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INVESTIGATIONS ON HARVESTING AND HANDLING FALL AND WINTER PEARS

PENTZER, W.T. ET AL

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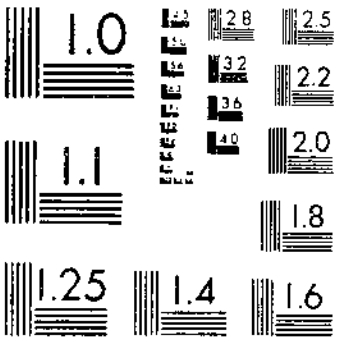

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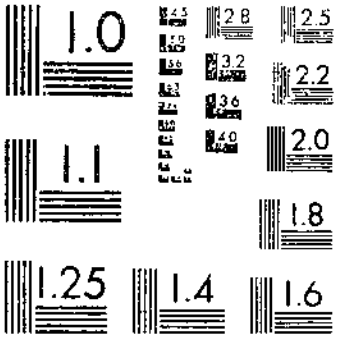

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TECHNICAL BULLETIN No. 290 FEBRUARY, 1932

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

INVESTIGATIONS ON HARVESTING AND HANDLING FALL AND WINTER PEARS [1]

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SCIENCE & INDUSTRY

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INTRODUCTION

Estimates based on new plantings coming into bearing indicate a marked annual increase in pear production for at least the next five years. The extension of both foreign and domestic markets is an economic necessity in disposing of the increased pear crop of the future (*11*).[2] The extension of markets must be predicated upon harvesting and handling methods that assure the marketing of first-class pears, in order to attract and hold new customers in the face of increased competition from other fruits. The dessert quality of the fruit when it is ripe and in the hands of the consumer is dependent to a considerable extent upon its maturity at the time it is picked and upon the temperatures to which it is subjected while in transit, in storage, and in the ripening rooms. These two problems, the determination of picking maturity and the effect of transit and stor-

[1] The writers wish to express their appreciation for the assistance of J. C. Shilletter, L. A. Fletcher, B. D. Ezell, and I. A. Van Valkenburgh. The cooperation of the commercial cold-storage companies that made possible the storage tests at different temperatures is also deeply appreciated. Valuable cooperation was also given by fruit growers who made fruit available for these investigations.

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

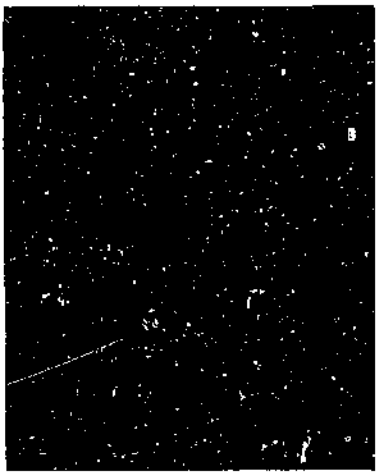
age temperatures upon the ripening and storage life of the pear, have been investigated in pear districts of California, Washington, and New York in an attempt to work out the best picking maturity and handling and storage methods for each commercial variety of fall and winter pears.

The commercial harvesting and handling of pears is complicated by certain characteristics of the fruit and by the location of the industry. Pears left on the tree until ripe usually show breakdown at the core and are of very poor quality; hence it is necessary to pick them when they are still unripe but mature enough to ripen with satisfactory dessert quality. It is also essential that harvesting be so timed as to insure maximum shipping, storage, and marketing quality, since most of the fruit is produced far from the consuming markets. At the present time about 68 per cent of the carload shipments originate in California, Oregon, and Washington, and increase in production is expected to continue in the Pacific coast districts. New York is the most important Eastern State in the production of pears, shipping about 18 per cent of the cars moved to market in the United States (*11*).

DETERMINATION OF PICKING MATURITY

As the pear develops on the tree there is a gradual increase in size and a change of the dark leaf-green color to a light or yellow green, accompanied by specific changes within the flesh and skin. The sugar content of the pear increases markedly, starch decreases, and acidity and astringent properties diminish as the fruit approaches proper picking condition (*6*). The growth in size results, of course, in an increase in weight, which for Bartlett pears, according to Murneek (*9*), may amount to over 20 per cent in nine days during the harvesting season. This fact indicates the added tonnage that may result from delayed pickings. As the fruit matures, the skin of some varieties develops a bloom or wax, and the lenticels in the skin become more or less filled by a corky substance that reduces the rate of moisture loss from the fruit. Early pickings of Bartlett pears have been found to lose 9.7 per cent of their weight in 11 days, while pickings made 15 days later lost but 6.3 per cent in the same length of time (*3*). Because of these changes accompanying maturity, fruit picked very early lacks sweetness and richness of flavor, is sometimes sour and astringent, and often shrivels if exposed to a dry atmosphere.

While these modifications are taking place within the flesh and skin, other developments are noticed as the fruit approaches picking maturity. The seeds may become brown, and the stem may loosen somewhat from the tree. The flesh gradually becomes "springy" and softer, although it may still be quite hard to the pressure of the thumb. By means of a mechanical tester, which measures in pounds the pressure required to force a smoothly rounded plunger into the flesh of the fruit to a definite depth, the softening of the pear can be determined in measurable terms. Such a tester is described and illustrated by Magness and Taylor (*8*). Other means of determining maturity, such as starch or sugar tests, specific-gravity tests, color, and size, have been used; but from one season to another, under varying growing conditions, the firmness of the flesh has been the



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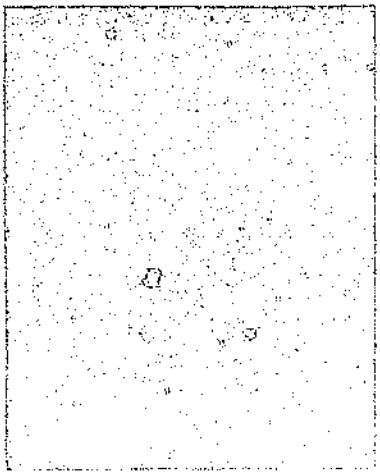

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COLOR CHART FOR USE IN DETERMINING PROPER TIME FOR PICKING FALL AND WINTER PEARS

best single index of maturity. The use of the pressure test, correlated with the ground color of the fruit expressed in numbers, as illustrated by the color chart (pl. 1), is increasing in the Pacific Coast States as a maturity standard for pears.

Picking the fruit from the tree early in the season materially reduces not only the tonnage but also the sugar content and dessert quality. On the other hand, allowing it to remain on the tree very late may favor the development of storage disorders and may necessitate special handling to enable the fruit to be shipped without arriving on the market in a soft condition. In the Santa Clara Valley of California, the Wenatchee Valley of Washington, the Hudson River Valley of New York, and the Grand Junction district of Colorado, picking, storage, and shipping experiments have been made with the principal commercial varieties of fall or storage pears grown in these districts. This work was carried on during the sea-

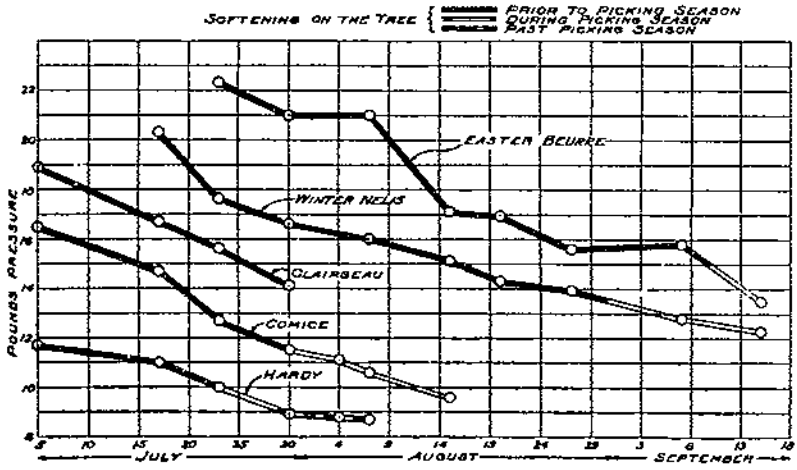

FIGURE 1.—Diagram showing rate of softening on the tree for five varieties of Santa Clara Valley pears in 1926

sons of 1926 and 1927 in California and New York; 1926, 1927, and 1928 in Washington, and in 1929 in Colorado.

EXPERIMENTAL METHODS

The rate at which the different varieties of pears softened on the tree was ascertained by making pressure tests regularly, beginning several weeks before the picking season and continuing beyond the commercial season. In this work, a plunger five-sixteenths of an inch in diameter, which is the size recommended for pears, was used. Care was taken to screw the plunger all the way in so that its depth of penetration should be uniformly five-sixteenths of an inch. Several orchards were visited in each district or in each part of the valley; and the fruit selected for testing was taken from the same trees each time, in order to eliminate variations due to stock or environmental conditions. By using 10 or more pears picked from several trees in each orchard for a single determination, a fairly significant average of the condition of the pears on successive dates was obtained. On each fruit the skin was pared from a small area on three sides and a

test made in each of these places. Curves portraying the softening rate of each variety are given in Figures 1 to 6.

In order to correlate the time of picking with the dessert and storage quality of the pears, several pickings of each variety were made during the season, consisting usually of a preseason, midseason,

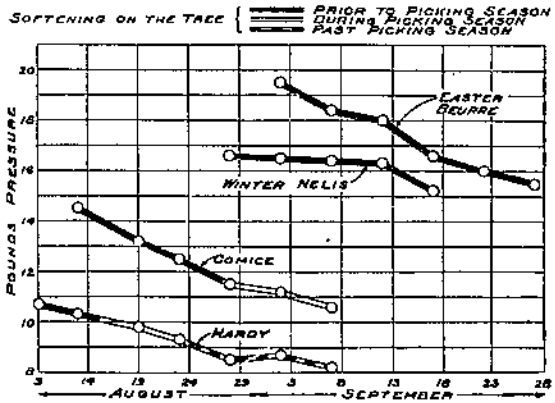

FIGURE 2.—Diagram showing rate of softening on the tree for four varieties of Santa Clara Valley pears in 1927

and late picking. These lots were held at commercial storage and transit temperatures and inspected from time to time for ripening quality, maturity, and storage troubles. The picking period in which the fruit developed the best quality and had a satisfactory storage life was determined from these records. The ranges are shown in Figures 1 to 6, and a discussion of each variety in regard to picking

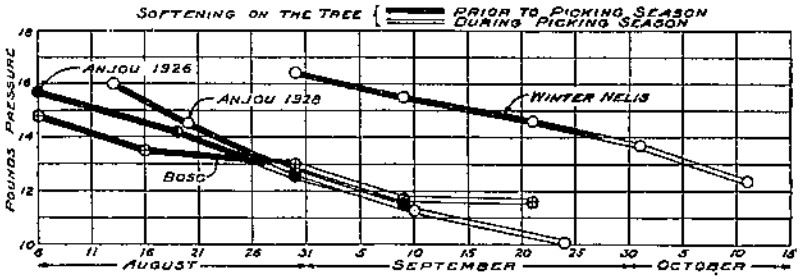

FIGURE 3.—Diagram showing rate of softening on the tree for three varieties of Wenatchee Valley pears in 1926 and one in 1928

season follows. Both of the seasons in New York during which the investigations were conducted were unusually wet and cold, as indicated by the weather records in Table 2; therefore definite conclusions can not be drawn for the picking maturity of pears in this district.

HARVESTING SUGGESTIONS FOR DIFFERENT VARIETIES

HARDY

The Hardy (*Beurre Hardy*) pear is one of the two leading varieties of California fall pears and is the earliest one on the market,

closely following the Bartlett of California. The movement of this variety generally begins about the first week in August. It is not a long-keeping variety, and its quality is more dependent upon careful handling than that of some of the later, firmer pears. Its tend-

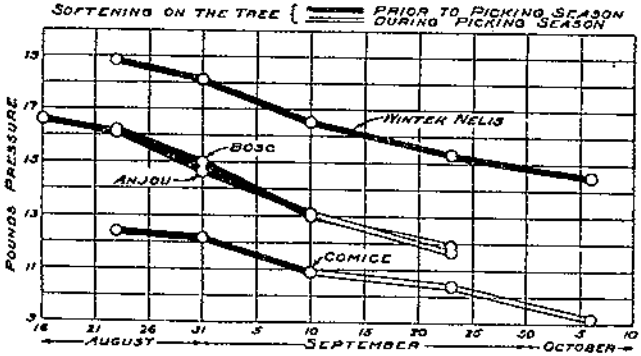

FIGURE 4.—Diagram showing rate of softening on the tree for four varieties of Wenatchee Valley pears in 1927

ency, if picked too early, to wilt and to develop only a mediocre, insipid, often astringent flavor necessitates leaving it on the tree until well matured. Since the Hardy tree will hold its fruit until late in the season, it is not so much the fear of losing some of the crop by dropping, but rather the desire to get a premium for early fruit that is responsible for shipments of immature pears. When

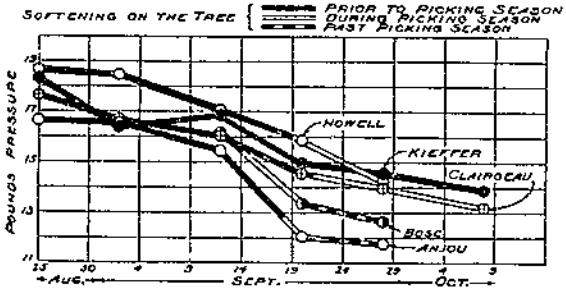

FIGURE 5.—Diagram showing rate of softening on the tree for five varieties of Hudson River Valley pears in 1927

this variety is at its best, its tender, juicy, aromatic flavor is distinctly attractive. If picked too late, its storage life is materially reduced.

As this pear approaches picking maturity its skin loses its dark-green color and begins to show a light-green hue, approximating color standard No. 2 in the color chart. (Pl. 1.) The flesh undergoes a gradual softening, usually at a slightly lower rate during the picking season than just prior to it. In 1926, the pears softened on the tree from July 5 to August 7 from 11.7 to 8.7 pounds, as determined by pressure tests, or approximately 0.1 pound a day. In 1927 the softening was at the rate of about 0.09 pound a day during the ripening period on the tree. Good dessert and storage quality

was obtained in both seasons when the pears were picked at a pressure test between 10 and 9 pounds. The pears of earlier pickings shriveled considerably and lacked sweetness and richness of flavor, and those of later pickings softened rapidly at storage and transit temperatures. On the basis of these tests, Hardy pears should not be picked at a greener stage than indicated by a pressure test of 10 pounds if fairly good quality is to be secured. The best dessert quality was secured in fruit testing 8.5 to 9.5 pounds. However, the larger pears testing less than 9 pounds when picked tended to develop core breakdown in storage.

CLAIRGEAU

Shipments of Clairgeau (*Beurre Clairgeau*) pears from California begin about the middle of August. The variety is classed as one of minor importance, only about 7 per cent of the total acreage in fall

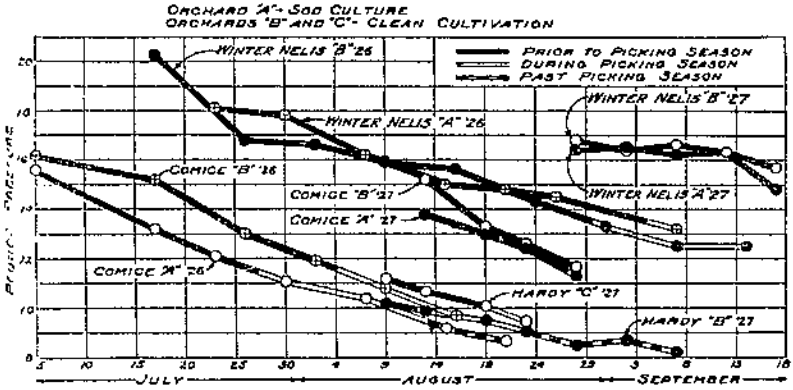

FIGURE 6.—Diagram showing comparative rates of softening on the tree for Santa Clara Valley pears grown in different orchards in 1926 and 1927

and winter pears being devoted to this variety. In the 1926 season the pears softened on the tree from 18.9 to 14.1 pounds as determined by pressure tests, from July 5 to 30, or an average of 0.19 pound a day. In the Hudson River Valley, where this pear is second to the Kieffer in importance, there was practically no softening on the tree in 1926 from September 7 to 30. However, in 1927, during the 44 days from August 25 to October 8, a softening of over 4.6 pounds was noticed, or about 0.1 pound a day. In the Wenatchee district the rate of softening was 0.08 pound a day in 1927 and 0.07 in 1928. The softening rate was fairly uniform throughout the season, which was terminated by the pears dropping from the tree.

The storage life of Clairgeau pears is limited by the development of scald. Since this storage disorder is decreased by late picking, the general recommendation is to allow this variety to remain on the tree as long as possible. The dropping of fruit from the tree usually determines the harvest date of this pear. By this practice the dessert quality is enhanced and the length of the storage life extended. In California the best time to pick was when the pears showed pressure tests of less than 13 pounds; in New York the range

was less than 14.5 pounds; while in the Wenatchee district it was generally less than 14 pounds.

ANJOU

The Anjou (*Beurre d'Anjou*) pear is not a leading commercial variety in California, but holds second place among the late pears in Washington, and is a very important variety in Oregon. It is grown to some extent in the Hudson River Valley of New York. Anjou pears are generally harvested in early September in the Pacific Northwest and somewhat earlier in California. As the Anjou pear matures on the tree its skin undergoes a noticeable change that is a valuable index of maturity. The skin takes on a characteristic waxy finish, losing to some extent its pebble-grained appearance as well as its dull, lusterless look. Since Anjou is very susceptible to wilting if picked immaturely, this skin change, with its accompanying corking over of the lenticels, is important as an insurance against moisture loss and subsequent shriveling. The fruit of the Anjou variety loosens from the tree somewhat markedly as it approaches picking maturity, and some loss from dropping frequently occurs. The increase in size of the fruit remaining on the tree, however, will compensate in tonnage for considerable loss from dropping.

In the Wenatchee Valley this variety showed a gradual softening on the tree, amounting to about a 0.12-pound pressure a day in 1926, 0.13 a day in 1927, and 0.14 a day in 1928. In the Hudson River Valley during the 1927 season there was a softening on the tree from 16.7 pounds on August 25 to 11.8 pounds on September 28, or a daily softening of about 0.15 pound. The rate of softening was most rapid just preceding the picking season. Figures 3, 4, and 5 show the softening rate of this variety in the Wenatchee and Hudson River Valleys. In Washington the best quality has generally been obtained with this variety when picked at a pressure test of 13 to 10 pounds, with a ground color from 2 to 2½, as indicated by shades between 2 and 3 in Plate 1. In New York the best range for picking is estimated to be between 13 and 12 pounds. In Oregon the pressure test range recommended by Hartman (*4*) is 14 to 10 pounds. In the Grand Junction district of Colorado during the 1929 season there was a softening of Anjou pears from 14.6 pounds on August 24 to 12.2 pounds on September 19, or a daily softening of 0.09 pound. Storage tests for the one season would indicate a picking range for this district of 14 pounds or less.

COMICE

Comice (*Doyenne du Comice*) first reaches market from the Pacific coast in the early part of September, the marketing season extending to the Christmas holidays. According to Shear (*11*), this variety ranks fourth in importance among fall and winter pears, Winter Nelis, Anjou, and Bosc preceding it, in the order of their importance, in the sales of Pacific coast pears in the New York auction. During the 1926 season in California this variety softened on the tree from 16.5 to 9.6 pounds from July 5 to August 15, or about 0.17 pound a day. The softening rate was most rapid just preceding the picking season. In 1927 these pears softened about 0.16 pound a

day; and the rate was fairly uniform throughout the season, as indicated in Figure 2. In the Washington district the rate of softening on the tree was somewhat less, amounting to 0.07 pound a day in 1927 and 0.05 pound a day in 1928.

Although Comice pears are not so subject to wilting as Hardy, they require very careful handling to prevent bruising and subsequent darkening of the skin. The use of paper between layers of pears of this variety in the picking boxes is not an uncommon practice to prevent stem punctures and bruising. When picked too early and ripened, this variety is inclined to be somewhat astringent and the skin tough. The best dessert and storage quality was obtained in California Comice by picking when the pressure test was 11.5 to 9 pounds. At the lower figure the fruit became soft sooner than earlier pickings, but the flavor was slightly sweeter. Washington Comice pears were of the best quality when picked at a pressure test of 10 pounds. Good results were also secured when these pears were picked at a pressure test of 11 to 9 pounds. The ground color at this stage of maturity is generally from 2 to 2½.

BOSC

Bosc (*Beurre Bosc*) pears are on the market about the same time as Comice. This variety is grown in all of the Pacific Coast States and also in New York. The Rogue River Valley in southern Oregon is the largest producer of this variety. As work with Bosc in California has been somewhat limited, definite recommendations are not available, but present results indicate that it should be picked at a lower range than in the Medford district of Oregon, where the recommended pressure-test range is from 16 to 14 pounds (*5*). In 1926 the California Bosc softened on the tree at a rate of about 0.08 pound a day. During the same season in Washington the softening rate was 0.07 pound a day, and 0.14 pound a day in 1927. Best quality was obtained with this variety in the Wenatchee Valley when the fruit was picked between 13 and 11 pounds, with the ground color 2½ to 3. The firmness of the best pears was usually about 12 pounds when picked.

The color chart can not readily be used with Bosc pears because of the peculiarly characteristic color of this variety. There is, however, a distinct development of a golden-yellow color as proper maturity approaches.

A characteristic smooth, glossy finish also appears on the Bosc pear as an index of maturity, and there is some loosening of the fruit on the spur.

The late picking of Bosc may predispose the fruit to core breakdown or to breakdown beginning in the slender neck of the fruit. If picked very late, Bosc, when ripened, may have a surface discoloration resembling scald, which occurs particularly on the neck of the pear.

The picking of Bosc in an immature condition generally results in the shriveling of the neck of the fruit while it is in transit or in storage.

In New York during the 1927 season these pears softened a little over 5 pounds from August 25 to September 28, or about 0.15 pound a day. During the picking season the pressure test ranged from

about 15.5 to 13.5 pounds, with only fair quality developing in any of the pickings in either season.

HOWELL

The Howell variety is grown to some extent in the Hudson River Valley and is one of the less important varieties in the Pacific Coast States. During the 1927 season in New York the pears softened on the tree from 18.7 to 14.3 pounds from August 25 to September 28, or about 0.13 pound a day. The softening was most rapid during the latter part of the season. It is probable that pressure tests of 16 to 14 pounds at picking would give satisfactory storage and dessert quality.

KIEFFER

In the Hudson River Valley and in most of the other eastern pear districts the Kieffer leads all other winter pears in commercial importance. During the 1927 season the pears softened from 18.4 to 14 pounds from August 25 to October 8, or at the rate of about 0.1 pound a day. The rate of softening was fairly uniform, as Figure 5 indicates.

In all the lots picked there was much shriveling, suggesting that as a general practice this variety is picked too early. It is likely that fruit picked at a firmness of about 13.5 pounds would be better in quality than earlier pickings.

FLEMISH BEAUTY

The Flemish Beauty variety is of some importance in the Wenatchee district and finds considerable favor in the export trade.

When the fruit is harvested immaturely it loses its characteristic flavor and becomes insipid and watery after it is ripened; it also wilts very readily and has a dull appearance. When properly picked, however, it has a very pleasing flavor, fine-textured flesh, and an attractive appearance in the ripened condition.

In the 1927 season in Washington the pears softened at the rate of about 0.13 pound a day; in 1928 the rate was about 0.17 pound a day. Flemish Beauty pears picked at a pressure test of 13 to 10 pounds, with a ground color from 2 to 2½, ripened satisfactorily and kept well in storage.

When the pear is mature its skin assumes a characteristic smooth finish and may often exhibit a blushed cheek. It drops from the tree quite easily when ready to harvest.

LAWRENCE

Lawrence pears are grown to some extent in the Grand Junction district of Colorado. They are of good quality and keep well in storage. During the season of 1929 this variety at Grand Junction softened from 16.9 pounds on September 13 to 13.2 pounds on October 3, or an average softening of 0.18 pound a day. Storage tests for the one season indicated that the dessert quality was not appreciably improved by allowing the fruit to remain on the tree after reaching a pressure test of 16.9 pounds. The storage quality

was improved, however; so that for best storage and dessert quality a pressure test range of 15.5 to 13.0 pounds at picking time would seem to be desirable.

WINTER NELIS

Winter Nelis is at the present time the leading late pear of the Pacific coast, making up an important portion of the crop from all three States. In California it is generally harvested in early September but is usually held in storage until after Christmas. Harvest in Oregon and Washington is in late September or early October. It is the principal dessert pear on the markets from midwinter until late in the spring. Because of its naturally long life, this pear is not so difficult to handle as some of the softer, more perishable varieties such as the Comice and Hardy. However, many boxes of Winter Nelis reach the consumer with most of the elements of its characteristic spicy, sweet flavor lacking because of its being picked too early. When harvested in an immature condition the pear is somewhat astringent upon ripening; it lacks the attractive yellow ground color showing through the russet and is often shriveled about the stem. Although such pears may be acceptable to those who have never eaten a Winter Nelis in prime condition, they do not stimulate the demand for this excellent winter pear.

During the 1926 season in California the pears softened 8 pounds from July 17 to September 15, or about 0.13 pound per day. (Fig. 1.) In 1927 the rate of softening was less, amounting to 0.07 pound per day. (Fig. 2.) Winter Nelis pears developed the best dessert quality and had a satisfactory storage life when picked at a pressure test of 13.5 to 12 pounds. When the pears were left on the tree until testing 12.5 to 12 pounds, the quality was very good, the pears being sweeter and richer in flavor than earlier pickings, and the storage season was not materially reduced. Fruit testing less than 12 pounds when picked has a tendency to core breakdown in storage, while that picked at a pressure test of over 14 pounds was often astringent in flavor.

In the Wenatchee Valley the rate of softening on the tree was 0.1 pound a day for each of the seasons of 1926, 1927, and 1928. Winter Nelis pears from this district were of the best quality when picked at a pressure test ranging from 14 to 10 pounds, with a ground color of 2 to 2½. The very best pears were usually those picked at about 11 pounds by pressure test. In Oregon, a range of 14 to 11 pounds is likewise recommended (*4*). Since this variety usually clings to the tree well and the market season for the pear is primarily winter and spring, it is best to leave the fruit until well matured.

EASTER BEURRE

Easter Beurre (*Easter*) pears are grown principally in California, but some plantings of this variety are being made in the Pacific Northwest. It is one of the longest-keeping pears, most of the fruit being marketed in the early spring months. Easter Beurre pears offer few hazards in handling, being hard, with a rather rough skin, and slow to ripen. However, in the present tests, earlier pickings of this variety did not ripen with an attractive yellow color when removed from storage and were inclined to be dry and insipid in flavor,

showing some wilting, especially on the smaller specimens. Later pickings were much more attractive and better flavored and held better in storage. In 1926 this variety softened on the tree in California at the rate of 0.16 pound a day just prior to, and during the harvest season, and exhibited the same rate in 1927; in Washington the rate was slightly less for these two years. Easter Beurre pears picked at pressure tests of less than 15 pounds gave the best results in both dessert and storage quality.

SUMMARY OF PICKING RECOMMENDATIONS

The pressure-test range and ground color indicating the picking condition for best dessert and storage quality for each variety studied in California, Washington, and Colorado where typical seasons were encountered are summarized in Table 1.

TABLE 1.—*Pressure-test ranges and ground color indicating best dessert and storage quality of pear varieties from California, Washington, and Colorado*

Variety	Pressure-test range	Ground color [1]	Locality
	Pounds	*Number*	
Hardy	10 to 9	2	Santa Clara Valley, Calif.
Clairgeau	Less than 13		Do.
Do	Less than 14		Wenatchee Valley, Wash.
Anjou	13 to 10	2 -2½	Do.
Do	Less than 14		Grand Junction, Colo.
Comice	11.5 to 9		Santa Clara Valley, Calif.
Do	11 to 9	2 -2½	Wenatchee Valley, Wash.
Bosc	About 14 or less		Santa Clara Valley, Calif.
Do	13 to 11	2½-3	Wenatchee Valley, Wash.
Flemish Beauty	13 to 10	2 -2½	Do.
Lawrence	15.5 to 13		Grand Junction, Colo.
Winter Nelis	13.5 to 12.0		Santa Clara Valley, Calif.
Do	14 to 10	2 -2½	Wenatchee Valley, Wash.
Easter Beurre	Less than 15		Santa Clara Valley, Calif.
Do	do	3	Wenatchee Valley, Wash.

[1] An exp' .nation of the color scale used is given in connection with the color chart illustrated in Plate 1.

EFFECTS OF TOO EARLY PICKING

A comparison of the best picking maturity for the foregoing varieties with the maturity at which many growers have been picking their pears strongly suggests that the practice of picking pears too early in the season has been followed by many orchardists in the past. In the last few years, however, there has been a commendable tendency toward paying more attention to the picking maturity of shipping pears, which has resulted in an improvement in the quality of the product. Certain varieties, particularly Winter Nelis, Anjou, Clairgeau, and in some cases, Hardy, are still generally picked too early for best dessert and storage quality. Overholser and Latimer (*10*), working with California varieties, call attention to this practice by some growers and emphasize the superior dessert and storage quality resulting from pickings of Santa Clara Valley Bosc, Comice, and Hardy made two weeks later than the commercial harvest period.

UNRELIABILITY OF PICKING DATES AND SIZE AS INDEXES OF MATURITY

The unreliability of dates as a picking guide is clearly brought out by the comparison of the seasons shown in Figure 6. In 1926

Comice pears had reached picking maturity by July 27 in orchard A, whereas in 1927 the same maturity was not reached until August 27, a difference of 31 days. In orchard B the difference was 26 days between the two years in this variety. While these differences are very marked because 1926 was an unusually early season, they exist to some extent from year to year, complicating the setting of picking dates.

It is recommended that the grower set a tentative harvest date for each variety, considering the earliness of the season in respect to past seasons and, before this date, give several weeks of attention to the maturity of the fruit itself. By using the pressure tester and color charts, the ripening of the fruit can be followed with the reasonable certainty of knowing when the pears should be removed from the tree.

VARIATION IN FRUIT MATURITY IN DIFFERENT ORCHARDS

The necessity of making the application of maturity data to one's own orchard rather than following the picking period of a neighboring orchardist, no matter how carefully determined by him, is shown by a comparison of picking data of orchards. (Fig. 6.) The three orchards A, B, and C were within a radius of 4 or 5 miles, but A was in sod, and B and C were clean cultivated. The Comice trees in A were older than those in B, while the Winter Nelis trees were about the same age. The Hardy trees in orchards B and C were approximately the same age. A rather marked difference is noticed between the rate of softening of the Comice in orchards A and B during the 1926 season; the difference was evident in 1927 but not so marked. In 1926 this variety was ready to pick about a week earlier in orchard A than in orchard B; in 1927 the difference was about three days, likewise in favor of orchard A. Although the rate of ripening of the Winter Nelis variety followed the same trend in both seasons, the fruit in orchard A reached picking maturity first in 1926 and 1927. As Figure 6 indicates, the Hardy pears were ready to pick about a week earlier in orchard B than in orchard C, both of the orchards being clean cultivated and about the same age. No attempt is made to explain the earliness of the harvest in one orchard with respect to another; but the character of the soil, age of the trees, cultural conditions, and kind of stock undoubtedly affect the maturity of the fruit. Hartman (*5*) found that in regions of lighter soil Bosc pears were ready to harvest earlier than in parts of the Rogue River Valley, Oreg., where heavier soils predominate. This fact has also been observed for a number of the varieties of pears grown in the Wenatchee district. Murneek (*9*) likewise noticed a difference in the time of ripening between orchards of Bartlett pears and emphasized the value of the pressure tester in showing these environmental differences.

CARE IN USE OF PRESSURE TESTER

In using the pressure tester certain precautions should be followed to eliminate errors. One of the most common mistakes made is that

of not selecting adequate or representative samples of fruit for testing. Not less than 10 pears should be tested from the orchard at one time, and these should be selected with regard to size and color, in accordance with picking practices. If the practice is to make several pickings, removing the largest and most mature-looking fruit at each picking, then this is the kind of fruit that should be selected for the pressure test. If all the fruit is to be removed at one picking, an assortment of sizes should be taken and consideration given to the amount of fairly ripe and somewhat green fruit on the tree. The flesh on two or three sides of each pear should be tested to get an average of its texture. By selecting fruit from several trees in different parts of the orchard, obviously a better average of the condition of the crop is obtained than if only one part of the orchard is tested. If decided differences in soil conditions are found in an orchard, it may be advisable to test the fruit separately from these different locations.

The actual manipulation of the pressure tester requires reasonable care and attention. The tip of the plunger should be screwed all the way in, as mentioned before, so that the depth of its penetration will be five-sixteenths of an inch, the same dimension as its diameter. If the tip of the plunger becomes rough or misshapen from careless handling, it should be discarded and a new one used. After removing a small area of skin, about one-half of an inch in diameter, the fruit is placed against the hand or wall or any convenient surface and the end of the plunger directed squarely against the cut surface. The opposite end of the apparatus rests against the hand, and the pressure is applied until the plunger penetrates to a sufficient depth (five-sixteenths of an inch) to push the collar against the metal disk, which completes the circuit, lighting the flash light. The number of pounds indicated on the scale by the sharp line between the black tip and the metal surface of the sleeve, called the "indicator line," is read. Some have made the mistake of using the end of the black tip as the indicator line. In using the new type tester the tip of the plunger is pushed into the pear as far as the groove on the tip and the reading is then taken at the place where the rider rests on the scale. It is important to test the reading of the tester from time to time with an accurate platform scale, pressing down on the scale with the tester until the scale registers a certain number of pounds and checking that figure with the one registered by the instrument. If the machine needs adjustment it should be returned to the manufacturer.

EFFECT OF TRANSIT AND STORAGE TEMPERATURES UPON RIPENING

Physical and chemical changes continue to take place within the pear after it is picked. It has been found that in Bartlett pears, from the time of picking until full ripe, there is a decrease in such substances as starch and pectin materials (*6*). The change in the amount and nature of some of these substances, such as pectose, which give rigidity to cell walls, may account for the softening of the flesh during the ripening period. The acid content of well-matured fruit

remained about constant during storage, and all pickings exhibited an increase in sugars while ripening in storage. Temperature has a direct bearing on most of the changes that occur. Pears held at 30° F. for a period of from six weeks to three months and then ripened at 70° contained more sugar than those held at 40° continuously until ripe, a fact which emphasizes the desirability of using temperatures low enough to nearly suspend physiological activities in the fruit rather than temperatures only sufficiently low to retard ripening somewhat. At 37° the respiration rate of Bartlett pears was found to be about twice that at 30° (*7*), and since the rate of CO_2 output and O_2 intake is an index of the speed at which the ripening process is going on, it follows that the pears were ripening about twice as fast at 37° as at 30°. Gore (*2*) found that for every increase of 18° in temperature, the respiration rate increased 2.23 times in Seckel pears and 2.24 times in Kieffer pears. However, Magness and Ballard (*7*) found that the maturity of the Bartlett pear more markedly affects the respiration rate than does temperature. Pears of the same maturity respired only 1.5 times faster at 60° than at 37° when green; as they ripened the rate increased at both temperatures, but much faster at the higher one. At 60° the respiration rate had reached in 16 days an intensity 8 to 9 times that reached at 37° in 25 days. Nevertheless the temperature at which the fruit was held was the controlling factor, as the higher temperature favored ripening and thus caused an increased respiration rate.

In the commercial storage of fall and winter pears one of two methods is generally followed. Where local storage facilities and conditions are favorable, some growers store their fruit at the shipping point and hold it there until ready to market; other growers and dealers prefer to ship the pears immediately after packing to the terminal markets, where they are held in cold storage. Shipping the fruit from the Pacific coast to the Atlantic coast markets takes about 12 days, during which period the pears are subjected to refrigerator-car temperatures. The temperatures of the top layers of fruit in cars during a 12-day transit period have been found to average about 53° F. in nonprecooled shipments and about 43° to 45° in precooled shipments. Thus, if warm fruit is loaded in the refrigerator car, the top layer will be subjected for 12 days to a temperature averaging about 10° higher than if the fruit had been cooled before shipping. Needless to say, the best precooling practices are those that lower the temperature of the fruit as rapidly as possible. Under ordinary conditions 24 to 48 hours are usually required to reduce the temperature of the pears in the center of the boxes to less than 40° F.; if temperatures much higher than this prevail, the fruit can not be considered precooled.

EXPERIMENTAL METHODS

In order to determine the effect of temperature and time of picking on the commercial storage life of the important varieties of fall and winter pears, investigations were conducted with fruit from California, New York, and Washington, in connection with the work of determining picking maturity. To imitate shipping-point storage, fruit from the early, midseason, and late pickings in California was

stored in rooms held at 30° to 32°, at 36°, and at 70° F. on the day on which it was picked, box lots being stored under each condition. In the Wenatchee Valley, Wash., a storage temperature of 32° was used, and with the New York varieties, storage temperatures of 32°, 40°, and 60° were used. The rate of softening at these temperatures was determined by making pressure tests at regular intervals. Samples of pears were removed from the lower temperatures from time to time and ripened at 70° to ascertain the effect of the storage temperature on ripening quality. The feasible commercial-storage period at shipping point for the different varieties was estimated by considering not only the quality and storage defects upon removal from storage but also the ripening and breakdown which would normally occur in transit and during marketing. A margin of safety has been allowed in arriving at these estimates in order to give reasonable assurance that the fruit will arrive at its destination in a firm condition suitable for marketing.

To imitate shipping and storage at terminal markets, lots from each of the pickings in the Santa Clara Valley were placed in storage at 43° and 53° F. on the day the fruit was picked, and after 12 days at these transit temperatures part of each lot was moved to 31° and held until the storage season ended. Pressure tests were taken at 3-day intervals while the pears were held in temperatures of 43° and 53°, and some of the fruit of most varieties was left at these temperatures until ripe. Observations could thus be made on the prolonged effect of such temperatures on the softening of the pear. From the 31° room, samples of pears were removed at successive dates and ripened at 70°, any difficulty in ripening and any defects in the fruit being noted. The end of the commercial-storage season was determined by taking into consideration the effect of longer holding on dessert quality, storage troubles, and softening, allowing some margin of safety for the disposal of the fruit through the ordinary commercial channels.

DATA FOR DIFFERENT VARIETIES

Although the pressure tester was found to be useful in determining the picking maturity of pears, it was of no particular value in the storage work except for studying the effect of temperature on rate of softening, since in many cases the storage life of the fruit is terminated not by gradual softening, but by storage troubles such as core breakdown, scald, wilting, and decay. The commercial-storage life of some of the pears was limited also by the inferior flavor which they developed when held beyond a certain period of time.

Table 2, compiled from United States Weather Bureau climatological data, gives the weather conditions for the three districts during the seasons in which the work was conducted and indicates that in California an almost normal season was encountered in 1927 and that in Washington the 1928 season was close to normal. However, in the Hudson River Valley of New York, the seasons of 1926 and 1927 were abnormally cold and wet, a fact which may have some bearing on the generally poor storage and dessert quality of the fruit from this section in both of these seasons. Rainfall data for

San Jose and Wenatchee are not given, because the rainfall during the growing season of the fruit is negligible and moisture is supplied by irrigation.

TABLE 2.—*Weather conditions during the latter part of the growing seasons*

SAN JOSE, CALIF.

Period	1926			1927		
	Mean temperature	Departure from normal	Clear days	Mean temperature	Departure from normal	Clear days
	°F.	°F.	Number	°F.	°F.	Number
July	68.8	+2.3	30	67.4	+0.9	20
August	67.0	+.9	25	65.9	−.2	18
September	62.6	−1.6	25	62.8	−1.4	23
October	63.0	+2.9	18	61.8	+1.7	19
Season			98			85

HUDSON, N. Y.

Period	1926					1927				
	Mean temperature	Departure from normal	Rainfall	Departure from normal	Clear days	Mean temperature	Departure from normal	Rainfall	Departure from normal	Clear days
	°F.	°F.	Inches	Inches	Number	°F.	°F.	Inches	Inches	Number
July	69.6	−2.3	3.10	−0.21	20	70.7	−1.2	8.49	+5.18	0
August	69.4	+.7	5.25	+1.23	10	64.3	−4.7	9.51	+5.49	11
September	60.2	−2.7	2.81	−.78	13	61.0	−1.9	2.60	−.99	21
October	47.2	−4.9	4.93	+1.76	10	52.2	+.1	0.37	+3.20	18
Season			16.09	+2.0	53			20.97	+12.88	59

WENATCHEE, WASH.

Period	1926			1927			1928		
	Mean temperature	Departure from normal	Clear days	Mean temperature	Departure from normal	Clear days	Mean temperature	Departure from normal	Clear days
	°F.	°F.	Number	°F.	°F.	Number	°F.	°F.	Number
July	75.5	+2.3	28	73.0	−0.2	25	76.3	+3.0	23
August	70.2	−1.6	23	71.0	−.8	21	71.0	−.7	24
September	56.9	−5.0	21	59.8	−2.1	10	62.6	+1.1	26
October	51.1	+.6	15	49.6	−.9	11	48.6	−1.9	13
Season			87			67			86

In view of the variation between seasons and pickings within the recommended pressure ranges, the storage periods given in Tables 3 to 5 are of more value in comparing the effect of temperature upon ripening than in setting a maximum storage limit that will hold from year to year.

TABLE 3.—*Maximum storage periods of California pears picked in optimum maturity condition*

SHIPPING-POINT STORAGE 31° F.

Variety	1926		1927	
	Storage period	End of storage period	Storage period	End of storage period
	Days	*Month*	*Days*	*Month*
Hardy	125–141	December	76–100	November to December.
Clairgeau	187–197	March		
Comice	120–131	December	55–60	November.
Bosc	167–176	January	115–124	January.
Winter Nelis	233	May	177	April.
Easter Beurre	251	May to June	195–203	April to May.

SHIPPING-POINT STORAGE 36° F.

Hardy	94–105	October to November	45–60	October.
Clairgeau	102–150	November to January		
Comice	87	October	40–43	Do.
Bosc	126–167	November to January	60	November.
Winter Nelis	175	March	141	February to March.
Easter Beurre	231	May	136–144	Do.

TERMINAL-MARKET STORAGE 31° F. (PRECOOLED SHIPMENTS)

Hardy	78–109	November to December	52–117	November to December.
Clairgeau	102–187	November to February		
Comice	120–131	December	58–61	November.
Bosc	167–170	January	60–95	November to December.
Winter Nelis	225	May	201	May.
Easter Beurre	231	do	144–225	April to June.

TERMINAL-MARKET STORAGE 31° F. (NONPRECOOLED SHIPMENTS)

Hardy	15–18	August to September	33–42	October to November.
Clairgeau	60–187	October to February		
Comice	40–47	September	30–45	October.
Bosc	107–116	November	83–124	December.
Winter Nelis	175	March to April	141	February to March.
Easter Beurre	191	do	136–144	Do.

TABLE 4.—*Number of days required for ripening California pears at different temperatures when picked at optimum maturity and stored immediately*

Variety	Time required for ripening at indicated temperature (°F.) for the year—					
	1926			1927		
	70°	53°	43°	70°	53°	43°
	Days	*Days*	*Days*	*Days*	*Days*	*Days*
Hardy	9–12	15–18	24–30	9	15–18	30–45
Clairgeau	15	20	50			
Comice	12	15–18	30–36	9–12	15	30
Bosc	11–12	21–23	56–60	12	18	45–60
Winter Nelis				12	15–18	30
Easter Beurre				18	27	

TABLE 5.—*Picking season and principal storage troubles, other than mold, of leading varieties of California fall and winter pears*

Variety	Picking dates		Principal storage troubles
	1926	1927	
Hardy	July 20 to Aug. 5	Aug. 20 to 31	Shrivel, core breakdown, scald.
Clairgeau	Aug. 8 to 18		Scald.
Comice	Aug. 1 to 12	Sept. 6 to 13	Core breakdown.
Bosc	July 23 to Aug. 3	Aug. 25 to Sept. 3	Surface and core breakdown, shrivel.
Winter Nelis	Sept. 15	Sept. 16 to Oct. 7	Core and flesh breakdown.
Easter Beurre	Sept. 19	Oct. 4 to 12	Surface and core breakdown.

These data show the storage behavior of California varieties of pears picked at optimum maturity and held at various temperatures, while Table 6 shows the amount of softening that takes place in each of the varieties during 12 days at temperatures representing precooled and nonprecooled shipments. The data show the rate of softening, at various storage and transit temperatures, of midseason pickings representing each variety, respectively. Later, a discussion of the storage life of each variety is given.

TABLE 6.—*Average amount of softening at temperatures approximately those of top layers in cars of different varieties of pears during a period of 12 days, as shown by pressure tests*

Variety	Softening as shown by pressure test		Variety	Softening as shown by pressure test	
	Nonprecooled (53° F.)	Precooled (43° F.)		Nonprecooled (53° F.)	Precooled (43° F.)
	Pounds	*Pounds*		*Pounds*	*Pounds*
Winter Nelis	6.5	1.4	Bosc	3.5	2.1
Hardy	5.4	1.2	Easter Beurre	2.5	.5
Comice	5.0	.6	Clairgeau	1.1	.9

HARDY

Table 3 gives the effect of two temperatures on the storage life of California Hardy pears at shipping point and at terminal market. The data given are for pickings made during the optimum harvesting period of 10 to 9 pounds, as determined by pressure tests, and do not include preseason or late pickings. This variety in 1926 was held at shipping point at 31° F. until December 8; in 1927 it was held until November 28. Although terminating at approximately the same date, the storage season in 1927 was much the shorter of the two, since the date of harvesting in 1927 was about one month later than that in 1926. At 36° the storage life was reduced three to four weeks, ending on November 18 in 1926, and on October 19 in 1927. The length of storage at 31° following 12 days at 43° closely approximated the commercial life at 31° in both seasons, but the amount of ripening resulting from transit temperatures 10° higher reduced the storage life by three to six weeks. After 12 days at 53°, many lots were nearly ripe and were suitable for only

very short holding, if any, at cold-storage temperatures. The New York auction reports (*11*) show that Hardy pears were off the market by the middle of November, 1926, the peak of sales occurring about September 15. In 1927 (*1*) the peak of sales was reached about a month later, as would be expected from the fact that the harvesting period was about a month later than in 1926.

The most common storage defect of Hardy pears was wilting, especially in the fruit of the earlier pickings. That this variety is more susceptible to moisture loss than either Bosc or Comice is indicated by Overholser and Latimer (*10*), who found that early pickings lost 13.7 per cent moisture on ripening as compared with 12.3 and 11.4 per cent, respectively, for Bosc and Comice. They found that in all cases the earlier pickings lost the most weight. Core breakdown was another limiting factor in the storage life of Hardy pears. This variety, except in the very late pickings, would not ripen at cold-storage temperatures but ripened with excellent quality at temperatures of 53° and 70° F. As mentioned later, Clairgeau and

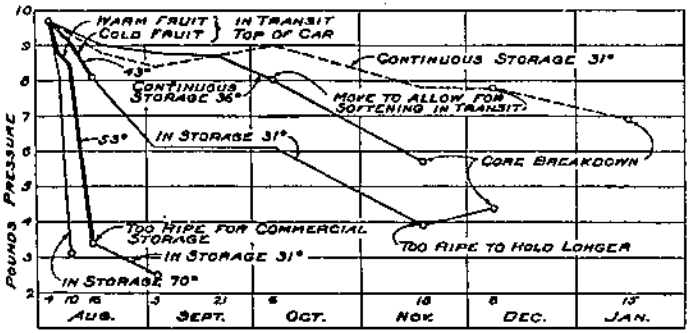

FIGURE 7.—Diagram showing rate of softening in transit and storage for Hardy pears picked late in 1926, in the Santa Clara Valley, Calif.

Bosc were similar to the Hardy in this respect, while Comice, Winter Nelis, and Easter Beurre ripened at 31° and at 36° if held long enough at these low temperatures. The effect of transit and storage temperatures on the rate of softening of Hardy pears is presented in Figure 7.

CLAIRGEAU

All lots of Clairgeau pears from the Santa Clara Valley, Calif., were held in storage at 31° F. in good condition continuously for more than six months, that is, until February 21. Some lots after being held 12 days at 43° and 53° had a similar storage period at 31°. Storage at 36° shortened the season by one and a half to three months, some lots ending their season on November 18. One lot, stored at 31° after being held 12 days at 53°, was in eating-ripe condition by October 6. These dates represent the minimum storage periods, some lots holding up considerably longer at each temperature. Scald was the most important storage trouble. The Clairgeau variety had disappeared from the New York auction by the last of December in 1926, the year in which the investigation was conducted, the peak being reached about the first week in October.

At 32° F. the storage life of the Clairgeau pears from the Hudson River Valley, N. Y., was 80 to 100 days, extending to December and

January; at 40° the storage life was reduced to 30 to 50 days. Clairgeau pears from the Wenatchee Valley, Wash., have been held satisfactorily in storage at 32° for periods of four to six months. This variety of pear from California, New York, and Washington failed to ripen when held continuously at 31°, 36°, and 40°, necessitating its removal from low temperatures to 50° or higher in order to ripen properly. Figure 8 gives the softening rate of California Clairgeaus at 31°, 36°, 53° to 31°, 43° to 31°, and 70°.

ANJOU

The Washington Anjou pears were held in satisfactory commercial condition at 32° F. storage for four to five months, and have been observed in excellent condition even after storage periods up to six months.

When properly picked the Anjou has a very delicious flavor and aroma, with a flesh of melting texture. This variety has frequently

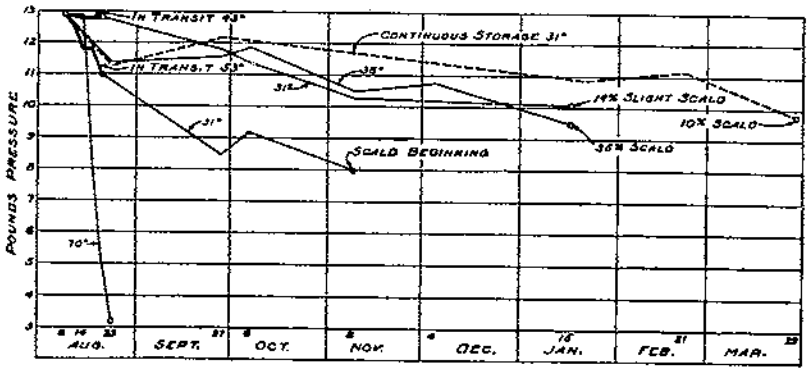

FIGURE 8.—Diagram showing rate of softening in transit and storage for Clairgeau pears picked in midseason, 1926, in the Santa Clara Valley, Calif.

been in a condition too immature to give the highest dessert quality. The highest quality found in any Anjou pears of the experimental lots has invariably been in those picked at a pressure test of from 11 to 10 pounds. If a considerable acreage of this pear is to be harvested, or very late storage is intended, it is generally desirable, however, to start picking when the fruit is somewhat firmer than this pressure, and for these reasons a range of 13 to 10 pounds has been suggested.

The best quality is achieved if the Anjou pears are taken from 32° F. while still green and ripened at temperatures of 60° to 70°.

New York Anjou pears were held in a commercially satisfactory condition at 32° F. for two to three months; at 40°, the limit of their storage life was one month. As heretofore mentioned, all the New York pears studied were of very poor storage and dessert quality, possibly owing to the cold wet growing season prevailing during both years in which the study was made. The softening rate of Washington Anjou pears stored at 32° in 1927 is given in Figure 9. The softening of fruit from four orchards, A to D, is shown. The commercial season for this pear, as indicated by market reports, extended to March in 1926 and to January in 1927, the peak of the sales in

both years falling in December. However, this pear is seen much later on the fruit stands and retail markets.

COMICE

The California Comice was held commercially until November and December at 31° F. Some lots held 12 days at 43°, then at 31° kept almost as long, giving this variety a storage life of 2 to 4 months. At 36° its life was 1½ to 2 months, while in storage at 31° after 12

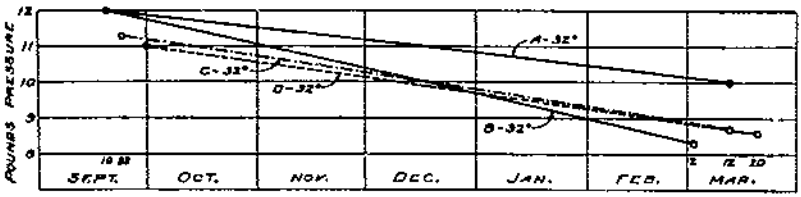

FIGURE 9.—Diagram showing rate of softening in storage for Anjou pears from Wenatchee Valley, Wash., during the 1927 season. Fruit from four orchards, A to D

days at 52°, representing storage at terminal markets after nonprecooled shipment, the pears kept only 1 to 1½ months. The commercial season for Comice pears is practically ended in December, and only lots kept at low temperatures can be held this long. The most common storage disorder was core breakdown. This variety does not need to be given a ripening period at warmer temperatures after cold storage, but may be kept at 31° and 36° until eating ripe, if desired.

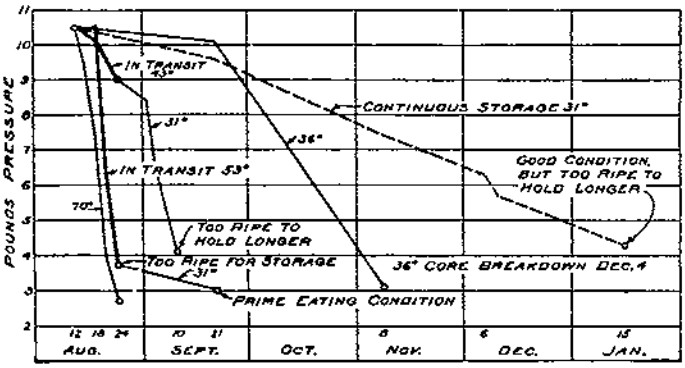

FIGURE 10.—Diagram showing rate of softening in transit and storage of Comice pears picked in midseason, 1926, in the Santa Clara Valley, Calif.

The Washington Comice has been held satisfactorily in storage at 32° F. at Wenatchee for two to three months. It is the common experience in many northwestern fruit districts, however, that the Comice pear requires special care in harvesting and handling. It ripens quickly, is at its best picking maturity when relatively soft, must be handled carefully to avoid injury, and, owing to its rapid ripening habits, must be placed at relatively low temperatures soon after harvest in order to avoid overripeness and core breakdown. The softening rate of this variety is shown in Figure 10.

BOSC

In 1926 California Bosc pears were held satisfactorily in storage until the middle of January, both continuously at 31° F. and at 31° after a 12-day period at 43°, the latter conditions representing terminal-market storage following shipment of precooled fruit. The fruit was held until the middle of November in storage at 31° following 12 days at 53° and about the same length of time in continuous storage at 36°. The storage season was generally shorter at all temperatures in 1927 than in 1926. The principal storage defects observed were surface and core breakdown and wilting, especially at the neck of the pear. The experience with the California Bosc in storage was that it did not ripen at temperatures less than 53° but ripened satisfactorily at that temperature and at 60° and 70°. This

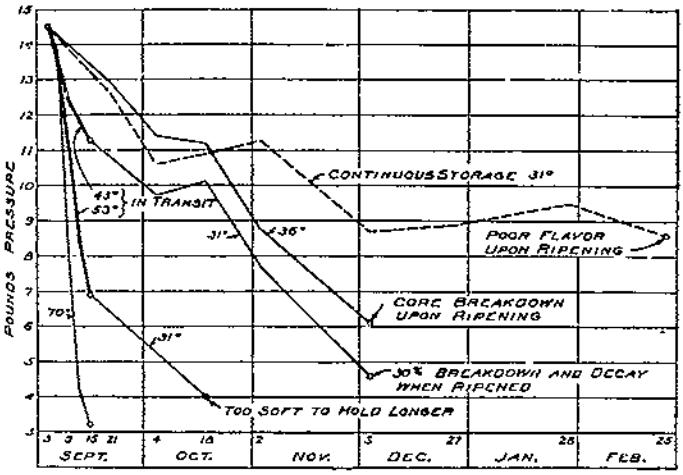

FIGURE 11.—Diagram showing rate of softening in transit and storage for Bosc pears picked in midseason, 1927, in the Santa Clara Valley, Calif.

is in accord with results of recent investigations on Oregon Bosc (5). In general, the Oregon Bosc pears had a similar storage life, holding up until the last of January at 32° continuously and at 32° after a 12-day period at 43°, and about a month less at 32° after a 12-day period at 53°.

The Washington Bosc pears from Wenatchee have been generally held in storage satisfactorily at 32° F. for a period of two to three months. Very late picking or very long storage seems to predispose the fruit to internal breakdown or surface discoloration. The Washington pears seem to behave in storage similarly to those from other sections.

In 1926 the storage life of New York Bosc was about 90 days at 32° F. and about 40 days at 40°, enabling it to be held until about the middle of December at 32° and to the last of October at 40°. The New York Bosc behaved similarly to the California, Washington, and Oregon fruit in not ripening at low temperatures. The New York Bosc pears would not ripen at either 32° or 40°, but at 50°

or 60° they developed good quality. Surface breakdown was the most common storage trouble in the New York Bosc. The softening rate of California Bosc pears is given in Figure 11. While most of the sales of this variety on the auction occur in October, some Bosc pears are sold as late as January.

HOWELL

Hudson River Valley Howell pears were held one to two months at 32° F., most lots being ready to move at the end of one month, or

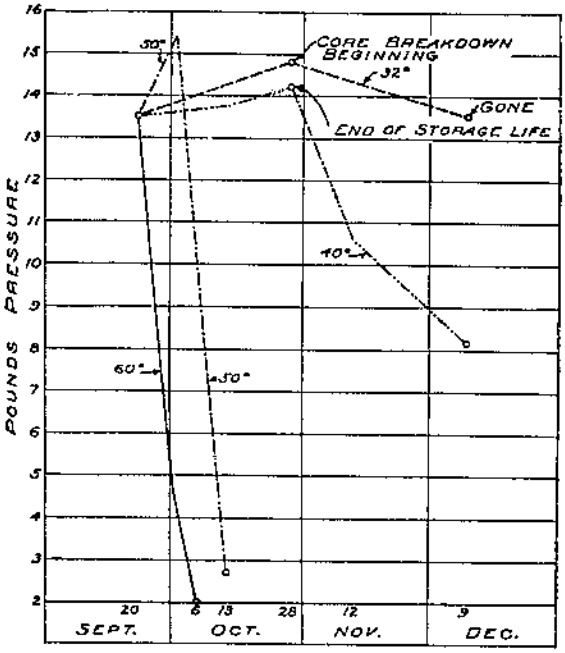

FIGURE 12.—Diagram showing rate of softening in storage for Howell pears picked in midseason, 1927, in the Hudson River Valley, N. Y.

about October 15. At 40° the fruit was held three to six weeks. The storage defects noticed on this variety were core and surface breakdown. Figure 12 shows the effect of temperature on the softening rate of Howell pears.

KIEFFER

The important New York variety, Kieffer, was held in storage one to two months in good condition at 32° F., bringing its season to the last of November; at 40° it held in storage about a month. The pears shriveled considerably and showed some surface breakdown. It is probable that late pickings or fruit grown in more representative seasons with respect to temperature and rainfall would exhibit better

storage quality. Its behavior at various temperatures is shown in Figure 13.

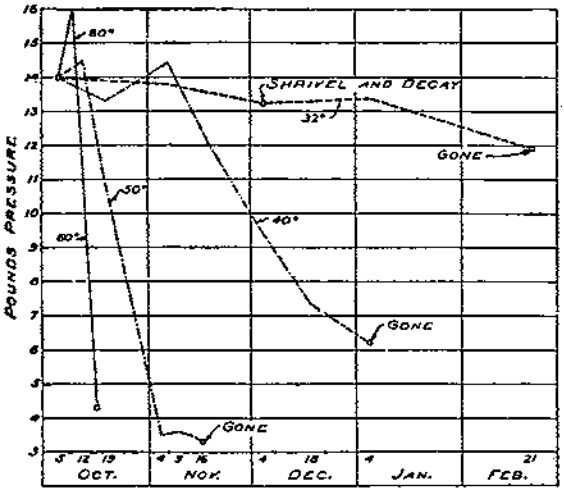

FIGURE 13.—Diagram showing rate of softening in storage for Kieffer pears picked in midseason, 1926, in the Hudson River Valley, N. Y.

FLEMISH BEAUTY

Washington Flemish Beauty from the Wenatchee Valley has been held satisfactorily in storage at 32° F. for four to five months. When picked in an immature condition the fruit wilts readily in storage and ripens with an insipid, watery flesh, but if harvested

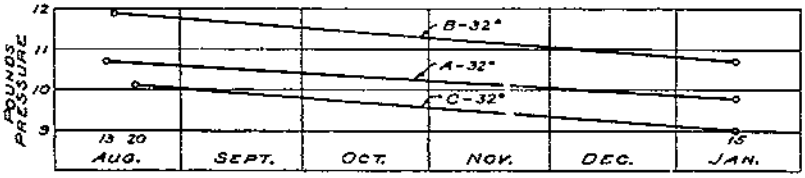

FIGURE 14.—Diagram showing rate of softening in storage for Flemish Beauty pears from the Wenatchee Valley, Wash., during the 1928 season. Fruit from three orchards, A to C

when properly matured it has a delicious, juicy flesh. The softening rates for Washington Flemish Beauty are given in Figure 14.

WINTER NELIS

During both seasons in which investigations were conducted, the Santa Clara Valley Winter Nelis pears were held continuously in storage until April or May at 31° F., and at 31° following 12 days storage at 43°. At 36° storage the pears held in commercial condition until about the first of March. Those held at 31° following 12 days of storage at 53° were in good condition until the last of March in 1926 and until late February in 1927. The results of the investi-

gations indicate that when Winter Nelis pears are kept at a continuous temperature of 31° or shipped after precooling and held at 31° at the terminal market, they can be held seven to eight months. The most common troubles in storage with the California fruit were core and flesh breakdown. Early pickings showed considerable wilting, but in those made in the recommended picking range, this trouble was not serious.

Winter Nelis pears from Washington have been satisfactorily held in storage at 32° F. for periods up to six months. The fruit matures on the trees at a time when atmospheric temperature conditions are favorable; therefore it does not usually require so much haste in harvesting as do most other varieties.

Occasionally the pears are picked in a too immature condition, when they wilt very readily in storage and will not ripen with the spicy, sweet flavor characteristic of the variety. The flesh of Winter Nelis pears picked in an immature condition is very likely to remain astringent when the fruit is ripened.

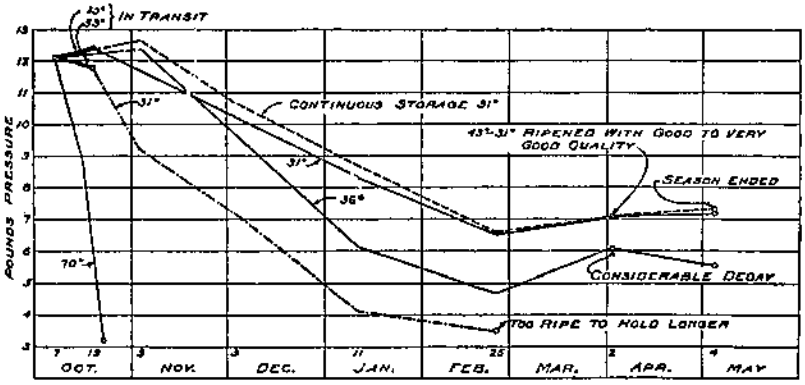

FIGURE 15.—Diagram showing rate of softening in transit and storage for Winter Nelis pears picked late in 1927 in the Santa Clara Valley, Calif.

Figure 15 shows the rate of softening of this variety at transit and storage temperatures.

Evidently some Winter Nelis pears are held to the limit of their commercial storage season, for records of the New York auction in 1926 show sales as late as May, and in 1927 some were disposed of in June at the top price for the year. This variety requires no special attention as to ripening temperature, for it ripens under cold-storage conditions if kept long enough.

EASTER BEURRE

Easter Beurre pears from California held about as long at the various storage temperatures as Winter Nelis. In continuous storage at 31° F. they held until the last of May in 1926 and until the last of April in 1927. In fruit held for 12 days at 43° and then stored at 31° the storage life was about the same; while at 53° to 31° the pears held until February or March. In storage at 36° continuously the fruit in 1926 kept about as long as at 31°, but in 1927 the storage life was a month less at the higher temperature. The effect of low

temperatures in slowing down the ripening processes is shown in Figure 16. Easter Beurre pears are sold chiefly in the late spring and can be found on the market as late as May and June.

Easter Beurre pears from Washington have a long storage life and have been held at 32° F. for periods up to 6 months, and a longer holding period is possible. This is a characteristically long-storage variety and does not seem to develop its best flavor until a period of some months has been passed in cold storage.

EFFECT OF TEMPERATURE ON RATE OF RIPENING

The best temperature for holding all the varieties of pears was 30° to 32° F. While the freezing point of the late varieties of pears has not been determined, the maximum freezing point for Bartlett pears was found to be 28.7° (*13*), indicating that storage tempera-

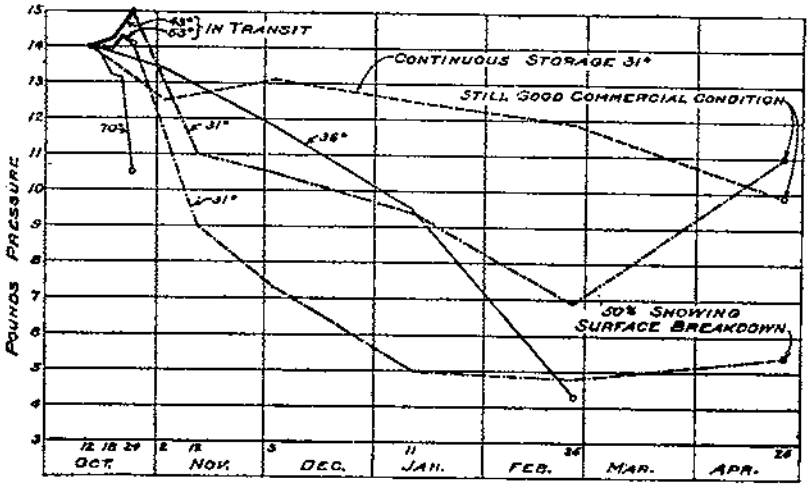

FIGURE 16.—Diagram showing rate of softening in transit and storage for Easter Beurre pears picked late in 1927 in the Santa Clara Valley, Calif.

tures of 30° to 32° may be used without danger of freezing the fruit, provided uniform temperatures are maintained in the storage rooms. As shown by the softening curves for the various temperatures, the ripening rate was markedly affected by temperature. Storage at 36° reduced the life of some of the shorter-lived varieties, such as Comice and Hardy, one-third to one-half as compared with their life at 31°. The effect was not so marked on the slower ripening sorts, such as Winter Nelis and Easter Beurre, but in all cases the storage life was less at 36° than at 31°.

Holding the fruit at fairly high temperatures for a short period immediately after picking has a marked effect upon its softening. Table 6 gives the average amount of softening in each variety as determined by pressure tests, during a 12-day period at 53° and 43°F. These data indicate the amount of ripening taking place in the top layers of fruit in nonprecooled and in precooled shipments, respectively, while in transit to eastern markets.

The difference in the amount of softening is least marked in the Clairgeau and Bosc varieties and most striking in the Comice, Hardy,

and Winter Nelis. From the amount of ripening that takes place during the short period at 53° F., it is not surprising to find the subsequent storage life at 31° only about one-fourth as long in the Hardy and one-half as long in the Comice as the storage life of fruit held at 31° continuously from the time of picking. In comparing the effects of transit at 43° and at 53° on the subsequent storage life at 31°, a study of Table 3 indicates that the lower transit temperature often added two months to the storage life of most varieties. Little difference was noted, however, in the subsequent storage life of Clairgeau pears held at 43° and at 53° during the transit periods. When pears were held 70°, 53°, and 43° from the time of picking to ripening, they reached the ripe stage in about half the time at 53° as at 43° and in about two-thirds the time at 70° as at 53°.

EFFECT OF TEMPERATURE ON DESSERT QUALITY

The temperature at which three of the varieties were ripened was of importance. Hardy, Clairgeau, and Bosc should be held as nearly as possible at 30° to 32° F. until ready for market but should then be removed to temperatures of 60° to 70° to ripen. If these temperatures do not prevail at the place of marketing, the fruit should be placed in a room held at this temperature until it is in firm, eating-ripe condition. Subsequently, it can be exposed to colder temperatures without impairing the quality. While the other varieties of fall and winter pears included in the investigation ripened at cold-storage temperatures, a more attractive yellow color and a more aromatic flavor usually result from ripening at a temperature of about 70°. Much higher temperatures are not desirable and may result in poorly flavored, tough-textured pears, or in losses from decay before softening, as pointed out by Villiers (*12*).

SUMMARY

Allowing pears to remain on the tree until sufficiently mature increases the sugar content and reduces the astringent properties, wilting, and, on susceptible varieties, scald in storage.

Leaving the fruit on the trees too long causes deterioration in quality and may cause serious troubles in storage and transit, such as core breakdown and too rapid softening. Fruit rots are generally more prevalent in pears that are harvested and packed when too mature.

Because of the importance of the effect of the maturity of the pear when picked upon its subsequent dessert and storage quality, the expression of picking maturity in more positive terms has been attempted by using the firmness of the flesh of the pear as the index of maturity and measuring this by means of a pressure tester.

The softening on the trees of the important varieties of fall and winter pears in the Santa Clara Valley, Calif., Wenatchee Valley, Wash., Grand Junction district of Colorado, and Hudson River Valley, N. Y., was determined during the latter part of several growing seasons. The best time to pick the fruit was ascertained by picking at intervals and holding it in storage until ripe. The picking recommendations for each of the varieties studied in California, Washington, and Colorado, where typical seasons were encountered, have been summarized in Table 1 (p. 11).

Chemical and physical changes continue to take place within the pears after they are removed from the trees, the temperature at which the fruit is held markedly affecting the rate of these changes.

For the longest storage life, pears should be held from the time of picking at a temperature of 30° to 31° F. Storage at 36° reduced the storage life one-third to one-half in the shorter lived varieties, such as Hardy and Comice, as compared with their storage life at 31°.

The lowered transit temperatures of precooled shipments generally added one to two months to the subsequent storage life at 31° F. as compared with that of nonprecooled shipments.

For the best dessert quality, the pears should be removed from cold-storage temperatures and ripened at 60° to 70° F. While some varieties will ripen with fairly good quality at low temperatures, Hardy, Bosc, and Clairgeau will not; they require special treatment in this respect.

When handled properly Easter Beurre and Winter Nelis pears can be held in storage at 32° F. for 7 or 8 months. Bosc pears at this temperature can be held 2 to 3 months, and Clairgeau can be held 4 to 6 months. Comice and Hardy can usually be held 2 to 4 months at 32° F. The storage life of Anjou pears at this temperature is usually from 4 to 5 months, although properly handled lots can be held up to 6 or 7 months.

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