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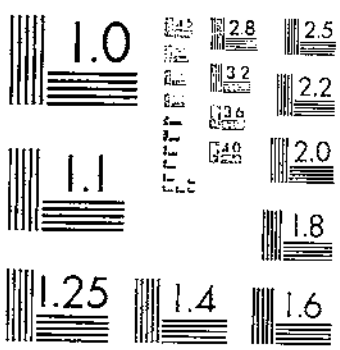
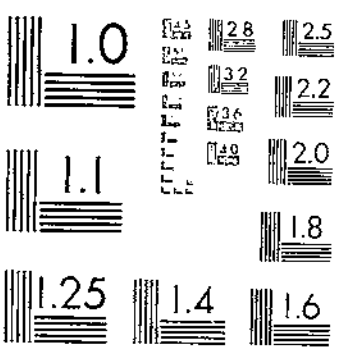


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A



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RELATION OF MATURITY AND HANDLING OF BARTLETT PEARS IN THE PACIFIC NORTHWEST TO QUALITY OF THE CANNED PRODUCT

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INTRODUCTION

The increased acreage planted to all varieties of pears in the Pacific Coast States during the past decade, which is being reflected in the increased tonnage, makes it evident that there must be an increased outlet if the growers of these pears are to continue in the business. Although the total yield has varied greatly from year to year, there has been a marked tendency toward increased production, which will be further augmented as the younger trees reach full-bearing age. For the 5-year period 1921–25 the average annual production of pears in California, Oregon, and Washington was 216,897 tons,[2] with a maximum crop of 272,208 tons in 1925. For the 6 years 1926–31 the average annual production was 353,440 tons, the largest crop being 445,928 tons in 1930 (*15*).[3]

One of the leading pear varieties grown in the Northwest is the Bartlett, but owing to its short storage period it cannot be successfully

[1] The writers wish to express their appreciation to J. S. Caldwell, senior physiologist, Division of Fruits and Vegetable Crops and Diseases, for helpful suggestions and criticisms; also to Libby, McNeill & Libby (in whose plant at Yakima, Wash., the experimental canning was done) for helpful cooperation, and especially to the personnel of the Yakima plant for assistance in the preparation and processing of the pear. Mention should also be made of the helpful interest and assistance given by the secretary and members of the Northwest Canners Association.

[2] On the basis of 1 bushel=48 pounds.

[3] Italic numbers in parentheses refer to Literature Cited, p. 23.

stored and marketed throughout the winter season. However, the Bartlett is the variety most desired by the canning trade, and a large percentage of the crop of this variety grown in the Pacific Northwest is taken by the canners.

In the Yakima and Wenatchee Valley districts of Washington during the years 1928 to 1931, inclusive, the Bartlett represented 67 percent of all pears shipped,[4] exclusive of those delivered direct to the canneries by the growers. The latter item would probably bring the percentage of Bartletts to 75 percent of the total pear crop. Data furnished by the Northwest Canners Association show that with an average crop of 55,500 tons of Bartletts produced in these districts during these 4 years, 39,850 tons, or 71.8 percent, were taken by the canneries. Comparable figures for Oregon show that with an average Bartlett crop of 23,000 tons, 12,625 tons (54.9 percent) were taken by the canneries. These figures will vary from year to year, depending upon the relative prices offered by the canner and by the fresh-fruit buyer. As production increases, it seems likely that an even larger percentage of the crop will find its way to the canneries.

PURPOSE AND PLAN OF WORK

The estimated annual per capita consumption of canned pears is 0.55 pound compared with 3 pounds for peaches and 1.02 pounds for apples (*16*). If the use of canned pears is to be stimulated, factors affecting the quality of the canned product should be known, and the practices that give the best quality in the finished product should be followed. Experimental work as well as commercial experience has demonstrated clearly that the maturity of Bartlett pears at picking time has a decided influence upon the dessert quality of the fruit when it is ripened for immediate consumption, as well as upon the length of time the fruit can be held satisfactorily in storage.

The search for definite indices for harvesting pears at the proper stage of maturity has resulted in the selection of such factors as firmness of flesh, color of skin, and corking of the lenticels as the most satisfactory. Firmness is measured by the resistance, expressed in pounds, offered to the piercing of the flesh with a steel plunger of a standard size to a definite depth (*7*, *9*). This index has been commonly called the pressure test. Experiments conducted by Magness, Diehl, and Allen (*6*), Hartman (*2*), and Hartman, Reimer, and Norris (*3*) have shown that there is a close correlation between the firmness of the flesh of Bartlett pears as measured by the pressure tester, the quality of the ripened product, and the length of time the fruit may be held in storage. The work of these investigators was done primarily with the idea of obtaining the best product from a fresh-fruit standpoint. The recommendations as to time of picking and methods of handling were made so as to secure the best product possible for the fresh-fruit market. However, the application of the same indices to Bartlett pears intended for the cannery has resulted in the question as to whether the same maturity and harvesting recommendations would serve for pears intended for the cannery. Mag-

[4] Information obtained from the State Horticultural Office at Yakima, Wash., and from the Wenatchee Valley Traffic Association, Wenatchee, Wash.

ness (5) called attention to the possibility of leaving the pears intended for the cannery on the trees until a more mature stage is reached than is desirable for fresh-fruit shipment, and emphasized the fact that in much of the canned fruit of poor dessert quality this quality is doubtless due to the inferiority of the fruit itself at the time of canning.

This question is of special interest to the grower because of the increased tonnage that may be secured by leaving the fruit on the tree until the lower pressure tests are reached. Since a drop of 1 pound in pressure requires that the fruit be left on the trees approximately 5 to 7 days longer, and during this time, owing to the increase in size (the tonnage increase is approximately 10 percent), it is advantageous for the grower to allow the fruit to remain on the tree and thus secure the additional weight. However, fruit that is allowed to remain on the tree too long tends to break down at the core before it reaches the stage of softness desirable for canning. The maximum length of time for which the fruit can be held in storage is usually of less importance for cannery pears, and so earliness of picking is not a major factor in that respect. The early-picked fruit generally receives no price premium from the canner as is usually the case with fruit shipped to the fresh-fruit market.

The matter of correct harvesting time is of interest not only to the grower but to the canner as well. The latter is concerned not only with the stage of maturity at which the fruit is picked but also with the effect of certain harvesting and handling practices, if such practices affect the final canned product.

Questions of particular interest to the canner at present are as follows: At what stage of maturity should Bartlett pears be picked in order to get the best product? Does cold storage of the fresh fruit alter the quality of the final product? If not, how long can the fresh fruit be stored to increase the operating period or seasonal capacity of the cannery? What effect does delaying at relatively high temperatures before storage have on the fruit when maximum length of storage is not important? What effect do the temperature and humidity of the ripening-room have on the quality of the canned product?

It was with these questions in mind that the experiments herein reported were undertaken. They deal entirely with problems of maturity and handling of the fruit prior to its entry into the preparation and processing rooms of the cannery. For this reason standard cannery practice was followed throughout in the preparation and processing, and conditions were kept as nearly uniform as possible. Therefore, any difference noted in the various lots may be ascribed to the treatment received before entry into the preparation room.

In 1927 at the annual meeting of the Northwest Canners Association, C. B. McCall [5] reported the results of some preliminary experiments carried on cooperatively with the junior writer of this bulletin, on the effect of the maturity and storage on the quality of canned pears. In this report McCall called attention to the need of additional work along this and related lines with the idea of securing a better quality of canned pears through an improvement in the raw

[5] McCALL, C. B. THE PROPER DEGREE OF MATURITY FOR CANNING PEARS. Northwest Canners Assoc. Circ. 394, Feb. 10, 1927. [Mimeographed.]

product. No further experiments were conducted at that time, but during the season of 1929 the present writers resumed the work. A mimeographed preliminary report of the investigations was issued in 1931.[6]

The effects of the various maturity, handling, and storage practices included in this study were checked in two ways, (1) as shown by the chemical and physical properties of the fruit, and (2) as shown in the final canned product. Enough material (a 50-pound lug) was included in each treatment to allow a sample to be taken for chemical analysis at the time of harvesting and again at the end of the treatment (i. e., at the time the fruit was ready for processing) and to permit canning of adequate samples for the subsequent examination of the canned product. The work herein reported was continued through the years 1929, 1930, and 1931.

MATERIAL AND METHODS

SOURCE OF MATERIAL

In order that conditions throughout the investigation might be uniform except for the experimental variations, arrangements were made with the growers before the work was begun, whereby the harvesting of the pears was under the control of a representative of the United States Department of Agriculture. For this purpose two orchards in the Yakima Valley of Washington were selected. One of these was located on a heavy loam soil, and pears taken from it were used throughout the 3 years. Another orchard planted on a gravelly loam was selected for the 1929 work, but was changed in 1930 and 1931 for one on a light sandy loam. In 1931 a third orchard was selected on a medium loam soil, and fruit from this orchard was used exclusively for the short-term (1 to 10 days) storage test, with a maximum storage of 30 days. Representative trees apparently in good vigor and normal as to water supply and similar significant factors were selected. The trees, of full bearing age, bore a good crop of fruit each year, and although the annual tonnage varied, the amount per tree was as good as or better than the average yield of the other trees in the same orchard for that year. Fruit from the two orchards was used throughout the experiments except in the case of the very short storage (1 to 10 days) lots of 1931. This procedure permitted a comparison of the effect of the two soil types as well as a check on the effect of the different precanning treatments.

SELECTION OF MATERIAL

In the preparation of the different lots a composite sample from the different trees was selected. In the earlier pickings the fruit was picked for size, the minimum diameter being 2⅜ inches (no. 1 cannery grade). Thus the earlier pickings served as a means of thinning the fruit, a common practice in the Yakima and Wenatchee districts. With trees used for the experiments this thinning was usually necessary to prevent breaking of the branches. Later in the season all of the fruit was picked from the selected branches, but

[6] EZELL, B. D., and DIEHL, H. C. THE RELATION OF MATURITY AND HANDLING TO QUALITY IN CANNED BARTLETT PEARS. Feb. 1931. [Mimeographed.]

pears taken from branches on several trees were included each time to give a composite sample.

In determining the maturity, 10 representative pears were taken and pressure tests were made on the pared flesh after harvest by means of the United States Department of Agriculture pressure tester, using the $\frac{5}{16}$-inch plunger.

Samples for chemical analysis were also taken from 10 representative fruits. With the aid of a cork borer, a portion of each fruit extending through the short axis and including portions of the blushed and unblushed sides was taken. The skin and core were removed and 100 g of the tissue sliced directly into the beaker containing 100 cc of 95-percent alcohol for preservation. This material was then added to enough boiling alcohol to make a final alcohol concentration of 80 percent, and boiled for 3 minutes. The preserved material was stored in tightly stoppered glass bottles until the final analytical work was done during the following winter.

METHOD OF HANDLING

Throughout the work the treatment of the fruit was uniform except for the particular handling or storage variation to be studied. Cold storage at 30° to 32° F. usually began within 2 or 3 hours after harvest, and there was never a delay of more than half a day at atmospheric temperatures, except for those lots which were ripened immediately or delayed a specified time before storing. When ripened immediately the fruit was placed directly in the ripening room at 70°. When storage of the pears was delayed, the period of delay was calculated from the time at which the fruit for immediate storage arrived at the warehouse. The delayed-storage lots were held at the warehouse at a temperature of approximately 70° until placed in cold storage. The immediate-storage lots were held at 30° to 32° until removed to the ripening room. The ripening-room temperature was about 70° with a relative humidity of 78 to 85 percent except as noted below where the effect of variation in these factors was studied.

Standard cannery procedure was followed in the preparation and processing of the fruit. The experimental lots were placed directly in the cannery line along with fruit being processed commercially at the same time. For analysis of the fruit at harvest the samples were taken within a few hours after the fruit was picked. Samples of the ripened fruit were taken when the fruit was ready for canning, and a uniform stage of ripeness was used as a criterion rather than a uniform period in the ripening room, because of the difference in time required for the various lots to reach a comparable stage of ripeness. Six days in the ripening room was usually sufficient for cold-storage fruit, and the time varied comparatively little with the different lots. Fruit delayed at a temperature around 70° F. before storage required somewhat less time, and fruit ripened without storage required several days longer. Throughout the work, either in canning or in taking samples for chemical analysis, the maturity of the fruit rather than the number of days the fruit had been in the ripening room was taken as a guide.

METHOD OF CHEMICAL ANALYSIS

The samples were prepared for analysis by decanting the alcohol from the preserved material through a weighed filter paper placed inside the extraction thimble. The thimble containing the sample was washed 2 or 3 times with 80-percent alcohol and then transferred to a Soxhlet apparatus and extracted with 80-percent alcohol for 8 hours. In the latter part of the work it was found that by macerating the tissue the extraction period could be reduced to 4 hours. The extract was combined with the preserving fluid made up to definite volume, and aliquot portions were taken for the various determinations.

The determinations made upon the material included total solids, alcohol-soluble and alcohol-insoluble materials, free reducing and total sugars, and total acidity. The alcohol-soluble material was determined by evaporating an aliquot portion of the alcohol extract at 78° C., followed by drying to constant weight in a vacuum oven at 75°. The alcohol-insoluble portion was determined by placing the filter paper and contents in a weighing bottle and drying to constant weight in a vacuum oven. The sum of the two gave the total solids. Free reducing and total sugars were determined from an aliquot portion of the alcoholic extract. The alcohol was driven off over a steam bath, water being added to the aliquot part to prevent caramelization of the sugars. The solution was then cleared with neutral lead acetate made up to volume and filtered. The excess lead was precipitated with sodium oxalate, and the solution was again filtered. This cleared solution was used for the determination of soluble sugars.

The reducing action of the sugar was determined in the 1929 and 1930 samples by heating the copper sulphate alkaline tartrate solution at 80° C. for 30 minutes, as recommended by Quisumbing and Thomas (*11*), and titrating the cuprous oxide with potassium permanganate as specified in the modified Bertrand method as given by Mathews (*8*). With the 1931 samples the Shaffer-Hartmann (*12*) idiometric method of titration was substituted for the permanganate method to determine the cuprous oxide. Preference was given to the Shaffer-Hartmann procedure because of its rapidity and convenience in the local laboratory. Total sugars were determined by hydrolyzing 50 cc of the cleared solution with 5 cc of concentrated hydrochloric acid for 24 hours. This was neutralized with sodium carbonate, made up to volume, filtered, and an aliquot part taken for reduction.

The acid content of the sample was determined by passing a portion of the fresh tissue, selected as noted above, through a Clark sampling press and determining the acid by the official method prescribed by the Association of Official Agricultural Chemists (*1*). The results are expressed as percentage of fresh weight.

The analytical data are given in connection with the different treatments, together with the discussion of the relation of the latter to the canned product.

METHOD OF CANNING

When the fruit reached prime canning condition it was taken to the cannery and prepared according to the standard procedure of

the cannery. From this point the treatment was uniform for all samples. The preparation and canning were usually done by the same persons each time, and the regular routine of the plant was followed, care being taken to prevent delaying the experimental lots longer than absolutely necessary. During the time of preparation the fruit was held in a 3-percent salt solution. It was then washed, sized, and placed in plain no. 2½ cans; 30° Brix sirup was added by hand, and the cans were placed in the regular line for cooking. They were given an exhaust of 7¾ minutes at 190° to 195° F., closed with a Canco closing machine, processed for 15 minutes in a rotary cooker at 211° (boiling water), and thoroughly cooled in running water.

Samples of the canned product were cut and examined at various intervals after canning over a period of a few days to as long as 2 years. In the examination of the material the writers were assisted by representatives of different bureaus in the United States Department of Agriculture, representatives of the National Canners Association, members of the Northwest Canners Association and of the California Canners League, members of the research staff of the leading can companies, practical cannery men, and others qualified to judge processed fruit or horticultural products generally.

POINTS CONSIDERED IN COMPARING THE CANNED PRODUCT

In judging the canned material, color, texture, clearness of the sirup, and flavor were the main factors considered, but no numerical values were assigned to these factors. In commercial practice flavor often receives less weight than the other factors, provided no "off" flavor is present. It has been found that the differences in flavor due to treatment are somewhat masked by the sirup. It was also true that when differences in flavor were evident, personal preference largely determined the selection of the treatment that seemed to give the best flavor. The comparative lack of emphasis on flavor at present, particularly from the wholesale buying standpoint, was shown by the fact that buyers and canners often made their decisions before tasting and seldom changed them afterwards. Consideration was necessarily comparative, each treatment being checked against others in the series. Size and workmanship were not considered in judging this material, as is usually done in judging the canned product, since these were not affected by the factors studied in this bulletin. However, pears of as nearly uniform size as possible were selected each time for comparison, and the workmanship was similar throughout.

The drained weight and sirup cut-out were determined in several cases, but it was found that a slight difference in the size of the pieces or the amount of sirup in the can more than offset any differences due to the treatment.

COLOR

In judging pears, a clear cream-yellow tending toward translucency is desired in the best material. Fruit with a darker color grading toward pale orange-yellow is not considered so desirable. While it is difficult to match the ideal color of canned pears with a standard color

chart, an effort was made to do this. Fruit judged as having the best color corresponded closely to cream color or massicot yellow, plate 16 in Ridgway's color standards,[7] while departures from the ideal often were in the direction of pale orange-yellow, Ridgway's plate 3.

TEXTURE

The texture of canned pears should be tender, the flesh being almost soft enough to fall apart when held at one end and shaken gently, but still firm enough to be cohesive. The pieces should retain their form and not break apart or disintegrate of their own weight.

CLEARNESS OF SIRUP

The sirup should be clear and bright with little sediment. In these studies the principal difference noted in an examination of the sirup was the amount of sediment present, indicating roughly the amount of disintegration which had taken place.

FLAVOR

The flavor apparently most desired in canned Bartlett pears is a moderately sweet, sprightly, slightly aromatic, characteristic Bartlett-pear flavor. It is recognized, of course, that individual tastes vary widely. The conclusions given are based upon the preference of a majority of those tasting the fruit.

EFFECT OF MATURITY

In order to study the effect of maturity on the quality of the canned product, pears were picked at different stages of maturity during the seasons of 1929 and 1930. In 1930 the first fruit was harvested on July 28, when it tested a little above 20 pounds according to the pressure test. Pickings were made at weekly intervals thereafter until September 11, when the fruit tested from 12 to 13 pounds, with a minimum of 7 to 10 pounds. This gave a range of maturity from the time the first Bartlett pears were being picked for fresh shipment until practically all the fruit intended for the cannery had been harvested. The dates of picking and the pressure tests in pounds are given in table 1.

TABLE 1.—*Date of picking and pressure test of Bartlett pears used in the 1930 tests*

Date of picking	Pressure test		Date of picking	Pressure test	
	Pears from heavy soil	Pears from light soil		Pears from heavy soil	Pears from light soil
	Pounds	*Pounds*		*Pounds*	*Pounds*
July 28	20.3	20.2	Aug. 27	15.0	15.0
Aug. 4	18.6	18.7	Sept. 2	14.3	14.6
Aug. 12	17.0	17.0	Sept. 11	12.0	13.0
Aug. 19	16.0	16.5	Do [1]	7.3	10.6

[1] Ripest fruit.

[7] RIDGWAY, R. COLOR STANDARDS AND COLOR NOMENCLATURE. 43 pp., illus. Washington, D.C., 1912.

One cannery lug of the ripest fruit, selected from that picked September 11 from each orchard, was placed in cold storage for 9 days and then removed to the ripening room. This fruit showed a very low pressure test at harvest (7.3 and 10.6 pounds), developed practically 100 percent internal breakdown before reaching the canning stage, and consequently was discarded. The other lots were held for 30 days at 30° to 32° F., ripened, and canned when in the proper condition.

The effect of pear maturity as demonstrated in different ways will be discussed separately for each factor.

ON YIELD IN THE ORCHARD

It has been shown by several investigators (*4*, *9*) that there is an increase in size and therefore in yield of Bartlett pears allowed to remain on the tree after the optimum picking maturity. Murneek (*9*) has shown that there is a close correlation between increase in the transverse diameter and increase in weight. It was found that by taking the transverse diameter and calculating the volume of the fruit by the formula $V=1/6\pi D^3$, as if it were a sphere, the volume was less than that indicated by water displacement. However, if the calculated volume was multiplied by the factor 1.1 the result was very close to the actual volume. This method made possible measurement of the same fruit throughout the season. The percentage increase in size was determined in this manner, and the increase in weight was assumed to be directly proportional, although there is evidence that the specific gravity of pears increases as they become more mature. This would indicate an even greater weight increment in weight than in volume. Hereafter, tonnage may be used in the discussion of yield differences instead of volume or size.

Studies made in this connection during 1930 in the Yakima Valley and in 1932 in the Wenatchee Valley show that this increase in size very materially affects the tonnage that can be harvested. Records were kept on the rate of growth of pears (1) on trees where only one picking was made, and that at the end of the season; (2) on trees where all fruit measuring 2⅜ inches in diameter and larger was removed when the fruit was testing around 18 pounds; and (3) on trees where weekly pickings of the larger fruit were made. Figure 1 shows the rate of growth of fruit remaining on the trees for the different treatments during the 1930 and 1932 seasons. Records were kept in 1930 over a period of 37 days and in 1932 for 18 days. It will be observed that the rate of growth for all treatments was less in 1932 than in 1930. This difference was probably due to the trees having a slightly heavier load of pears in 1932 and to a much larger amount of fruit dropping in 1930, which would serve as additional thinning of the pears for all plots.

Differences in climatic and orchard conditions in the two years doubtless also influenced the rate of growth. It is a general practice to make two or more pickings of cannery pears, the first early in the season serving to thin the crop and lessen the danger of a heavy load breaking the trees. During the 1930 season records were made at weekly intervals from August 5, when the fruit was testing 18.5 pounds, to September 11, when the pressure had dropped to 13

pounds. By correlating the increase in size with the number of tagged fruits dropping in any period, it was possible to determine at what stage of maturity the greatest tonnage could have been harvested. Figure 2 shows the relation between the amount of fruit dropped and the increase in weight of tagged fruit on an unthinned tree throughout the harvest season of 1930.

The average increase in size of fruit per day during the season on the unthinned trees was 1.95 percent. The date of maximum load

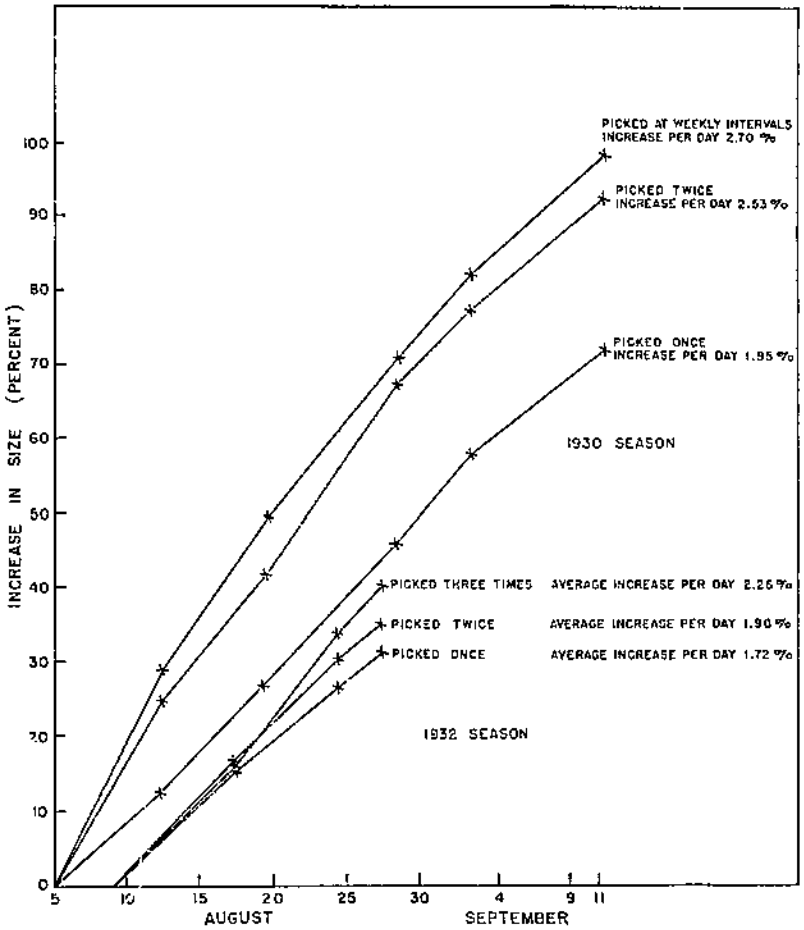

FIGURE 1.—Relationship between number of pickings and rate of growth of pears.

was August 19, when the fruit tested 16.5 pounds; at this time 10 percent of the fruit had dropped. On August 28, 41 percent of the fruit had fallen, but the tonnage had decreased only 19 percent and was still equal to the tonnage of August 5.

When the no. 1 cannery fruit (2⅜ inches in diameter) was removed early in the season the pears showed an average increase in size of 2.53 percent per day. The date of maximum load from this tree, as judged from the tagged fruit, was August 12, when the fruit tested

17 pounds; at this time 14.5 percent of the fruit had fallen. On August 19, 36 percent had fallen and the tonnage had decreased 16 percent. However, the tonnage then remained about the same until August 28, at which time 50 percent of the fruit had dropped. Where the largest fruits were removed at weekly intervals the average increase in size per day was 2.7 percent. The date after which the percentage of dropped fruit was greater than that made up by the increase in size was August 28, at which time the fruit tested 15 pounds. At this date 16 percent of the fruit had fallen. Five days later 36 percent had fallen and the tonnage had decreased 16 percent.

After observing the amount of fruit dropped from other trees in the same block it seemed safe to assume that the rate of dropping was due to natural causes rather than to the experimental treatment.

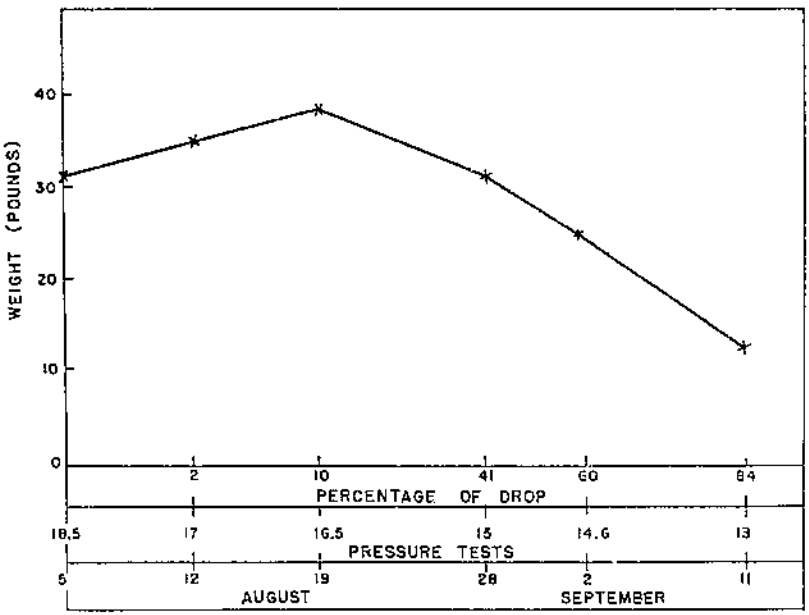

FIGURE 2.—Effect of maturity as measured by pressure tests on increase in size and rate of dropping of pears on the amount of fruit on the tree. (Weight of fruit calculated from diameter measurements of tagged fruit, as explained in the text.)

These results are from trees grown on a light soil. A much smaller percentage of fruit dropped early in the season from trees growing on the heavy soil. In measuring the fruit a certain amount of movement was necessary, which probably caused some of the fruit to drop earlier than it would normally. This would tend to exaggerate slightly the percentage of drop given above.

Work carried on in 1932, with trees on heavy soil, in which records were kept of the total drop from the trees as well as the increase in size of tagged fruits, showed similar results. Records were kept from August 9, when the fruit tested 17.5 pounds, to August 27, when the pressure test was slightly under 14 pounds. Data were secured from trees where 1, 2, and 3 pickings were made. Where 2 pickings were made all fruit 2⅜ inches in diameter or larger was

removed on August 9, 16 percent of the total fruit harvested being removed at that time. Where 3 pickings were made, all fruit 2⅜ inches or larger was removed on August 9 (16.5 percent of the total harvested) and again on August 19 (38.5 percent of the total harvested). Table 2 gives the results of these tests.

TABLE 2.—*Effect of 1, 2, and 3 pickings on fruit remaining on tree*

Pickings		Fruit harvested		Average growth per day	Total growth	Fruit dropped (percentage of total)	Average weight per fruit harvested
Number	Date	Pears	Weight				
		Number	*Pounds*	*Percent*	*Percent*		*Pound*
1	Aug. 27	2,273	913	1.72	34.6	2.9	0.402
2	Aug. 9	345	112				
	Aug. 27	1,561	686				
Total		1,906	698	1.93	30.6	7.0	.366
3	Aug. 9	418	142				
	Aug. 19	985	331				
	Aug. 27	1,113	388				
Total		2,516	859	2.20	46.0	.8	.341

The percentage of culls due to lack of size was not influenced markedly by removing the larger fruits, and amounted to only 2 pounds on the unthinned tree out of a total of 913 pounds harvested. The difference in amount dropping from the different treatments is perhaps largely due to natural causes and without particular significance. It is worthy of note that the smaller fruit dropped more readily than the larger on the same tree. Of 318 pears dropped from trees in 1932, 137 were 2⅜ inches or above in diameter, 134 were from 2⅛ to 2⅜ inches, and 47 were below 2⅛ inches. Of fruit harvested from the same trees, 6,184 were 2⅜ inches or larger, 480 were 2⅛ to 2⅜ inches, and only 31 were below 2⅛ inches. Expressed as percentage of no. 1's, no. 2's, and culls, based on size alone, in the fruit that dropped from the tree, the amount is 43, 42, and 15 percent, respectively. In the harvested fruit the percentages are 92, 7, and 0.5 percent for the corresponding grades. Figure 3 shows graphically the relationship between the size of the tagged fruit on an unthinned tree at the beginning of the 1930 harvest season and the length of time the fruit remained on the tree. The average of all fruits measured on August 5 was 130.9 cc, showing a direct correlation between relative size at the beginning of the season and the length of time the fruit adhered to the tree.

On trees of which records were kept of the total number of pears on the tree, the amount of fruit harvested, and the rate of growth of tagged fruits, it was possible, by assuming the specific gravity of pears to be 1.0 (which is very close to the actual), to compare the actual yield with the estimated yield if 1, 2, or 3 pickings had been made. Assuming the tagged fruit to be representative in size of all the pears on the tree, there were 706 pounds on an unthinned tree on August 9. This weight, with an increase of 1.72 percent per day after the beginning of the harvest (fig. 1, 1932 season) until August 27, should give a yield of 925 pounds; the actual yield,

including 35 pounds of fallen fruit, was 948 pounds. Similarly, on a tree where 2 pickings were made the estimated yield on August 9 was 578 pounds. On that date 112 pounds were harvested. If to this yield is added 59 pounds that dropped from the tree and might be classed as additional thinning, there would be 407 pounds remaining on the tree. An increase of 1.98 percent per day for 18 days would give a yield of 724 pounds. The actual yield, including fallen fruit, was 757 pounds. If only 1 picking had been made, the estimated yield with a 1.72-percent increase per day would have been 755 pounds.

Again, on a tree where pickings were made on August 9, 19, and 27, the actual yield including fallen fruit was 866 pounds, and the estimated yield for 1, 2, and 3 pickings was 893, 875, and 859 pounds, respectively. On three trees where 1, 2, and 3 pickings were made the total actual yield was 2,571 pounds, compared with an estimated yield for the same number of pickings of 2,508 pounds.

While the yield is practically the same whether 1, 2, or 3 pickings are made, other factors may make the greater number of pickings desirable. If all the fruit is harvested at one time there may be

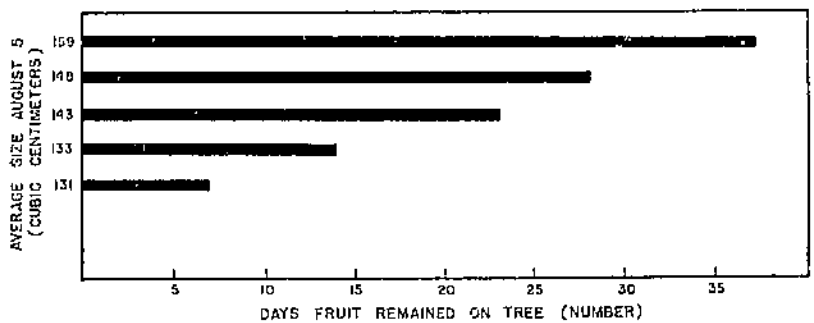

FIGURE 3.—Relationship between size of pear fruit at the beginning of the harvest season and the number of days it remained on the tree.

a wide range in size, some fruits being larger than that most desired for canning. Additional pickings will give a more uniform product of the desirable sizes. Also, if the fruit is not well distributed on the tree and there is danger of limb breakage, or if the tree is overloaded, 2 or more pickings will tend to prevent this breakage.

ON LOSS OF WEIGHT IN THE RIPENING ROOM

In order to determine the effect of maturity on shrinkage, or loss of weight of the fruit while in the ripening room, pears picked at 18 pounds and at 15 pounds pressure test were weighed and ripened under varying conditions. Several small lots consisting of about a dozen representative fruits were used instead of a single large lot. These small lots permitted more accurate weighing, and there was less danger of decay developing and influencing the results. Numerous small lots were used in studying the loss in weight. These studies were made on fruit after a period in cold storage. Table 3 gives the conditions under which the fruit in the two stages of maturity was ripened and the percentage of weight lost in the period

extending from the time of removal from cold storage until the fruit was ready for canning.

TABLE 3.—*Effect of maturity in Bartlett pears on loss in weight during ripening*

Picked at 18 pounds pressure				Picked at 15 pounds pressure			
Lots (number)	Ripening-room conditions		Weight lost	Lots (number)	Ripening-room conditions		Weight lost
	Temperature	Humidity			Temperature	Humidity	
	°F.	Percent	Percent		°F.	Percent	Percent
3	65	80	1.69	3	65	80	1.65
5	65	93	1.24	9	65	93	1.00
3	65	94	1.31	2	65	94	1.09
4	75	70	2.93	4	75	70	2.19
8	75	78	2.10	8	75	78	1.70
4	75	87	2.51	4	75	87	1.74
2	85	68	2.08	4	85	68	1.68
5	85	75	3.30	11	85	75	2.00
4	85	94	1.09	2	85	94	1.42
38 [1]	[2] 75	[2] 82	[2] 2.14	47 [1]	[2] 75	[2] 81	[2] 1.66

[1] Total. [2] Weighted average.

It will be noted that in every case the pears picked at a pressure test of 18 pounds lost more weight during ripening than did those picked at a pressure test of 15 pounds. A comparison of the average loss in weight from the two maturities shows that the less mature fruit lost 29 percent more weight during ripening than did pears picked at the more mature stage and ripened under similar conditions. Even with a humidity of 93 to 94 percent there was a loss in weight amounting to 1 percent or more in every lot. It is likely that much of the loss at the higher humidities is due to respiration in ripening.

ON FRUIT WHILE RIPENING

The fruit from the early-picked lots showed considerable wilting during ripening. Often it failed to develop the uniform bright skin color characteristic of later pickings and showed a distinctly greenish spotted appearance after having been in cold storage 6 weeks or longer, even though ready for canning. The earliest-picked lots never developed the sprightly aromatic flavor characteristic of the Bartlett pear. All through the season it was observed that the immature fruit was not only darker when first peeled but tended to oxidize much more rapidly while being prepared for processing. This was true to such an extent that it was possible to pick out at a distance of several feet and before the fruit was processed the trays containing open cans of immature pears. However, some of the darkening due to oxidation was lost while the fruit was in the exhaust box, so that when the fruit emerged the differences were not so apparent. In pulping the fruit for acid determination, the immature fruit took on a brown color almost immediately, while the more mature pears required several minutes before reaching a color stage comparable to that of the immature fruit at the time pulping was completed. Fruit picked at a pressure test of 14

pounds showed a tendency to break down at the core before reaching a stage of softness desirable for canning. This tendency developed quite rapidly as the pressure test dropped below the 14-pound figure.

ON CHEMICAL COMPOSITION

Table 4 shows the effect of maturity on composition of the fruit. The first series of analyses were made at the time of harvesting. The fruit for the second series was stored at 30° to 32° F. for 30 days after harvest and then ripened at 70° to the most desirable stage for canning. These analyses were made on pears grown on heavy soil. Analyses of fruit from the light soil gave similar results.

TABLE 4.—*Effect of maturity of Bartlett pears on composition at time of harvest and when ripened for canning* [1]

AT HARVEST

Date harvested	Pressure at harvest	Alcohol-insoluble material	Alcohol-soluble material	Total solids	Reducing sugars	Total sugars	Cane sugar	Acid as citric
	Pounds	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
July 28	20.3	4.36	9.84	14.20	5.23	5.94	0.71	
Aug. 4	18.6	4.06	10.21	14.27	5.12	5.94	.82	0.33
Aug. 12	17.0	4.13	9.60	13.73	5.22	5.94	.72	.33
Aug. 19	16.0	4.13	10.38	14.51	5.40	6.69	1.29	.28
Aug. 27	15.0	3.37	10.03	13.40	5.37	7.00	1.63	.31
Sept. 2	14.3	3.27	10.00	13.27	4.87	7.00	2.13	.28
Sept. 11	12.0	2.53	11.32	13.85	4.75	8.21	3.46	.20
Do	[2] 7.3	2.34	12.36	14.70	4.79	9.13	4.34	.15

AFTER RIPENING

July 28	20.3	3.32	11.43	14.75	6.01	7.79	1.78	0.26
Aug. 4	18.6	3.30	11.70	15.00	6.24	8.21	1.97	.34
Aug. 12	17.0	3.16	11.90	15.06	6.02	7.99	1.97	.31
Aug. 19	16.0	3.18	11.45	14.63	5.87	8.30	2.43	.31
Aug. 27	15.0	2.68	11.70	14.38	5.97	8.71	2.74	.28
Sept. 2	14.3	2.43	12.19	14.62	5.73	9.20	3.47	.23
Sept. 11	12.0	2.19	11.84	14.03	5.52	8.98	3.46	.15

[1] Analyses expressed as percentage of fresh weight. [2] Tree-ripe fruit.

An examination of table 4 shows that the stage of maturity at which the fruit was picked exerts a considerable influence on its chemical composition, both at the time of harvest and after the fruit has ripened. As the season advances there is a decrease in the alcohol-insoluble solids and in the acids and reducing sugars and an increase in alcohol-soluble materials, cane sugar, and total sugars. In the ripened fruit, owing to variations in total solids, the increase in the alcohol-soluble materials in terms of fresh weight is not distinctly noticeable; however, the increase is readily shown if calculated as percentage of total solids. In the early-picked fruit the insoluble solids make up 28 to 30 percent of the total solids, dropping in storage and ripening to 22 to 23 percent. In the later-picked fruit insoluble solids amount to only 18 to 20 percent of the total solids, dropping to 15 to 18 percent on ripening. Cane sugar increases both in total amount and in percentage of total sugars. On ripening it increases greatly in the early-picked fruit, but remains about constant in fruit picked near the end of the season. Ripening had but little effect on acid changes, as the acids remained practically

the same after ripening as at harvest. The increased acid content at the higher pressure tests explains the more sprightly acid flavor of the early-picked fruit. From a canner's viewpoint, perhaps the most outstanding effect of maturity on raw material, as shown by the analyses, is the increase in total sugars and the decrease in the alcohol-insoluble materials as the season advances. Apparent increase in sweetness is largely dependent upon these two changes along with changes in astringency and acid content. The increase in sugar adds sweetness directly; the decrease in insoluble solids affects the ease of disintegration of the tissue and the consequent perception of sweetness. While no astringency determinations were made, it is realized that a progressive decrease takes place during ripening, giving the effect of increasing sweetness to the taste.

ON THE CANNED PRODUCT

An examination of the canned product shows that there is a considerable difference in the appearance of the early- and late-picked pears. Fruit picked at the higher pressure tests tended to have a distinctly darker or a pale orange-yellow appearance as compared with the clear translucent cream color of the fruit picked at the more mature stage. There was a gradual improvement in color as maturity advanced, although the differences were not so great in the latter part of the season. Considered as to color alone, the lots picked last were probably the best, judged from the commercial viewpoint. Other factors, such as the prevalence of internal breakdown and the amount of fruit dropped from the trees, prevent the commercial harvesting of pears at such low pressure tests. This color difference was very distinct when the various lots were compared directly, even though the fruit picked at the higher pressure tests might be classed as satisfactory if judged alone.

The differences in dessert quality or taste were not so distinctly noticeable, although most of the persons who examined the canned fruit agreed that there were differences in flavor. The majority opinion was that, in order to get the best flavor, pickings would have to be made a little earlier than the optimum for best color. Fruit from the lots picked very late seemed to have lost some of the sprightly aromatic flavor characteristic of canned Bartlett pears.

In the usual judging of canned pears, color probably has played a more important part than flavor. Since the consumer likewise buys primarily on appearance, the question arises among canners as to the feasibility of developing a more aromatic and sprightly flavor in canned Bartlett pears at the expense of color. Possibly a compromise can be effected by picking the pears at pressures somewhat higher than at present desired for best color, but not so high as to affect the color seriously. Seasonal variations will probably have some effect, since the differences between the different maturities were greater in some seasons than others.

Time of picking has comparatively little influence on color of sirup. The texture of the canned product was perhaps a little more granular and firmer in the late-picked fruit. This firmness was probably due to the character of the fruit at time of canning, since it was difficult to get it to soften properly before internal breakdown took place.

STAGE OF MATURITY FOR BEST RESULTS

From the foregoing data and discussion it is seen that the stage of maturity at which the fruit is picked exerts a marked influence on its yield, behavior, and composition. There is an increase in both total and cane sugars and a decrease in acidity as maturity advances. The canned product has a better color and the raw material is oxidized less rapidly during preparation and canning when the fruit is more mature. There is also less loss of moisture in ripening, and the increase in weight during the season while the fruit is on the tree is approximately 2 percent per day.

The fruit picked at a pressure test of from 17 to 15 pounds seemed most desirable, when everything was considered. At these pressures there may be some dropping of the fruit, and growers may insist on picking earlier. However, unless the dropping amounts to about 2 percent per day the increase in size of the pears remaining on the tree will probably make up the difference. The pressure tests indicated above as the most satisfactory will ordinarily permit the harvesting of a maximum tonnage.

EFFECT OF COLD STORAGE

For the cold-storage experiment, pears were picked at the pressure tests given in table 1 and stored at 30° to 32° F. for varying lengths of time. In 1929 and 1930, aside from fruit ripened immediately after harvest, the storage periods ranged from a minimum of 30 days with removal at 10-day intervals up to a maximum storage of 90 days. In 1931 the period of storage was reduced to a maximum of 30 days and shorter periods of storage were also used.

ON FRUIT WHILE RIPENING

A general examination of the fruit after ripening showed that prior storage at 30° to 32° F. caused it to ripen much more uniformly when placed in the ripening room. Fruit ripened immediately after harvest usually has to be sorted once, and sometimes twice or more, in order to use the fruit at the best canning stage. Fruit that has been in cold storage ripens quite uniformly, at least that grown in the arid sections of the Pacific Northwest, so that it is seldom necessary to do any sorting unless lots of well-matured fruit are mixed with lots less mature or with fruit subjected to different handling practices. Even then, sorting by lugs is usually sufficient. This fact is of value in three respects: (1) Less handling of the fruit is required, and a consequent saving in labor is effected; (2) there is less loss from bruising, owing to less handling of ripening fruit; and (3) a more uniform product is provided, since in hand sorting there is always some question among the sorters as to whether particular fruits should be canned immediately, even though slightly green, or should be left until later, when they may be slightly overripe.

It is quite possible that some of the improvement in texture in the stored lots was due to the more uniform ripening, so that as a consequence the fruit could be canned at the time when a large percentage of the individual pears was at the optimum canning stage.

While precooling and very short periods of cold storage (1 to 10 days) were not so effective in improving the quality of the canned product as longer periods in storage, they were of value in causing the fruit to ripen more uniformly, provided the period of storage was sufficient to bring the fruit to a uniform temperature of 30° to 32° F. Pears picked at a pressure test above 18 pounds and held over 60 days in cold storage tended to wilt when placed in the ripening room. This fruit also failed to develop a desirable golden-yellow color and had a distinctly greenish tinge. The flesh of the immature long-stored fruit was not only darker when first peeled but darkened much more rapidly in the preparation for canning.

Eggs of the codling moth are frequently present on Bartlett pears when they are harvested. If the pears are ripened immediately the eggs hatch and the larvae enter the fruit. As a result, fruit that is practically free from worms, or at most 3 or 4 percent wormy at time of harvest, may be 15 to 20 percent or more wormy when ready for canning. Newcomer (*10*) studied the effects of cold-storage temperatures for short periods of time on codling-moth eggs. The maximum time of treatment was 5 days, during which approximately 50 percent of the eggs were killed. He states that the fruit would probably have to remain at 30° F. for at least 10 days or 2 weeks in order to kill all the eggs. A cold-storage period of 15 to 30 days would therefore be beneficial in reducing loss from this source.

ON CHEMICAL COMPOSITION

Table 5 shows results typical of analyses made of the ripened fruit after varying periods in cold storage.

TABLE 5.—*Effect of cold storage for different periods on chemical composition of Bartlett pears when ready for canning*[1]

Stored at 32° F. (days)	Alcohol-insoluble material	Alcohol-soluble material	Total solids	Reducing sugars	Total sugars	Cane sugar	Acid as citric
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
FRUIT PICKED AT 18.5 POUNDS PRESSURE							
0	3.03	12.80	16.43	7.15	8.10	0.95	0.33
40	3.02	11.28	14.30	6.12	7.76	1.64	.28
60	3.57	11.32	14.89	6.22	7.41	1.19	.33
74	3.11	12.33	15.44	6.07	8.00	1.93	.31
82	3.47	11.98	15.45	6.39	8.29	1.90	.26
90	3.40	12.20	15.60	6.36	8.30	1.94	.20
FRUIT PICKED AT 16 POUNDS PRESSURE							
0	3.07	10.09	13.16	6.52	7.72	1.20	----
Precooled to 30° F. overnight	2.97	9.88	12.83	5.80	7.20	1.40	----
15	2.99	10.25	13.24	5.73	7.58	1.85	----
30	3.13	10.53	13.66	5.95	7.72	1.77	----
FRUIT PICKED AT 15 POUNDS PRESSURE							
0	2.19	11.71	13.90	6.54	8.56	2.02	0.36
43	2.53	11.70	14.23	5.97	8.71	2.74	.28
51	2.48	12.07	14.55	6.33	8.86	2.53	.28
59	2.80	11.52	14.32	6.25	8.73	2.48	.28
67	2.56	11.63	14.19	6.02	8.60	2.58	.26
81	2.46	11.26	13.72	5.96	8.49	2.53	.23

[1] Analyses expressed as percentage of fresh weight.

The amount of cane sugar in the pears increases and the acid decreases if the fruit is placed in cold storage. This increase in cane sugar is very pronounced in fruit picked at higher pressure tests, and is also greater in the later picked lots. It has but little influence, however, on total sugars in pears. The acids decrease in storage. By comparing the acid changes in fruit stored at 30° to 32° F. then ripened at 70° (table 5) with those ripened immediately after harvest (table 4) it is seen that long storage is more effective in lowering the acid content than is ripening at 70°. Differences in the other constituents are comparatively negligible. Because of the differences observed in the texture of the canned product from the stored lots (as noted below), it was expected that there would be a difference in the alcohol-insoluble material found in these lots. However, analyses that showed this was true in only a small number of cases.

In 1931 the period of storage was reduced to a maximum of 30 days, since it was shown in the earlier work that pears in cold storage for 30 days gave a better canned product than either fruit ripened immediately or that held in storage for longer periods. Fruit was picked at a pressure test of 15, 16, and 17 pounds and held in cold storage for varyling lengths of time up to a maximum of 30 days, in order to determine the minimum time necessary to secure the benefits of cold storage. The periods in storage were precooling overnight to a fruit temperature of 30° F. and storage for 1, 2, 4, 6, 10, 15, 20, or 30 days. Chemical analyses were made on fruit which was ripened immediately, precooled overnight to 30°, and stored for 15 days and for 30 days. Results of analyses on the fruit picked at 16 pounds are given in table 5 and are typical of results from fruit harvested at other pressures.

An examination of these analyses shows that the factors affected by cold storage over long periods are similarly affected by precooling overnight, but to a lesser degree. A 15-day storage period seems to be as effective as a longer period.

ON THE CANNED PRODUCT

Bartlett pears that have been held in cold storage seem to have a better color and texture when subsequently canned than fruit ripened and canned immediately after harvest. With a range of storage periods from 0 to 90 days at 30° to 32° F., the best canned fruit was obtained from the lots that had been in storage from 15 to 30 days. Fruit stored for either shorter or longer periods was less desirable. A shorter period failed to give the full benefit of cold storage, and longer periods brought on additional complications.

Fruit ripened immediately after harvest had a poorer texture, which may best be characterized as lacking in cohesion and firmness. It was also of a darker, less desirable color and did not seem to have so desirable a flavor. The effect of precooling or storage for less than 10 days was not distinctly noticeable on the canned product, although after 3 or 4 days there seemed to be a slight improvement in texture, indicating that this quality is more readily influenced by short periods of cold storage than is color. Storage for 15 days apparently was as effective as longer periods, since there was little differ-

ence between the 15-day and the 30-day lots. Longer periods caused a gradual darkening of color, although at 40 to 45 days it was only slightly noticeable and at 50 to 60 days there was a resemblance to the color of canned pears made from fruit ripened as soon as picked. Storage for longer than 60 days cannot be recommended because the color of the canned product tended to darken rapidly when this period was exceeded. The pears stored for very long periods tended to be more granular in texture and to have lost much of the melting, buttery consistency in the flesh, characteristic of pears of the intermediate stored lots. The darkening of color was especially noticeable in fruit picked at the higher pressure tests and gradually decreased in the more mature fruit. At 14 pounds and below there was but little difference in the intermediate and long storage lots insofar as color was concerned.

Cold storage of the fruit will be advantageous to canners also, because they may thus prolong the canning season without loss of quality in the finished product. For fruit that could be processed during the harvest season it may mean an additional expense. However, since advantages other than an improved product result from cold storage, such as a saving in labor due to more uniform ripening and reduced losses from bruising and "pinworms", these savings will act to reduce or offset the initial cost of storage. In some cases these economies may more than equal the cost of storage.

EFFECT OF HOLDING AT HIGH TEMPERATURES BEFORE COLD STORAGE

Bartlett pears held for 2, 4, and 6 days after picking before cold storage, at the high atmospheric temperatures prevailing during the pear harvest, were less satisfactory when ripened than fruit stored immediately after harvest. The chemical composition of the delayed lots at the time of canning was very irregular and no definite conclusion could be drawn from the analyses. There was a tendency for the total sugars and the cane sugar to be less in the delayed-storage lots, but this was not true in all cases. Fruit held for 4 or 6 days at high temperatures sometimes completed the ripening process within 30 days in cold storage at 30° to 32° F., with a resultant loss by decay and a poor texture in the canned product. Fruit delayed 4 days and then stored at 40° was a total loss from scald and break-down within 30 days. The fruit placed in cold storage immediately after harvest gave the best canned product, in both quality and appearance, with a gradual deterioration in these factors proportional to the time for which the fruit was delayed before storage.

EFFECT OF RIPENING-ROOM TEMPERATURES AND HUMIDITIES

To test the effect of ripening-room temperatures and humidities on the quality of the canned product, Bartlett pears were ripened at 60° to 65° F. and 80° to 85° and at relative humidities of 70 and 90 to 95 percent. Similar fruit ripened at 70° with a relative humidity of 78 to 85 percent was used as a check for comparison in judging the canned product. Table 6 gives analyses typical of those made on fruit ripened at the two temperatures, that held at the

higher showing an increase in the alcohol-soluble material and reducing sugars and a slight increase in the total sugars.

TABLE 6.—*Analyses of Bartlett pears ripened at 65° and at 85° F.*[1]

Ripening-room temperature (° F.)	Alcohol-insoluble material	Alcohol-soluble material	Total solids	Reducing sugars	Total sugars	Cane sugar	Acid as citric
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
65	3.08	11.27	14.35	6.38	9.51	3.13	0.28
85	2.99	11.99	14.98	6.98	9.65	2.67	.23

[1] Analyses expressed as percentage of fresh weight.

Two lots of fruit were held for 30 days after harvest at 90° F. and a relative humidity of 90 percent. At the end of that time the fruit was still hard and tough, and it failed to ripen satisfactorily when removed to a lower temperature. This is in agreement with results reported by Shamel (*13*) and Taylor and Overholser (*14*) on the effect of high temperatures in ripening Bartlett pears. They found that storage at temperatures above 85° retarded ripening.

An examination of the canned product indicated that fruit ripened at 70° to 75° F. gave a product as good as or better than fruit ripened at either a higher or a lower temperature. Fruit ripened at 60° to 65° was slightly darker in color than that ripened at 70° to 75°. Fruit ripened at 80° to 85° was slightly slower in ripening, and that ripened at 90° was very markedly slower.

Fruit held for 3 days after harvest at 90° F. and then ripened at 70° to 75° had an objectionable chalky appearance around the core. Fruit held for 3 days at 90° and then stored at 30° to 32° did not have the chalky appearance, but was not as desirable as that given immediate storage. It was also observed that a greater loss of weight occurred during ripening at the higher temperatures.

Humidity is of importance in the ripening room, and where there are special rooms for ripening the fruit for canning, this factor seems to take care of itself very well, since considerable water is given off by the fruit in ripening. Special precautions will probably be necessary only where fruit is placed in an open shed for ripening. Low humidity will cause some wilting during ripening, but small losses of weight may not be serious and may even have an advantage in that the subsequent siruping and processing may permit recovery of some of the weight lost and may allow expansion to take place during the exhausting and cooking, resulting in a better texture of the canned product.

Fruit ripened at very high humidities loses comparatively little weight in ripening, and the flesh is firm and juicy. However, during the steam exhaust of the product the outside cells completely filled with juice are often ruptured, giving a slightly ragged appearance to the fruit and increased cloudiness in the sirup.

Table 7 shows the effect of humidity on the loss of weight during ripening. These lots include fruit picked at pressure tests of 18 and 15 pounds.

TABLE 7.—*Effect of humidity on loss of weight of Bartlett pears during ripening*

Low-humidity storage				Medium-humidity storage				High-humidity storage			
Lots	Ripening conditions		Loss of weight	Lots	Ripening conditions		Loss of weight	Lots	Ripening conditions		Loss of weight
	Temperature	Humidity			Temperature	Humidity			Temperature	Humidity	
Number	*° F.*	*Percent*	*Percent*	*Number*	*° F.*	*Percent*	*Percent*	*Number*	*° F.*	*Percent*	*Percent*
2	85	68	2.08	8	75	78	2.10	4	85	94	1.69
4	85	68	1.98	8	75	78	1.70	2	85	94	1.42
5	85	75	3.30	3	65	80	1.70	4	75	87	2.51
11	85	75	2.00	3	65	80	1.66	4	75	87	1.74
4	75	70	2.99					3	65	94	1.31
4	75	70	2.19					2	65	94	1.09
								5	65	93	1.24
								9	65	93	1.89
[1] 30	[2] 82	[2] 72	[2] 2.38	[1] 22	[2] 72	[2] 79	[2] 1.84	[1] 33	[2] 71	[2] 92	[2] 1.69

[1] Total.
[2] Weighted average.

In some years pear canners experience considerable difficulty because the stems[3] of the fruit turn yellow or brown after canning. Many canners now remove the stem, and of course where this is done there is no problem. A slight yellowing of the stems was noted in some of the writers' experimental lots, but it was impossible to connect its appearance with maturity, handling, or storage treatment. Neither freezing of the fruit in storage nor deliberate change of acidity at time of canning seemed to influence this yellowing.

EFFECT OF SOIL TYPES

Soil types apparently play a minor role in pear growing insofar as the canned product is concerned. So long as normal growing conditions prevail with reference to water supply, soil fertility, and similar factors, and the crop quality is comparable, there is probably no appreciable commercial difference in the quality of the canned product. In 1929 fruit from the heavy soil gave a slightly better product; in 1930 the reverse was probably true, and in 1931 there was no apparent difference. Where differences due to soil types were noticeable after canning, the orchard that produced the best pears as judged by the fresh fruit also gave the best product when canned.

SUMMARY

The experimental work described herein has been concerned with the effect of maturity, handling, and storage of Bartlett pears on the quality of the canned product. The phases studied were those that take place prior to the entry of the fruit into the preparation or canning room. In the preparation and processing, standard cannery procedure was followed, and methods were made as nearly uniform as possible throughout. Chemical analyses were made at

[3] Stem, as used in this discussion of the canned product, refers to the prominent vascular tissue between the external stem and the carpels or seed cavities of the pear.

harvest and again when the fruit was ready for canning. The work extended over a period of more than 3 years.

Bartlett pears were picked at pressure tests ranging from 20 to 7 pounds (using the U. S. Department of Agriculture tester with the $\frac{5}{16}$-inch plunger and with the skin removed), and covered a period extending from the time when the first fruits were picked for commercial fresh shipments to the time when the last commercial pickings were made for the cannery.

Bartlett pears in the Yakima and Wenatchee Valleys increased in size from 1¾ to 2 percent per day throughout the season. If the percentage of fruit dropping from the trees was less than this figure, the increase in size balanced the loss from dropping. The pressures recommended will normally permit a maximum tonnage to be harvested.

Fruit picked at the higher pressure tests tended to lose weight more rapidly in the ripening room than that picked at the lower pressure tests, and often wilted noticeably.

Pears intended for the cannery gave the best finished product when the fruit was harvested at a pressure test of from 17 to 15 pounds. Fruit picked at a higher pressure test was generally darker when cut and became more so during preparation for canning. At pressure tests much below this range there was some loss from internal break-down by the time the fruit reached the canning stage, and the amount increased rapidly as the pressure dropped.

Pears held for a period of 15 to 30 days in cold storage had a better color and texture when canned than either those ripened without storage or those stored for longer periods. However, fruit harvested at the pressure tests from 17 to 15 pounds gave a fairly good product, even when stored for 2 months before canning.

Pears placed in cold storage at 30° to 32° F. immediately after harvest were better colored when canned and showed less loss from break-down and decay than the fruit delayed for 2, 4, or 6 days at higher temperatures before placing in cold storage.

A ripening temperature of 70° to 75° F. gave the most rapid and uniform ripening and resulted in the best canned product. A relative humidity of 78 to 85 percent in the ripening room gave satisfactory results.

Soil types had no appreciable effect upon the quality of the canned product, provided normal growing conditions prevailed.

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