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PEAR HARVESTING AND STORAGE IN BRITISH COLUMBIA

A December scene in a Bartlett pear orchard in Summerland, B.C.

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CONTENTS

EIGHT RULES FOR SUCCESS WITH PEARS

1. Prune and fertilize the trees and thin the fruit to produce good sized, high quality, evenly matured fruit.
2. Pick pears at correct maturity as judged by the pressure tester.
3. Harvest the crop of each variety in a period not exceeding 7 days.
4. Deliver pears to the packing house within 24 hours of picking.
5. Cool pears promptly to 32°F., core temperature whether packed immediately or held for later packing.
6. Ship from 30°-32°F. storage—in iced cars to distant markets—in stock cars to nearby market.
7. Hold fruit at destination in 30°-32°F. storage if still green, or if turning yellow, ripen at 60-75°F. for immediate sale. Avoid storing pears at temperatures between 35° and 45°F.
8. Ripen all varieties of pears at 60°-75°F. and high humidity to ensure highest quality.

PEAR HARVESTING AND STORAGE IN BRITISH COLUMBIA

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Introduction

Correct methods of growing, harvesting and storing are essential to the development of profitable markets for the increasing tonnage of pears grown in British Columbia. It is to present clear, concise and easily understood information on these subjects that this bulletin has been written. The extent of the increase in new plantings and the rise in production is shown. Attention is drawn to the importance of proper fertilizing, pruning, thinning and spraying. Detailed recommendations are given as to the stage of maturity at which to pick the fruit. Refrigeration, storage and ripening treatments are fully discussed, and methods of controlling storage disorders described.

Production Trends In Pear Varieties

The production of pears in the Okanagan and Kootenay districts has long been an important feature of the British Columbia fruit industry. Many varieties have been grown, but commercial production has largely narrowed down to Bartlett, Flemish Beauty and Anjou. Statistics on trends in pear production, compiled from the Tree Fruit Survey Sheets issued by the British Columbia Department of Agriculture, are given in Table 1.

These data indicate that the total number of trees of Flemish Beauty is slightly on the increase in the Okanagan, while Anjou shows a moderate, and Bartlett a very large increase in plantings. Miscellaneous varieties show a slight over-all increase in plantings. This increase in Bartlett and Anjou during the past ten years is not surprising, since these have been profitable varieties to grow and are the most popular pears on the market.

With increased plantings of Bartlett and Anjou, corresponding increases in pear tonnage have resulted. Data on production of Bartlett, Flemish Beauty, Anjou and other varieties are presented in Table 2.

While these figures indicate that during the past 16 years the tonnage of Bartletts has risen from less than 80,000 boxes to almost 400,000 boxes, there is nevertheless still a profitable market for all good sized Bartletts that are being produced. This situation has been brought about in large measure by increased cannery demand for pears, and by improved size and quality of fruit

* Died March 26, 1953.

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Table 1.—Pear Plantings in the Okanagan and Kootenay Districts of British Columbia from 1935 to 1952, Showing Total Number of Trees of Different Varieties and Ages

District	Bartlett				Flemish Beauty				Anjou				Other Varieties			
	1935	1940	1945	1952	1935	1940	1945	1952	1935	1940	1945	1952	1935	1940	1945	1952
Okanagan																
1 to 10 years.....	39,689	72,326	118,441	181,795	5,436	1,372	2,454	8,669	3,622	5,048	13,807	42,769	3,429	2,948	6,409	7,754
Over 10 years.....	18,905	32,071	53,052	87,139	16,123	16,194	15,276	11,963	11,496	12,045	14,078	15,010	8,378	8,219	6,813	4,715
Total Trees.....	58,594	104,397	171,493	268,934	21,559	17,566	17,730	20,632	15,118	17,093	27,885	57,779	11,807	11,167	13,222	12,469
Kootenay																
1 to 10 years.....	5,925	7,344	7,659	6,729	2,545	1,019	327	264	1,377	876	469	1,217	1,246	876	769	330
Over 10 years.....	7,041	5,599	6,585	7,619	3,750	3,717	3,475	2,176	1,906	2,207	2,536	2,372	2,124	2,180	2,207	2,139
Total Trees.....	12,966	12,943	14,244	14,348	6,295	4,736	3,802	2,440	3,283	3,083	3,005	3,589	3,370	3,056	2,976	2,469

reaching the consumer. How much longer the market will be able to absorb the increasing production from the new plantings is difficult to predict. However, if a real effort is made to maintain good size and quality in Bartletts, and to deliver them to the consumer in prime condition there should be a correspondingly increasing demand for this popular fruit for some time to come.

The market for Flemish Beauty has never been so favourable as for Bartlett, and prices have been correspondingly lower. The market acceptability of Flemish Beauty has been improved by harvesting the fruit at proper maturity. It is also possible that advances in methods of canning may provide a large outlet for fruit of this variety. With the exception of early varieties such as Clapp Favorite and Dr. Jules Guyot, miscellaneous varieties are becoming increasingly more difficult to sell.

A somewhat different situation exists with regard to Anjou, which is in good demand as a winter variety, and of which a larger tonnage could be marketed in some seasons. Prices for Anjou have been good. However, the experience of many growers has been that Anjou is a shy bearer, in some seasons develops cork spot and is a difficult variety in which to stimulate increased bearing by special horticultural treatment. Accordingly growers have been rather cautious about increasing their plantings of Anjou, with the result that there has been only a moderate increase in production.

Table 2.—Production of Pears in Okanagan and Kootenay Districts of British Columbia from 1935 to 1951*, in Packed Boxes

Year	Bartlett	Flemish	Anjou	Other Varieties
1935	79,854	79,449	42,478	31,391
1936	72,750	121,601	36,673	27,555
1937	198,952	98,369	49,673	29,966
1938	134,389	125,852	60,457	33,745
1939	123,442	106,742	68,187	30,822
1940	132,007	100,965	52,557	35,666
1941	185,352	134,099	66,111	33,912
1942	171,273	103,146	48,054	34,107
1943	133,528	115,261	49,945	24,396
1944	287,318	143,783	83,914	42,164
1945	287,408	138,002	87,680	37,882
1946	394,150	171,143	97,503	44,009
1947	337,868	134,262	97,026	38,865
1948	326,752	152,036	105,871	40,359
1949	349,546	151,634	83,893	34,190
1950	223,852	61,185	53,237	21,511
1951	392,605	123,140	117,080	37,871

* Figures Courtesy B.C. Fruit Board.

Cultural Requirements of Pears

In order to stimulate market demand it is necessary to grow pears of superior quality. This is a production problem and only by a study of pear trees right in his own orchard can the grower produce the kind of pears the market wants. While methods of management differ from orchard to orchard, there are certain general principles which apply to all cases in the production of good sized, high quality fruit.

First and foremost, pear trees must be maintained in a vigorous condition. A full grown pear tree should be making an average annual terminal growth of about 12 inches. To maintain vigor in the tree while producing full crops of pears it is generally recommended that 2 to 6 pounds of ammonium nitrate per tree (or corresponding quantities of other nitrogen fertilizers) be applied each year to maintain an adequate nitrogen supply. On alkali soils ammonium sulphate is generally preferred as a nitrogen fertilizer because of its soil acidifying effect. A vigorous tree is characterized by well distributed growth and large green leaves. Large green leaves are necessary to manufacture abundant food materials for sizing up the fruit and developing fruit buds for the next year's crop. If the tree is low in vigor and carries a heavy load, the fruit will be small in size and few fruit buds will be formed. Therefore, care must be taken to see that pear trees are well supplied with nitrogenous fertilizers.

Other factors beside nitrogen supply, however, influence tree vigor. Pruning is often necessary to reduce the number of growing points on the tree so as to promote increased vigor in the remaining spurs. Pruning, especially spur pruning, has the effect of thinning out the set of fruit, and encouraging development of strong fruit buds for the next season.

Thinning heavily laden pear trees is a necessary step in producing good sized fruit. In the past, some growers have thinned lightly, hoping to size the crop satisfactorily by making several pickings at harvest. This practice has in some cases resulted in overmature fruit of "local maturity grade" reaching the packing house and market. To ensure prompt harvesting of the crop, a B.C. Tree Fruits ruling is now in effect which demands that Bartlett picking in any orchard be completed within seven days of commencement date.

On heavily laden pear trees, a spacing of 6 or 7 inches between fruits helps to eliminate small sizes without reducing tonnage to any marked degree. Size 180 to the box is now the smallest pear packed, which represents fruit of two and five sixteenths inches diameter. Thinning should be done as early as possible, certainly not later than 40 days after full bloom, in order to achieve full effect in fruit sizing and development of fruit buds for the following season. Careful thinning results in good-sized, uniform-maturing fruit which may be harvested speedily in one picking.

A great many pear trees are annually infested with mites. These pests may cause serious damage in undermining the vigor of otherwise normal pear trees. They feed so heavily on the leaves that they materially reduce food manufacturing capacity with the result that a large proportion of the fruit is too small to market. The same can be said to a lesser degree of leaf damage caused by the pear psylla. These pests can be controlled by proper spray treatment, as indicated in government circulars on control of fruit insects.

If the trees receive only a scant water supply, growth will be restricted. Water is the most important single material in plant life, since it is required in large quantities in all growth processes, is used in manufacturing sugar in the leaves and is largely responsible for the rapid increase in size of fruits just preceding maturity. Accordingly, careful attention to irrigation of pear trees is most important from the standpoint of promoting vigor in the tree and good size in the fruit.

Harvesting Requirements of Pears

It has just been pointed out that good pears can only be produced where careful attention has been paid to cultural methods in the orchard. However, the object of growing good pears is defeated if they are not harvested at the correct stage of maturity and handled properly after picking. Accordingly the following pages are devoted to discussion of some important factors related to the harvesting of pears.

Increase In Size Prior To Harvest

There is a tendency, especially with Flemish and Anjou pears, to harvest the fruit in a somewhat immature condition. Besides reducing quality very materially, harvesting immature pears results in a serious loss of tonnage. In the few weeks immediately before pears reach proper picking maturity, they have been found to increase in weight approximately 16 per cent each week. Increase in size of Bartletts over a 4-week period is illustrated in Figure 1.

Figure 1. Relative sizes of Bartlett pears picked at weekly intervals from August 9 to September 6, 1940.

Photograph by J. E. Britton.

Pears picked too soon also suffer loss in weight through shrivelling after removal from the tree. Even when kept under conditions of high humidity, early-picked Bartletts have been found to lose as much as 10 per cent of their weight by the time they are ripe. Accordingly, early picking is decidedly to the grower's disadvantage, even if it saves a few windfalls, as with Anjou. Furthermore, pears which are picked too soon are undesirable from the dessert standpoint. They fail to develop full flavor, remaining insipid and astringent. Immaturely picked Anjous also sometimes fail to soften properly.

On the other hand, delaying the picking of pears beyond proper harvesting maturity has equally undesirable results. Bartlett pears picked at Summerland three weeks later than correct harvesting maturity increased in size 50 per cent over those picked at the proper stage, but these late-picked Bartletts ripened very rapidly. In fact at packing-house temperatures they were over-ripe in eight days. Many of them developed breakdown in the region of the core without ever reaching desirable eating condition. Shipment of such pears to market is bound to result in wastage, claims and dissatisfaction.

Maturity Tests For Harvesting Pears

In order to assist growers to pick pears at the proper stage of maturity, the Summerland Experimental Station has carried on a number of pear harvesting experiments over a period of years. Results obtained indicate that as pears approach maturity on the tree, several changes take place which may be used in determining the most satisfactory picking time. With some varieties, color of skin has proved useful as an index of maturity. Thus, with Bartlett and Anjou the dull green color of the skin is replaced by a slightly yellowish-green tinge and a characteristic waxy finish. Ease of removal from the tree has proved somewhat deceptive as an indication of maturity. Flemish Beauty and Anjou commonly separate readily from the spur long before they are ready to pick, whereas Bartlett and Beurre Bosc usually hang well to the tree even after they have passed the most desirable harvesting condition. For this reason consideration should be given to spraying Flemish Beauty and Anjou with one of the new effective stop-drop hormone sprays.

Softening of the flesh has proved a useful maturity test. This change in the hardness of the flesh can be measured accurately by means of a mechanical pressure tester. This tester is illustrated in Figure 2. The pressure tester now in commercial use in Okanagan orchards consists of a spring scale device which indicates in pounds the pressure required to force a blunt rounded

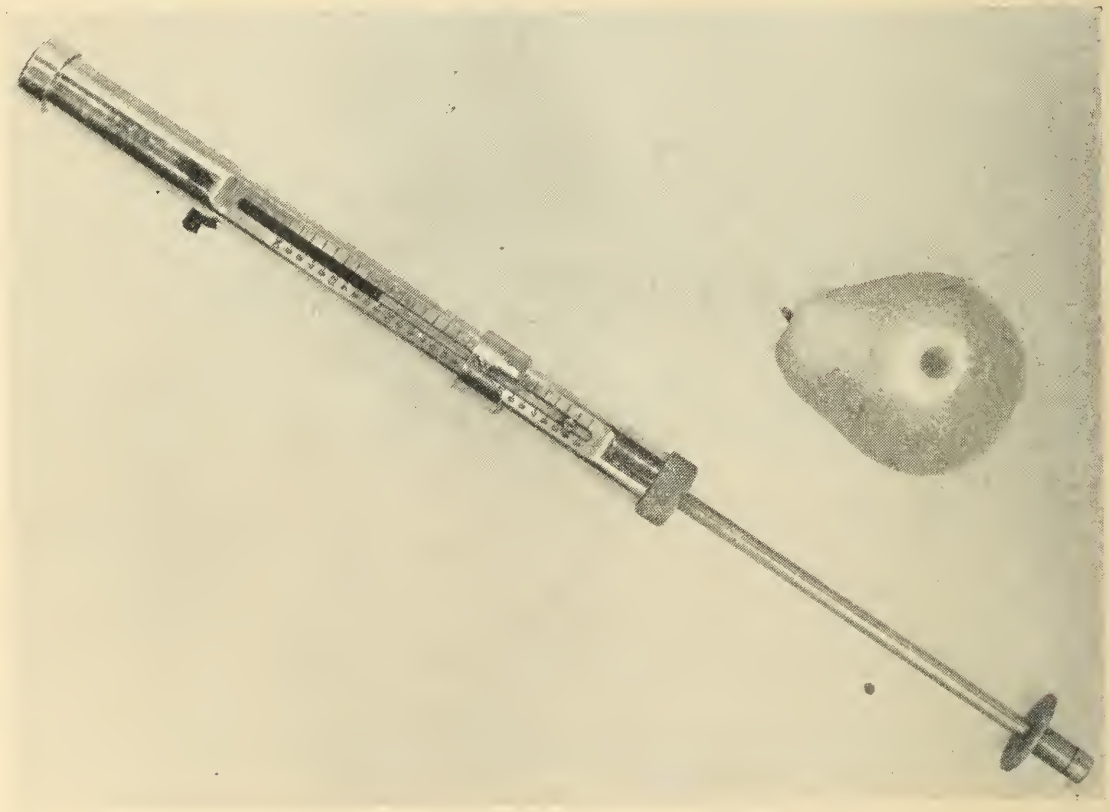

Figure 2. The Ballauf pressure tester which is used to measure in pounds the degree of flesh hardness of pears and apples.

plunger, 5/16 of an inch in diameter, to a depth of 5/16 of an inch into the peeled flesh of the fruit. The pressure tester is of most value with Bartlett, which commonly softens at the rate of about a quarter of a pound per day during the period just previous to harvesting maturity. With later varieties the rate of softening is much slower. Anjou softens at the rate of about one pound per week. Table 3 shows suggested pressure ranges for harvesting the varieties of pears grown most extensively in the Okanagan Valley. This table also indicates the approximate number of weeks before or after Bartlett that other varieties can be expected to reach desirable harvesting maturity.

Table 3.—Suggested Pressure Ranges for Pears Grown in the Okanagan Valley

Variety	Pressure range	Approximate harvesting date
	lb.	
Clapp Favorite	16–14	2 weeks before Bartlett.
Dr. Jules Guyot	20–18	1 week before Bartlett
Bartlett	20–18	
Doyenne Boussock	14–12	Same as Bartlett.
Flemish Beauty	12–11	2 weeks after Bartlett.
Beurre Bosc	14–12	3 " "
Duchesse d'Angouleme	11–10	4 " "
Howell	15–12	4 " "
Beurre Clairgeau	14–12	5 " "
Anjou	13–12	5 " "
Winter Nelis	14–12	7 " "

A high quality canned product with excellent flavor can be made from Bartletts picked in the 17-15 pound pressure range. However, pears picked at this maturity ripen more rapidly, have a shorter storage life and are more likely to develop core browning than fruit picked in the 20-18 pound range.

While the pressure tester has proved a very useful instrument in the hands of experienced operators, it is by no means fool-proof. In order that the readings of the pressure tester may be correctly interpreted, certain conditions must be fulfilled. In determining the maturity of pears in an orchard, pressure readings should be made on at least ten pears representative of the condition of the crop as a whole. Pears to be tested should be picked from several normal trees carrying an average crop and the average of all readings determined. In selecting the specimens for the test, care should be taken to avoid those affected with russet, black-end, mildew or sun scald. Such pears usually register an abnormally high pressure. The testing should be done in the orchard as experiments have shown that some pears actually become harder for several days after they are picked. Thus, pressure readings made in packing houses several days after the fruit is picked, are likely to give an erroneous indication of the stage of maturity at which the fruit was picked. Furthermore, the pressure tester is of doubtful value as a maturity index towards the end of the harvesting season. Pears which have been left on the tree later than the ideal picking stage commonly become hard and woody. Thus, a grower may delay his pear picking beyond the best stage and still find the pressure test of his pears within the suggested pressure range.

It might be mentioned here that pears on branches suffering from fire blight should not be harvested since they usually are of very inferior quality.

Experiments indicate that the degree of maturity of all pears on a tree is practically identical at any given time. Therefore, the practice of making two or more pickings to allow smaller sized fruits to gain size has the effect of permitting them to become overmature for best handling. Pears should be thinned properly to ensure that all fruits reach desirable size at the same time,

so that all the crop may be harvested at one picking. From any one orchard, the span of the picking period from start to finish, for Bartlett in particular, should not exceed seven days. In this connection it may be well to point out that after part of the crop has been picked the fruits remaining on the tree often fail to soften normally, with the result that pressure tests made after harvesting has commenced are not reliable indices of maturity.

The accuracy of the pressure tester itself should be carefully checked. The Summerland Experimental Station undertakes to check and adjust pressure testers free of charge. In spite of all these complications, the pressure tester has proved of real value and has resulted in great improvement in the quality of pears shipped out of the Okanagan Valley.

Storage Requirements of Pears

Bartlett and Flemish Beauty pears usually mature during the hot weather of mid August to early September. At these high temperatures ripening is very rapid, hence particular care is necessary to slow down ripening and lengthen the keeping life of the fruit. Pears should be placed in 30-32°F. storage, preferably within 24 hours after picking. This is especially true for later picked pears which may ripen as much as twice as fast as similar fruit picked at optimum maturity. It is desirable, though not always possible, to pick pears in the afternoon, leave them in the orchard to receive the benefit of the cooling effect of the night air, and deliver them to the cold storage plant the next morning before the heat of the day has set in.

Prompt Refrigeration Is Most Important

As soon as they are delivered at the packing house, pears should be packed and then placed in cold storage. If more pears are being received than can be packed the same day, the surplus fruit should be held in 30-32°F. cold storage until the graders are able to handle it. Contrary to popular opinion, Bartlett pears may be cold stored loose in orchard boxes immediately after picking and removed a month or more later for packing, without danger of subsequent injury to the fruit.

Unless pears are to be shipped to nearby points, they should be pre-cooled for several days to lower the temperature to 32°F. before shipment. In fact, the standard requirement for custom pear storage in this area is to cool Bartletts to a core temperature of not higher than 33°F. in not over 5 days from date of packing.

This precooling is particularly desirable with fruit that is loaded into iced cars, and which will require several days to be transported to market. Loading warm pears into iced cars is an expensive and wasteful procedure since the first charge of ice is melted rapidly in cooling the fruit, and the car temperature is raised above the desired level. Moreover, the inner stacks of fruit cannot be cooled nearly so readily in an iced car as they can be in the moving air of a cold storage warehouse. For shipment of pears in stock cars, or without ice, it is recommended that the pears be loaded at 32°F. core temperature. Upon arrival at market such pears should be sold as soon as possible.

Low Temperatures Must Be Maintained

The importance of prompt storage of pears at a temperature of 30-32°F. has just been emphasized. Once harvested, early pears such as Clapp Favorite, Dr. Jules Guyot, Beurre Boussock and Bartlett ripen very rapidly and usually reach eating condition after about 7 to 10 days at 70°F. The lower the temperature at which they are held the slower is the rate of ripening.

The rate of softening of Bartlett and Flemish Beauty pears, held at about 68°F. as measured by the pressure tester, is depicted in Figures 3 and 4. The influence of maturity when harvested upon rate of softening is also illustrated in these figures. At eating ripeness these varieties show a flesh firmness of 3 to 4 pounds.

It will be observed from these charts that the later the fruit was harvested the more rapid was the rate of ripening. With Bartlett, late picked fruit ripened in about half as many days as earlier picks. With Flemish Beauty only very early harvested pears were notably retarded in ripening. Extremely early harvested pears of many varieties ripen unevenly and often shrivel without attaining proper eating softness.

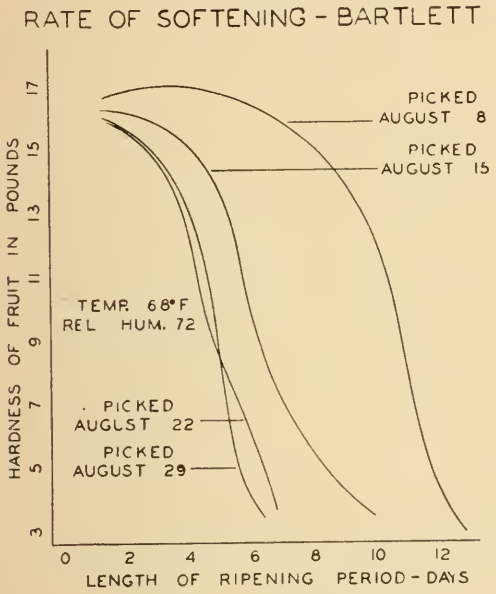

Figure 3. Influence of date of picking on rate of ripening of Bartlett pears. Optimum maturity August 15th (1934).

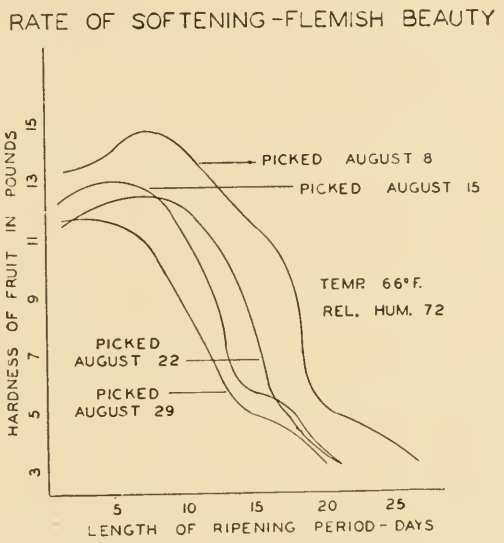

Figure 4. Influence of date of picking on rate of ripening of Flemish Beauty pears. Optimum maturity August 29, (1934).

Pears soften little or none for the first few days after picking and then complete their softening at a greatly accelerated rate. Bartlett is sometimes slightly firmer for a day or so after picking than when picked. Flemish Beauty often gains several pounds in firmness after harvest and does not start to soften until a week after picking.

At a temperature of 70°F. Bartlett and Boussock become eating ripe in about 8 days, Bosc in about 18 days, Flemish Beauty and Winter Nelis in about 3 weeks and Anjou in about 4 weeks after picking.

As temperatures are lowered, keeping life of pears correspondingly increases. The most satisfactory temperature for storing pears for either long or short holding is 30-32°F. Where possible, 30°F. is preferred. At a temperature of 30-32°F. safe storage limits for the different varieties are shown in Table 4.

Table 4.—Safe Storage Periods for Pears Stored Promptly at 30 to 32°F.

Variety	Storage Period
Bartlett	2 months
Doyenne Boussock	2 months
Flemish Beauty	2 months
Beurre Bosc	$2\frac{1}{2}$ to 3 months
Anjou	$4\frac{1}{2}$ to 5 months
Winter Nelis	$4\frac{1}{2}$ to 5 months

However, pears picked at optimum maturity and promptly cooled to 30°F. may keep in satisfactory condition much longer than the above data indicate.

When removed from 32°F., storage to a ripening temperature of 60 to 70°F. pears stored within the time limits listed above will ripen into juicy delicious fruit. If held beyond these limits they may fail to soften and often develop scald and flesh breakdown.

If pears are held at temperatures between 32° and 40°F. keeping life is greatly reduced and susceptibility to storage disorders increased. Storage at 36°F. reduces keeping life of pears to one third or one half the keeping life at 30-32°F. Storage of pears at 40° is almost certain to cause trouble for this temperature is neither sufficiently low to depress ripening satisfactorily, nor sufficiently high to permit the fruit to ripen normally. If pears start to show yellowing of the skin in cold storage they should be ripened for consumption immediately.

In storing and handling pears, it should be borne in mind that the longer the fruit is kept under refrigeration the shorter is its keeping life after removal from cold storage. The hardness of the fruit upon removal from 32°F. storage may be somewhat deceptive in this regard. At this temperature softening takes place to a very limited degree and the fruit to all appearances may seem nearly as firm as when it was picked. Despite this apparent firmness, cold storage pears ripen much more rapidly than fruit ripened immediately after picking, often becoming eating ripe within 4 to 7 days after they are removed from 32°F.

High Humidity Essential In Storage Rooms

Pears have a greater tendency to shrivel than other fruits, particularly when picked in an immature condition. For this reason humidity should be kept over 85 per cent in storage houses. When pears are ripened at home, a damp basement provides high humidity conditions, or the box of pears may be enclosed in a cotton sack dipping in water to act as a wick.

Controlled Atmospheres Prolong Storage Life

Under ordinary conditions of storage, keeping life of pears at 30-32°F. is rather limited. With Bartlett, for example, the safe period of storage is only two months. However, extensive experiments have shown that when pears of the Bartlett variety are stored at 32°F. in a sealed storage compartment and allowed to build up 5·0 to 7·5 per cent of carbon dioxide gas through respiration, they can be removed from storage in perfect condition four or five months after picking.

At present there appears to be no difficulty in selling all available Bartletts. Canneries and the fresh fruit market readily absorb the entire crop within two months of harvest. However, production trends indicate that the time may come when difficulty may be experienced in marketing the increased Bartlett tonnage. The controlled atmosphere method for storing pears could then assume real significance in prolonging the marketing span for this variety.

Carbon Dioxide As A Supplement To Precooling

High initial carbon dioxide exposures have also been investigated as a substitute for, or supplement to, ice in shipping pears in refrigerator cars. Bartlett pears subjected to 20 per cent carbon dioxide at 45°F. for as much as 20 days kept in as firm condition as similar fruit held in air at 32°F. Fruit subjected to this treatment ripened normally without impairment of dessert quality. This method of handling pears may have value in long distance shipments during hot weather or with fruit which is fairly advanced in ripening

before shipment. It involves the additional expense of "dry ice" (solid carbon dioxide) and requires refrigerator cars which are especially well sealed so as to prevent excessive loss of the carbon dioxide gas.

Ripening Requirements of Pears

As pears ripen, numerous chemical changes take place in the fruit. The heavy deposition of starch in the flesh is converted into sugar. The protopectin compounds which give firmness and rigidity to the flesh of an unripe pear change into the soluble pectin form and the pear becomes juicy and melting in texture. The acidity and astringency of the fruit also decrease and the fruit develops the delicate flavoring which characterizes each variety at its best.

To develop their highest quality, pears should be ripened in a warm atmosphere of 60-75°F., with a high degree of humidity. The high temperature favors the development of rich flavor and the high humidity prevents shrivelling. When ripening small quantities of pears in a warm room it is a good plan to ensure a high humidity by surrounding them with a damp cloth.

Progressive wholesalers who make a specialty of handling pears maintain ripening rooms at temperatures of 65-70°F. The time required to ripen pears in one of these rooms varies from 4 to 28 days depending on the variety, the pressure test at which the fruit was picked and the length of time it has been held in storage. The required quantities of pears are removed from cold storage each day and placed in the ripening room where they are kept until they reach the proper ripeness for distribution to the retail trade. By this procedure retailers receive each day the desired quantity of pears ripe enough for sale to the consumer.

Most canners maintain ripening rooms to ensure a steady flow of pears at the proper stage of ripeness for canning. In some large scale canneries the pears, immediately after removal from cold storage, are passed through a warm water bath to bring their temperature to 65°F. rapidly and uniformly. This procedure promotes quick and uniform ripening.

Pears, as they ripen, generate an interesting gas called ethylene which acts as a powerful stimulant to the ripening of other pears exposed to it at temperatures above 45°F. Bartletts stored at 70°F. in proximity to ripe pears have been found to ripen in two-thirds the time required by pears not thus treated. In fact, some cannery operators use ripe pears, or ethylene gas to hasten ripening and increase uniformity of ripening of pears being held for canning.

Pears should never be held at temperatures around 40°F. as they lose ripening capacity and tend to develop storage disorders such as scald at these temperatures.

Storage Disorders

When pears are picked and handled incorrectly they become subject to various disorders. These take the form of core breakdown, scald, rots and loss of ripening capacity. A further disorder which is not attributable to picking or handling methods, but which causes a great deal of trouble for packers and fruit distributors, is the physiological disease called black-end. Freezing injury is also occasionally encountered. These disorders and appropriate control measures are discussed briefly below.

Core Breakdown

Core breakdown may arise from two separate causes; harvesting in an overmature condition, and natural disintegration of the fruit after ripening. When permitted to remain on the tree until the fruit becomes yellowish in

color, pears often develop a soft brown area around the core without ever reaching the eating ripe condition. This form of core breakdown can be prevented by picking the fruit at the proper stage of maturity as indicated in the section of this bulletin entitled "Harvesting Requirements of Pears".

On the other hand, pears which ripen normally remain in good eating condition only for a few days after which the flesh in the vicinity of the core begins to turn brown. This browning soon spreads till the whole of the flesh becomes mushy although the skin may retain a normal appearance for several additional days. Obviously the only means of preventing this type of breakdown is consumption of the fruit while it is in good eating condition.

Pear Scald

Scald develops on pears held too long in cold storage, and particularly on fruit picked immature. Often it is not evident on the fruit at time of removal from cold storage, but soon develops after the pears are exposed to a warm temperature for a day or two. In affected fruit, the skin turns dark brown, and the flesh underneath usually becomes soft and watery so that the skin easily sloughs off. The fruit takes on a disagreeable odor and flavor resulting in complete wastage. Pear scald may affect any variety and is not controllable by oiled wraps. Control lies in removing the fruit from cold storage before the time limits stated at the end of this bulletin. Only a few weeks difference in length of cold storage period may determine whether pears ripen normally or develop severe scald. This is illustrated by fruit shown in Figure 5.

The two pears shown on the left of Figure 5 were removed from cold storage seven weeks after date of harvest. All the fruits removed at that time ripened normally into juicy good tasting fruit. However, similar pears from the same samples when removed from cold storage two weeks later, after nine weeks of cold storage, developed severe scald.

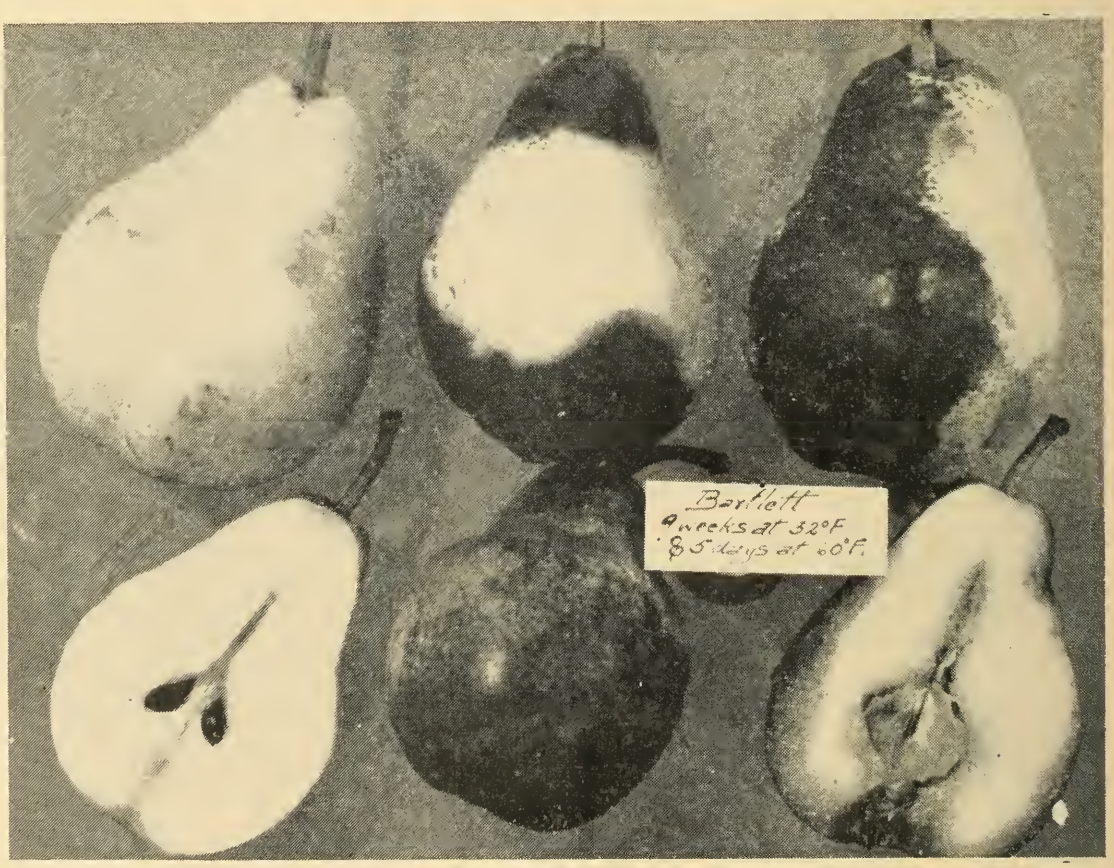

Figure 5. Bartlett pears showing severe scald and flesh breakdown. Normal pears at left. *Photograph by J. E. Britton.*

With the Anjou variety, scald of a different type occurs from that which develops on other varieties. The skin assumes a mottled brown or black discoloration but does not slough off from the flesh. No undesirable odor is present and affected pears are fully edible. The disorder does not ordinarily make its appearance until after the fruit is removed from cold storage to warm temperatures, and as a rule develops only on fruit cold stored late in the season. Anjou scald differs from ordinary pear scald in being readily controlled by the use of oiled wraps.

The Anjou variety has a tender skin which makes it very susceptible to marking once the fruit becomes ripe. Merely touching the skin causes light brown discolored marks to make their appearance. This marking of the skin of the Anjou variety does not affect the eating quality of the fruit but detracts from appearance. Anjou should therefore be handled very carefully so as to avoid, as far as possible, injury to the skin. The same can be said in a lesser degree of the Bartlett variety.

Loss of Ripening Capacity

When pears have been cold stored too long they lose their ability to ripen. Even after prolonged exposures to room temperatures following cold storage the flesh remains hard and woody. It is thought that excessive cold storage has the effect of inactivating enzymes in the tissue which are responsible for breaking down the pectin compounds into soluble forms, and thus causing the fruit to become soft and juicy. Any variety may lose its ripening capacity if cold stored too long, but perhaps the most striking example of this disorder occurs with the Bosc variety. Overstored Bosc pears appear in perfect condition when removed from cold storage to ripening temperatures, and weeks afterwards will be a beautiful golden yellow, and still completely hard in texture. With Bartlett this loss of ripening capacity usually occurs about the same time that pear scald sets in. Anjou loses its ripening capacity, or at least ripens with rather poor texture, after about 6 months of 32°F. storage. In fact the keeping life of most varieties is conditioned by loss of ripening capacity more than any other single factor. For this reason care should always be taken to see that pears are not cold stored longer than the limits recommended at the end of this bulletin.

Rots

Pears that are roughly handled so that stem punctures or lacerations in the flesh occur, are liable to be invaded by different kinds of rot organisms which sometimes cause serious spoilage during storage. Most serious of these organisms is botrytis or grey mold which converts the pear into a leaky mess and spreads rapidly from pear to pear even through wrappers. Sometimes a nest of 15 to 30 pears may be found in a box. The Anjou variety is especially susceptible to nest rot. Rhizopus rot which gives the fruit a black downy appearance sometimes produces "nesting" in pears, more especially in fruit held above 50°F. Paper wraps impregnated with copper sulphate have proved of some value as a means of preventing the spread of "nesting" in pears, but careful handling and prompt cold storage provide the most effective means of control.

Black-end

Black-end or hard-end of pears is a physiological condition which causes serious annual losses to Bartlett and Anjou pear growers. The terms "black-end" and "hard-end" are used to describe two different forms of the same disease. Black-end fruits are characterized by a hard brownish-black area at the calyx end of the fruit. The area of skin involved may vary from a visible

spot of black to a patch of 2 square inches or more. Sometimes instead of a solid black area, a black speckling of the skin occurs. Furthermore, affected fruits frequently show a premature yellowing of the skin and early dropping.

Figure 6. Black-end on Bartlett pears. Note the protruding calyx ends and the variability in degree of blackening.
Photograph by J. E. Britton.

Figure 7. Black-end on Anjou pears.
Photograph by J. E. Britton.

Certain abnormalities in shape and appearance of fruit are characteristic of the disease. The fruits may have a flat, shiny area surrounding a calyx with small constricted lobes. In other cases, the calyx end may protrude, with tightly closed calyx lobes and with a bluish-green cast to the skin. This protruding type of calyx has been described as a "sheep's-nose" effect. The black-end condition is depicted in various forms in Figures 6 and 7.

Black-end pears are poor in quality besides being tough and woody at the calyx end. The affected area never softens. Light cases of black-end are particularly troublesome since they scarcely show up at time of picking, but after packing may develop the blackened calyx area or become "woody" with resulting heavy claims from the buyer.

Black-end in pears is most common in fruits from trees grown on the oriental pear rootstocks, especially *P. serotina* which was popular with nurserymen 25 years ago. Pears grown on French pear roots seldom develop the disorder. Sometimes only a few typical black-end pears are found on a tree, but this is sufficient evidence to suspect the rest of the crop on the tree. Trees suffering from black-end should be marked and picked separately from the rest of the crop. Years of experience indicate that most black-end and hard-end fruits can be detected and discarded at picking. The only sure cure yet found for black-end is to determine which trees produce black-end fruit and pull them out.

Freezing Injury

Freezing damage to pears occasionally occurs in refrigerated warehouses. While the freezing point of pears is usually taken to be 28·5°F., this figure is approximate and can vary slightly up or down depending on the soluble-solids content of the fruit.

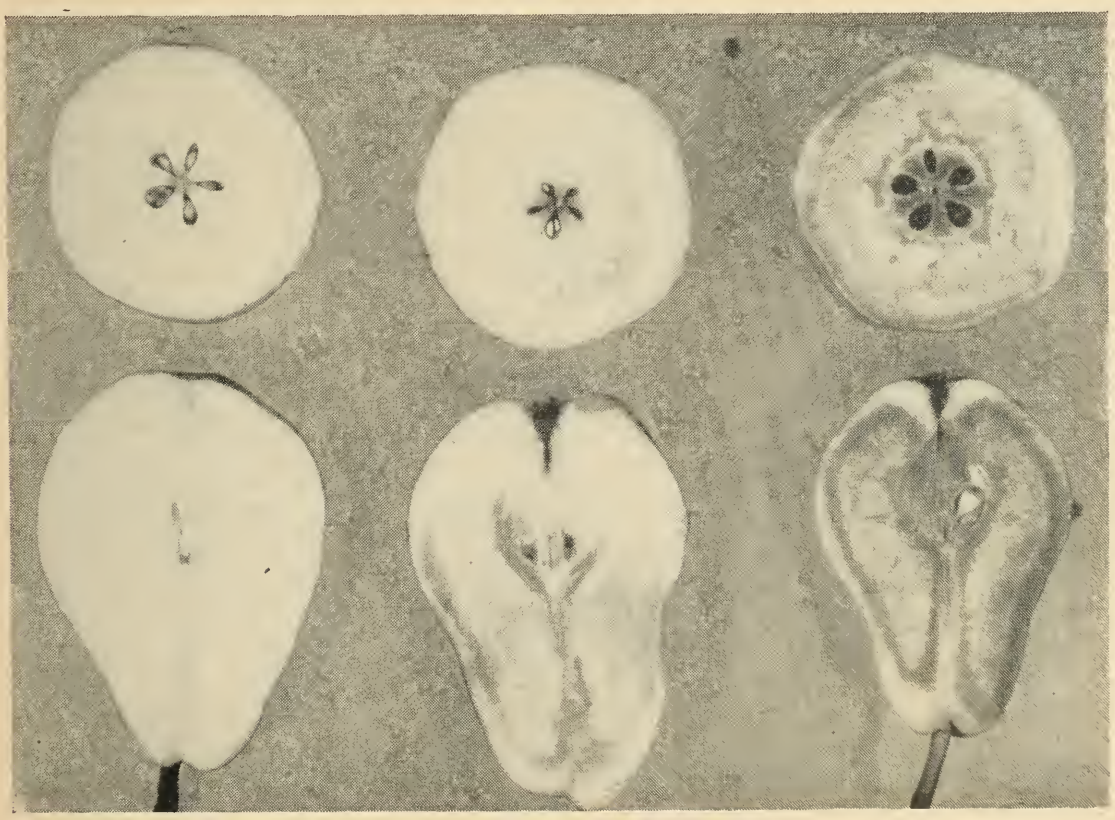

Figure 8. A peculiar freezing injury caused by prolonged exposure of the fruit to temperatures just below freezing point of the flesh. Normal pears on extreme left, Variety, Bartlett.

Freezing damage to storage pears can result from exposure of fruit to 27°F. air for four weeks. An example of this type of injury is shown in a sample of Okanagan Bartlett pears photographed in the storage season of 1950 (Figure 8). This injury is generally not apparent from the outside of the fruit and usually is found scattered among normal pears in the same box. In such a case, the frozen fruit shows a slightly lower soluble-solids content than the undamaged fruit.

Freezing injury is almost invariably traced to fruit which has been stored in such a position that cold air from the supply duct discharges directly onto unwrapped pears. This usually occurs with underside delivery ports on ducts or with fruit stored at the "cold" end of a storage room where openings on delivery ports have not been adjusted to ensure uniform air discharge throughout the length of the duct. Under such circumstances, air discharged at normal temperatures of 27° to 28°F., can cause freezing injury since delivery duct arrangements do not ensure adequate air mixing or uniform rates of air delivery throughout a pear storage room.

Absolute safety from the danger of freezing can be assured by raising discharge air temperatures to 29°F. after the fruit has had field heat removed.

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Safe Storage Periods For Pears Stored Properly At 30 to 32°F.

Variety	*Storage Period*
Bartlett	2 months
Doyenne Boussock	2 months
Flemish Beauty	2 months
Beurre Bosc	$2\frac{1}{2}$ to 3 months
Anjou	$4\frac{1}{2}$ to 5 months
Winter Nelis	$4\frac{1}{2}$ to 5 months