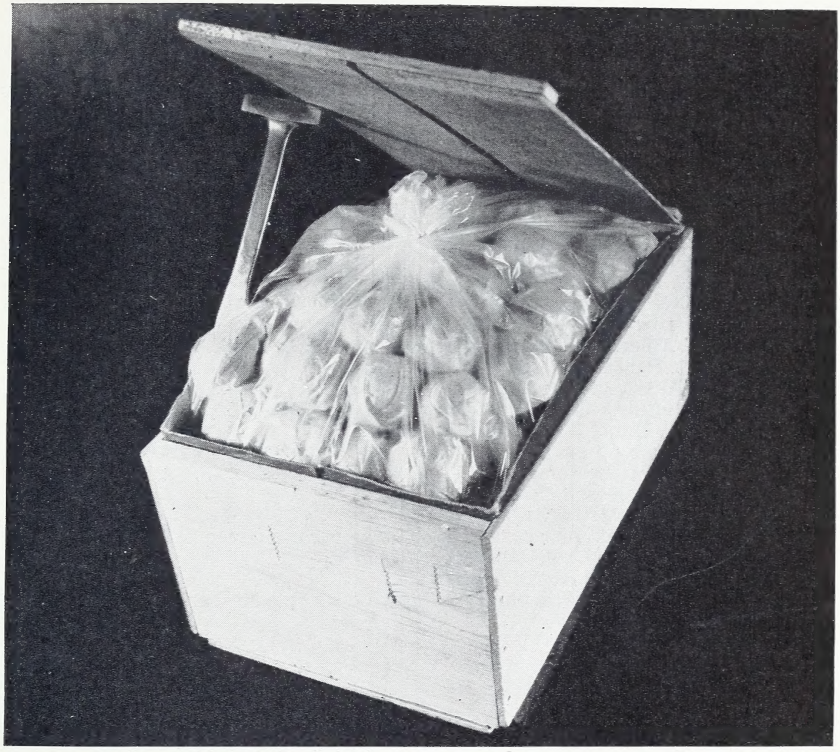

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FIGURE 10.—Commercial pear pack in film liner, showing method of closure by twist seal.

carton. It is suggested that sealed film liners should be used only for that portion of the tonnage destined for late storage (after January), as visible shrivel rarely develops before that time in Golden Delicious apples packed in the standard wooden apple box.

Limited commercial use of Pliofilm 80 FM1 and polyethylene 150 as sealed liners for packaging Golden Delicious apples in cell cartons was made during the season of 1952. About 4,000 cell cartons were packed and stored until April and May before shipment. Trade acceptance was excellent; the fruit sold for premium prices as high as $11.72 per carton for one of the last carlot shipments. There were approximately 67,600 boxes (loose and packed) of Golden Delicious apples held in sealed polyethylene liners during the season of 1953.

The results obtained in this study show that it is possible to improve the appearance and prolong the storage life of pears and Golden Delicious apples by packaging them in certain sealed film box liners at harvest. Hazards due to improper handling and to fruit decay must be recognized. With intelligent use of these films, however, the marketing season of Bartlett, Bosc, Comice, and Anjou pears, and Golden Delicious apples can be significantly extended.

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