Station Bulletin 206 July, 1924

Oregon Agricultural College

Experiment Station

Studies Relating to the Harvesting and Storage of Apples and Pears

By

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CORVALLIS, OREGON

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CONTENTS

Studies Relating to the Harvesting and Storage of Apples and Pears

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INTRODUCTION

It is generally conceded that the ultimate commercial worth of fruits is dependent, in a large measure, upon time and manner of harvesting and general methods of handling. The importance of these phases of fruit production became apparent upon the recognition of the fact that fruits, whether attached to the tree or vine, whether in storage or transit, are living organisms, which carry on life activities and which are influenced by environmental as well as internal factors. Since that time, much attention has been given to the study of both the physiology and the chemistry of fruits. Significant as the discoveries along these lines have been, however, they have left many questions unanswered, and there is still need for much more specific information relative to the activities of fruits during their period of ripening and decay. Only in the light of such information may improved methods and practices of handling be evolved.

Scope of investigations. Studies relating to the harvesting and storage of pears at the Oregon Experiment Station have been in progress since 1917. Four reports dealing with various phases of the investigations have already been published. The present report is confined primarily to the results obtained in 1923 by the home station at Corvallis. Observations are confined to fruit grown and harvested under Willamette Valley conditions. Several of the phases treated here are new to these investigations, and all the data presented are being published for the first time. The scope of the work has been enlarged so as to include more generally the winter varieties of pears and certain studies dealing with the handling of apples. In the present discussion no attempt is made to review completely the literature appertaining to the harvesting and storage of fruits.

Principle of pressure test. In view of the fact that a great deal of the material presented here relates directly or indirectly to the pressure test, a short account of this test and the principles upon which it is based is not out of place. Though several tests of maturity were considered by the Oregon Experiment Station, it soon became apparent that any reliable test applicable to the pear must be based wholly or in part "upon the physical rather than the chemical contents of the cells," and of the various methods tried the pressure test was the only one to give promise.

This test is based upon the fact that during the growth and ripening of the pear there is a gradual and consistent lowering of the physical resistance to pressure or wounding of the epidermal and cortical region. In the case of Bartlett, the decrease in resistance is close to 2 percent every twenty-four hours. This decrease according to Murneek (1923)

is occasioned by several factors, chief among which seem to be (1) increase in the size of the cells, (2) decrease in the thickness of the cell walls, (3) decrease in the amount of cell solids, and (4) wider separation of the stone cells.[1]

To measure the changes in resistance, a simple apparatus now known as the "pressure tester" has been perfected. This instrument merely expresses in convenient units the gradual changes in resistance that take place from time to time. A complete description of the pressure tester and its application is given in Oregon Agricultural Experiment Station Bulletin 186.

EXPERIMENTAL—PART I. PEARS

LOSS OF WEIGHT AFTER HARVEST

It is a matter of common knowledge that fruit loses weight following removal from the tree or vine. In extreme cases loss of weight while in storage may amount to as much as 15 percent of the total weight of the fruit. Two factors account for loss of weight in fruits: (1) natural decomposition, and (2) excessive loss of moisture. In the case of winter apples, loss of weight through natural decomposition would not exceed 0.2 to 0.3 percent of the total weight for the entire storage period.[2] It appears, therefore, that most of the loss must be attributed to the latter factor, which in general is governed by (1) relative humidity, (2) aeration, (3) temperature, (4) time of picking, (5) condition of the epidermis, and (6) kind and variety of fruit.

The relation of humidity to loss of weight in Bartlett pears. On August 14, one hundred representative specimens of Bartlett pears were gathered and divided into two lots of fifty each. Both lots were placed in an open container, the specimens being unwrapped. Lot 1 was stored at a relative humidity of 52 to 56 percent, while Lot 2 was stored at a relative humidity of 80 to 86 percent. The temperature in each case was 65° F. Both lots were under observation 408 hours, the pears having reached "prime eating" condition during this time. Weighings were made at the beginning and again at the end of the storage period. Table I shows the losses in weight recorded.

TABLE I. THE RELATION OF HUMIDITY TO LOSS OF WEIGHT IN BARTLETT PEARS

Lot No.	Pressure test	Temperature of storage room (Fahr.)	Relative humidity of storage room	No. of hours in storage	Loss of weight in percents
	lbs.				%
1	40.3	66°	52-56	408	13.9
2	40.3	66°	80-86	408	1.1

The data given in Table I are of primary importance in showing (1) that loss of weight may be a considerable factor in the handling of Bartlett pears, and (2) that insufficient humidity is its chief causal agent. Seemingly, loss of weight can be practically prevented by storage at a relative humidity of 80 to 86 percent. This observation corroborates the results of Magness and Diehl,[2] 1924, who found that loss of weight in winter apples was practically nil at a relative humidity of 85 to 90 percent over a period of five to seven months.

Fruit gathered during a period of low relative humidity may lose considerable weight if left unprotected in the orchard or packing house. Bartlett pears of the first picking showed a loss of nearly four percent when left for four days under the trees. It was found, however, that much of this loss can be eliminated by merely covering the boxes with wet canvas.

Effect of loss of weight upon the appearance and quality of the fruit. Excessive loss of weight invariably results in wilting, which seriously impairs the appearance of the fruit. Wilted pears, in the main, have lost their gloss and waxiness, are dull and unattractive, and do not become aromatic. In the case of Bartlett, Anjou and Comice, it was found that a loss of weight of three to four percent was sufficient to cause noticeable wilt. There is no indication, however, that wilted fruit goes down more rapidly, or that its texture and juiciness are impaired to any extent. Fruit in this condition seems to be slightly more resistant to attack of decay organisms.

Time of picking in relation to loss of weight. It is a well known fact that fruit picked while in an immature condition wilts more readily than that picked later in the season. This seems to be due to the fact that while the fruit is growing, its lenticels or breathing pores are open and that as the season advances, these become covered over with a layer of cork-like cells[3] which seem to be instrumental in preventing loss of moisture.

To determine the effect of time of picking on the rate at which pears lose weight, Bartlett pears were picked at three different times, during the harvesting season, the first lot being picked on August 14, the second on August 29 and the third on September 14. Pressure test readings were made at the time of each picking. Each lot was accurately weighed and placed in storage for 264 hours at a temperature of 66° F. and a relative humidity of 52 to 56 percent. At the end of the time the lots were again weighed and the percentage of loss of weight computed. Table II gives the percentage of weight lost in each case.

TABLE II. TIME OF PICKING IN RELATION TO LOSS OF WEIGHT IN BARTLETT PEARS

Lot No.	Date of picking and storing	Pressure test	Temperature of storage room (Fahr.)	Relative humidity	No. of hours in storage	Loss of weight in percents
		lbs.				%
1	8/14	40.3	66°	52-56	264	9.7
2	8/29	33.0	66°	52-56	264	6.3
3	9/14	25.8	66°	52-56	264	5.8

All things being equal, the rate at which pears lose weight after harvest is greater in the case of those picked early in the season than in the case of those picked later. It is obvious, however, that all pears, whether picked early or late, lose considerable weight when kept at low humidities for any length of time.

Effect of type of wrappers upon loss of weight. The material for this test consisted of typical specimens of Bartlett pears gathered on August 29. The pressure test reading on these pears was 31.5 pounds. The specimens were arranged into three lots of equal size. Those of

Lot 1 were stored in an open crate without wrappers. Those of Lot 2 were wrapped in common fruit tissue. Those of Lot 3 were wrapped in commercial oiled paper containing about 4 percent "Tecol." The three lots were placed in storage for 352 hours at a temperature of 66° F. and a relative humidity of 52 to 56 percent. Weighings were made at the beginning and again at the end of the storage period. A summary of the results is given in Table III.

TABLE III. THE EFFECT OF TYPE OF WRAPPERS UPON LOSS OF WEIGHT IN BARTLETT PEARS

Lot No.	Date of picking and storing	Pressure test	Temperature of storage room (Fahr.)	Relative humidity of storage room	No. of hours in storage	Type of wrap	Loss of weight in percents
		lbs.					%
1	8/29	31.5	66°	52-56	352	unwrapped	7.9
2	8/29	31.5	66°	52-56	352	common fruit tissue	6.8
3	8/29	31.5	66°	52-56	352	oil wrap	6.7

From these figures it appears that the type of wrappers used had but little effect upon the rate at which the specimens lost weight in storage. It is true that loss of weight was slightly less in the case of both the fruit fiber and oil wraps, but the difference is too small to be of practical significance.

Rate of loss of weight. This test was undertaken with the aim of answering the following questions: (1) All factors being equal, do pears after picking, lose weight at a constant rate, or (2) does the rate vary from time to time?

Twelve typical specimens of Bartlett were gathered on August 29. These were kept in storage in an open container at a temperature of 66° F. and a relative humidity of 52 to 56 percent for a period of 16 days. Accurate weighings were made at 9 a.m. each day. The data obtained are given in Table IV. Fig. 1 illustrates graphically the rate at which loss of weight occurred.

TABLE IV. RATE OF LOSS OF WEIGHT IN BARTLETT PEARS

Date	Weight	Daily loss of weight	Daily loss of weight in percents	Total loss of weight in percents
	grams	*grams*	%	%
Aug. 29	2405.5			
Aug. 30	2391.9	13.6	.56	.56
Sept. 1	2379.6	12.3	.51	1.07
Sept. 2	2359.0	20.6	.78	1.87
Sept. 3	2344.8	14.2	.59	2.44
Sept. 4	2331.7	13.1	.54	2.98
Sept. 5	2319.2	12.5	.52	3.50
Sept. 6	2306.6	11.6	.48	3.98
Sept. 7	2292.8	13.8	.57	4.55
Sept. 8	2278.8	14.0	.58	5.13
Sept. 9	2265.5	13.3	.55	5.68
Sept. 10	2251.6	13.9	.57	6.25
Sept. 11	2240.2	11.4	.48	6.73
Sept. 12	2229.4	10.8	.45	7.18
Sept. 13	2218.3	11.1	.47	7.66
Sept. 14	2206.7	11.6	.48	8.14

These pears evidently lost weight at a fairly constant and uniform rate throughout the period of storage. Minor fluctuations occurred

from day to day, but as Fig. 1 indicates, these did not cause radical changes in the rate at which the fruit lost weight. Data from other lots of pears in storage indicate that this is a general rule.

LOSS OF VOLUME AFTER HARVEST

Both growers and dealers are aware of the fact that pears lose volume following removal from the tree. Tightly packed boxes frequently become slack while in storage or in transit, this being a common cause of controversy in the fresh fruit trade. Loss of volume in pears was considered in the present investigations (1) to ascertain the importance of such loss and (2) to consider methods for its prevention.

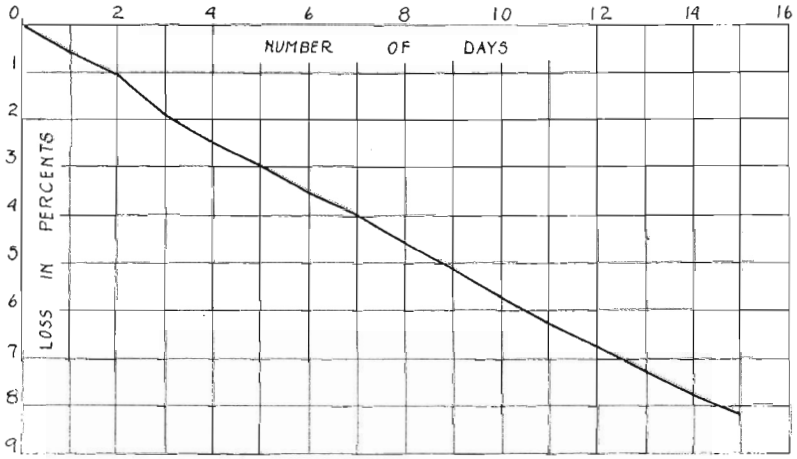

Fig. 1. The rate of loss of weight in Bartlett pears.

Amount of volume lost. Three lots of Bartlett pears which had been gathered and stored for the test relating to loss of weight, furnished the data on loss of volume. These, as already indicated, were picked on August 14, August 29, and September 14, and stored at a temperature of 66° F. and a relative humidity of 52 to 56 percent. The volume of each lot was computed at the time of picking and again at the end of the storage period, by immersing the pears in water and measuring the amount of displacement. The weight records of these lots afforded an opportunity to compare loss of volume with loss of weight. Table V shows the loss of volume in percents and also the relationship between the loss of volume and the loss of weight.

TABLE V. COMPARISON OF LOSS OF WEIGHT WITH LOSS OF VOLUME IN BARTLETT PEARS

Lot No.	Date of picking and storing	Pressure test	Temperature of storage room (Fahr.)	Relative humidity of storage room	No. of hours in storage	Loss of weight in percents	Loss of volume in percents
		lbs.				%	%
1	8/14	40.3	66°	52-56	408	13.9	14.5
2	8/29	33.0	66°	52-56	352	7.8	9.2
3	9/14	25.8	66°	52-56	264	5.8	6.2

From the data of Table V it appears (1) that loss of volume may be a factor of considerable importance, and (2) that there is a close correlation between loss of volume and loss of weight. Seemingly, every loss of weight is accompanied by a corresponding loss in volume.

Method of prevention. Since loss of volume is closely correlated with loss of weight, it is obvious that what will prevent one will also prevent the other, and as already indicated the prevention of loss of weight is primarily a matter of maintaining a fairly high relative humidity at all times.

AMOUNT OF CROP IN RELATION TO DEGREE OF MATURITY

Considerable difficulty has been encountered in the handling of pears because of rather wide variation in the time of maturity manifested by specimens within the same lot. Dealers and canners, in particular, have often referred to this condition. Since unevenness in ripening takes place among pears picked at the same time and stored under identical conditions, it appears that this condition must occur because all pears from a given orchard are not of the same degree of maturity at the time of picking.

From casual observation it is fairly clear that there is a difference in degree of maturity between fruit from heavily and lightly loaded trees. That from heavily loaded trees appears to be farther advanced. It is usually lighter in color, more glossy in appearance, and somewhat softer in texture. The importance of this apparent difference in maturity was ascertained in the following manner:

On August 15 fruit was selected at random from fifty heavily loaded Bartlett trees in the Oaco orchards at Monroe. At the same time, fruit was selected in a like manner from fifty lightly loaded trees. Pressure test readings and caliper measurements were then made of each lot. This test was repeated on August 24, and again on September 7. The following table gives the results for the three determinations:

AMOUNT OF CROP IN RELATION TO DEGREE OF MATURITY

Nature of crop	Transverse diameter	Pressure test
	in.	*lbs.*
Test No. 1, August 15.		
Heavy	2 7/8	38.4
Light	2 9/16	43.8
Test No. 2, August 24.		
Heavy	2 8/16	34.9
Light	2 10/16	39.3
Test No. 3, September 9.		
Heavy	2 11/16	27.2
Light	2 14/16	32.9

As indicated by the pressure test, there is a relationship between the amount of crop present on the trees and the degree of maturity of the fruit, that from heavily loaded trees being relatively more mature than that from lightly loaded trees. This difference seems to obtain throughout the harvest season and is sufficient to account for much of the un-

evenness in ripening manifested by pears after harvest. Again, as the caliper measurements indicate, the fruit from lightly loaded trees, though considerably less mature, is larger in size. This is significant since in many instances pears are picked according to size. Obviously, where this practice is in vogue, the less mature fruit is often the first to be gathered.

FACTORS AFFECTING THE PRESSURE TEST

Murneek[3] 1921, mentions certain factors which may affect the pressure test and calls attention to their practical significance. The work of the past season, however, shows that the results obtained with the pressure tester may be affected by several factors which did not receive attention in the previous reports.

Temperature of the fruit. The recent work of Hawkins and Sando[5] shows that in the case of cherries and certain cane fruits, the resistance of the epidermis and cortical region to mechanical injury varies more or less with the temperature of the fruit. The resistance, it seems, varies in inverse proportion to the temperature. Obviously, if this situation obtains in the case of pears, temperature of the fruit should have influence upon the pressure test. Data on this point were furnished by the following experiment:

On August 29, forty typical specimens of Bartlett were gathered and placed in a common ice-box. At the end of six hours the temperature of this fruit was 51° F. Pressure test readings were then made, and the pears were placed in the Freas electric oven, where their temperature soon registered 97° F. Pressure test readings were again made while the fruit was at this temperature. Table VI gives the results obtained.

TABLE VI. THE EFFECT OF THE TEMPERATURE OF THE FRUIT ON THE PRESSURE TEST

Date	Temperature of fruit (Fahr.)	Pressure test
		lbs.
August 29	51°	35.0
August 29	97°	31.6

Resistance to pressure, obviously, fluctuates with the temperature of the fruit at the time the test is made. In this case, an increase in temperature of 46° F. was accompanied by a decrease in resistance of 3.4 pounds. The significance of this factor is apparent when it is borne in mind (1) that a difference of 3.4 pounds in the pressure test reading of Bartlett pears means a difference of approximately 7 days in the time of picking, and (2) that the temperature of fruit in the orchard may vary as much as 50 degrees F. in the course of 24 hours.

Removal of part of the crop. Preliminary observations on Bartlett during the season of 1923 showed that the removal of a portion of the crop interferes with the pressure test for the remainder of the crop. When three-fourths of the pears were removed at mid-season, those remaining on the trees failed to show the usual decrease in resistance for some time following. Up to the time this picking was made, the entire crop had shown an average decrease of about one-half pound per

day, but following this picking the decrease noted was less than one pound in ten days.

Several interesting questions are suggested by this behavior. (1) Is the part of the crop remaining on the trees actually ripening in spite of its failure to show a material decrease in resistance or is it merely in a state of suspended animation? (2) Are other varieties subject to this irregularity? (3) Does this condition render the pressure test ineffective as an indicator of maturity for the later pickings?

The following test on Anjou and Comice throws light upon these questions: On September 25, about three-fourths of the crop was removed from certain Anjou trees. The average pressure test reading at this time was 19.5 pounds, and for 32 days previous to this picking Anjou had shown an average decrease in resistance of nearly one-half pound per day. Pickings of the remainder of the crop were made on September 28, October 1, October 5, and October 9. Pressure tests were made and the pears from each picking were placed in storage at a temperature of 66° F. and a relative humidity varying from 80 to 86 percent. This experiment was repeated with Comice, the major portion of the crop being removed on October 5, and subsequent pickings being made on October 9, October 13, and October 19. From September 17 to October 5, the Comice had shown an average decrease in resistance of about four-tenths pound per day. Check trees of both varieties were left untouched so that a comparison of the relative decrease in resistance could be obtained. Tables VII and VIII give most of the data obtained in the course of this experiment.

TABLE VII. REMOVAL OF PART OF CROP IN RELATION TO SUBSEQUENT PRESSURE TESTS IN ANJOU PEARS

Lot No.	Date of picking and storing	Pressure test	Temperature of storage room (Fahr.)	Relative humidity of storage room	Date of prime eating condition	No. of days to attain prime eating condition
		lbs.				
1	9/25	19.5	66°	80-86	10/31	36
2	9/28	19.1	66°	80-86	10/31	33
3	10/1	19.3	66°	80-86	11/1	31
4	10/5	19.4	66°	80-86	11/1	27
5	10/9	18.9	66°	80-86	11/1	23

TABLE VIII. REMOVAL OF PART OF CROP IN RELATION TO SUBSEQUENT PRESSURE TESTS IN COMICE PEARS

Lot No.	Date of picking and storing	Pressure test	Temperature of storage room (Fahr.)	Relative humidity of storage room	Date of prime eating condition	No. of days to attain prime eating condition
		lbs.				
1	10/5	18.2	66°	80-86	11/3	28
2	10/9	18.0	66°	80-86	11/2	24
3	10/13	18.1	66°	80-86	11/1	19
4	10/19	17.7	66°	80-86	11/1	13

From these data it appears that removal of a major portion of the crop affects the pressure test for the remainder. After three-fourths of

the crop had been removed, in the case of Anjou, the effect was so marked that the remainder of the pears showed a total decrease in resistance of only six-tenths of a pound in 14 days, while those on the check trees from which no fruit had been removed showed a total decrease in resistance of 5.6 pounds during the same period. Specimens of Comice showed a total decrease in resistance of only five-tenths of a pound in 13 days, while fruit from the check trees of this variety showed a total decrease of 4.1 pounds.

But even though the removal of a portion of the crop does arrest or retard the usual decrease in resistance, there is indication that this has no relation to the ripening process. The data from the storage tests seem to show that while there is no material decrease in resistance for some time following removal of a portion of the crop, the pears are ripening at the usual rate. Specimens of Anjou picked on September 25 required 35 days to reach "prime" eating condition, those picked on October 9 required only 23 days, this in spite of the fact that the total decrease in resistance between these pickings was only six-tenths of a pound. Specimens of Comice picked on October 5 required 28 days to reach maturity, while those picked on October 19 required only 13 days. In this case, the total decrease in resistance between picking dates was only five-tenths of a pound.

Thus it would seem that after a goodly portion of the crop has been removed, the pressure test is no longer an accurate indicator of maturity for the fruit that remains on the trees. This has practical significance in cases where the crop is disposed of in more than one picking. It is suggested that in such cases, the theoretical rather than the actual decrease in resistance be used as the indicator. If, for example, the average rate of decrease in resistance has been four-tenths of a pound a day for some time prior to the first picking, it can be assumed that this indicates the rate of maturity for the entire season.

Turgidity of the fruit. Murneek, 1921, observed that following harvesting, pears frequently register an increase in resistance instead of the expected decrease due to advancing maturity.[4] Bartlett pears picked on August 6, for example, gave a pressure test reading 33.0 pounds six hours after picking and 36.0 pounds 36 hours after picking. This seemed to be especially true of pears of the early pickings.

Though not fully understood, this irregularity in the behavior of resistance following the time of picking appears to be associated with the turgidity of the fruit. It seems possible that the increase in resistance is due to the wilted or leathery nature of the epidermis and cortical tissue following loss of moisture. Magness and Burroughs, 1923, found that in all varieties of apples the skin becomes tougher after the fruit goes into storage and concluded that this condition is probably due to lessened turgidity.[6]

The data relative to the effect of turgidity on the pressure test was furnished in part by two lots of Bartlett pears gathered on August 24. Pressure test readings were made at picking time and both lots were then placed in storage at a temperature of 66° F. Lot 1 was subjected to a relative humidity of 80 to 86 percent, while Lot 2 was kept at a relative humidity of 52 to 56 percent. At the end of 36 hours, both lots were removed from storage and again subjected to the pressure test. Table IX gives the results obtained.

TABLE IX. TURGIDITY OF THE FRUIT IN RELATION TO THE PRESSURE TEST

Lot No.	Temperature of storage room (Fahr.)	Relative humidity of storage room	Pressure test at picking time	Pressure test 36 hours later
			lbs.	*lbs.*
1	66°	80-86	35.9	33.9
2	66°	52-56	35.7	36.4

Apparently, when pears are kept at high humidity where loss of moisture is practically nil and turgidity is not lessened, the resistance shows the expected decrease. When they are subjected to low humidity, however, where loss of moisture and lessened turgidity are the rule, an increase in resistance is noted.

Loss of turgidity while on the trees. It has been noted several times that during periods of drought and low humidity, pears attached to the trees often fail to show the usual decrease in resistance. In fact, during the dry spell of 1922, Anjou pears in the Oaco orchards at Monroe actually showed an increase in resistance from day to day, for a considerable period of time. Fruit of the same variety in the orchard of the Corvallis Orchard Company displayed the same tendency in 1923. On September 15, these pears gave a test of 30.1 pounds. Five days later they gave a test of 31.0 pounds, this in spite of the fact that they were rapidly becoming lighter in color and gave evidence of approaching maturity. Due to heavy pruning and abundant moisture in spring, the trees in this orchard were covered with unusually heavy foliage, which at this time, gave unmistakable evidence of lack of moisture. On September 23 and 24, however, a considerable amount of rain fell. The drought came to an end and the leaves immediately regained their turgidity. Pressure tests on the fruit made on September 25, gave a reading of 23.1 pounds, showing a decrease of 7.9 pounds in five days.

Here, again, there seems to be a correlation between the turgidity of the fruit and the response from the pressure tester. During dry periods, several factors may contribute to lessened turgidity: (1) the fruit itself may give up moisture to the air; (2) the supply of moisture from the soil is apt to be limiting; and (3) the leaves may actually draw water from the fruit.[7]

The results of the following tests are interesting in this connection. Two lots of Anjou pears were gathered on September 15. The specimens of Lot 1 were gathered in the usual way, while those of Lot 2 were gathered with the leaves and spurs attached. Pressure test readings of each lot were made at the time of picking. Both lots were then placed in storage at a temperature of 66° F. and a relative humidity of 80 to 86 percent. At the end of 36 hours, both lots were removed from storage, and pressure test readings were again made. Table X gives the data from these readings.

TABLE X. APPARENT EFFECT OF LEAVES ON TURGIDITY

Lot No.	Treatment	Temperature of storage room (Fahr.)	Relative humidity of storage room	Pressure test at picking time	Pressure test 36 hours later
				lbs.	*lbs.*
1	Stored without leaves	66°	80-86	31.6	30.0
2	Stored with leaves attached	66°	80-86	31.3	33.1

The pears of Lot 1, as might be expected, show the usual decrease in resistance, there being a reduction of 1.6 pounds during the 36 hours. Those of Lot 2, on the other hand, show an increase of 1.3 pounds for the same period. The leaves, apparently, continued to draw moisture from the fruit and thus lowered its turgidity.

The effects of paring. Magness and Burroughs, 1923, found an interesting comparison between the relative toughness of the peel in apples.[6] These authors report a wide variation among the different varieties between the pressure test readings of pared and unpared fruit; Baldwin at picking time showing a difference in resistance of 3.4 pounds; Rome, a difference of 4.52 pounds; and Yellow Newtown, 8.00 pounds. The difference in resistance between pared and unpared fruit seems to increase as the fruit remains in storage, and in order to obtain a more indicative test of the degree of hardness of the flesh, it is recommended that the fruit be pared before pressure test readings are made.

When the pressure test is being applied to determine the time of picking, however, paring has advantage only when it is known that this treatment lessens the amount of variation between individual determinations. A constant difference of 1.5 pounds between pared and unpared fruit would have no bearing upon the test; but, on the other hand, if differences in thickness and texture of the epidermis add to the variability between individual determinations, then paring of the specimens might give more uniform results.

Information on this point was furnished by 21 specimens of Bartlett gathered on August 22. Four pressure test determinations were made on opposite sides of each specimen, two upon pared surface and two upon unpared surface. The amount of variation was recorded and compared as shown in Table XI.

TABLE XI. VARIATION BETWEEN PRESSURE TEST DETERMINATIONS MADE ON PARED AND UNPARED SURFACES OF BARTLETT PEARS

No.	Readings on unpared surface	Variation	Readings on pared surface	Variation
	lbs.	*lbs.*	*lbs.*	*lbs.*
1	39-37	2	35-33	2
2	37-40	3	35-34	1
3	37-39	2	35-37	2
4	38-39	1	37-39	2
5	35-39	4	35-33	2
6	39-39	0	35-37	2
7	39-37	2	38-35	3
8	37-40	3	35-36	1
9	37-37	0	35-37	2
10	39-37	2	35-36	1
11	38-38	0	37-35	2
12	39-39	0	39-38	1
13	35-34	1	34-34	0
14	39-40	1	37-36	1
15	38-38	0	36-36	0
16	39-37	2	37-36	1
17	38-37	1	37-37	0
18	37-37	0	33-33	0
19	35-35	0	35-36	1
20	36-36	1	35-35	0
21	38-37	1	33-33	0
	Total variation	26		25

It is noticeable that while the unpared surfaces gave a slightly higher resistance throughout, the total amount of variation among individual determinations made on such surfaces was not materially greater than that found among the determinations recorded on pared surfaces. If these results are indicative of the general situation, practically nothing is gained by paring so far as Bartlett is concerned. Similar tests with Anjou, Comice, Howell, and others indicate that this rule holds true for the clear skinned varieties in general.

Effects of russeting. Apparently, the kind of russeting such as sometimes occurs in Bartlett, Anjou, and Comice has but little effect upon the pressure test. In the case of such varieties as Bosc and Winter Nelis, however, russeting may affect resistance in a material way. This is shown by Table XII, which represents variation in readings manifested by Winter Nelis pears from the same tree on October 27.

TABLE XII. EFFECT OF RUSSET ON RESISTANCE IN WINTER NELIS PEARS

Lot No.	Condition of epidermis	Pressure test
		lbs.
1	Pared	21.2
2	Clear	26.4
3	Heavily russeted	29.1

It will be noted that the average difference between the determinations made on clear and russeted surfaces is 2.7 pounds. When it is borne in mind that the average daily rate of decrease in resistance in Winter Nelis is less than 0.3 pound, the significance of this variation is apparent and it is obvious that erroneous conclusions will result unless it is taken into account. Again, this factor complicates the situation in that the increased resistance occasioned by russeting varies with the intensity of the russet. In this particular case, differences varying from less than one pound to nearly three pounds were recorded. The difficulty of making allowance for the russet is at once apparent, and it is suggested that clear skinned specimens be used whenever possible, and when these cannot be obtained it is perhaps best to pare the fruit as indicated under another caption.

Effect of red color. Zschokke, 1897, found that with the exposure of fruits to the sun, there is a thickening of the cuticle and subepidermal area.[3] Magness and Diehl, 1924, found that in apples, there is a distinct variation in the thickness of the subepidermal region, the heavily blushed sides of Rome Beauty showing 8 to 10 layers of cells in this portion whereas the unblushed part shows but six layers.[2] These authors note, also, that blushed surfaces are harder in texture. Murneek, 1923, calls attention to the fact that the pigmented part of pears offers greater resistance to wounding than do the green portions.[1]

Table XIII shows the possible effect of a red blush on the pressure test. Specimens of Bartlett gathered on August 18 were used for this test. Pressure test determinations were made on both the blushed and uncolored surfaces of the same specimens.

TABLE XIII. THE RELATION OF COLOR TO RESISTANCE IN BARTLETT PEARS

Lot No.	Condition of the epidermis	Pressure test
		lbs.
1	Blushed	41.2
2	Uncolored	38.7

Evidently, the difference in resistance offered by blushed and uncolored surfaces of the same specimens is considerable. Tests at various times during the season showed about the same relative difference. Anjou and Comice gave very much the same results. As in the case of russet, the resistance varies somewhat with the intensity of the blush, a deep blush offering considerably more resistance than one less intensely colored.

Relative seasonal decrease in resistance of cortex and epidermal regions. Nine separate pickings of Comice were made during the harvest season of 1923. Comprehensive pressure tests of both pared and unpared specimens of each picking were made and recorded. The data obtained in this manner afford an opportunity to compare the seasonal changes in resistance manifested by both the cortex and epidermal regions. Table XIV gives these data.

TABLE XIV. THE RELATIVE SEASONAL DECREASE IN RESISTANCE OF THE CORTEX AND EPIDERMAL REGIONS OF COMICE PEARS

Lot No.	Date of picking	Pressure test, unpared specimens	Pressure test, pared specimens	Difference in resistance
		lbs.	*lbs.*	*lbs.*
1	9/17	25.7	21.2	4.5
2	9/21	24.3	20.2	4.1
3	9/25	23.0	20.0	3.0
4	9/28	21.6	18.8	2.8
5	10/1	19.1	16.0	3.1
6	10/5	18.2	15.3	2.9
7	10/9	18.0	15.2	2.8
8	10/13	17.3	14.8	2.5
9	10/19	16.5	14.2	2.2

Obviously, less resistance was recorded for the pared fruit in each case, but the difference in resistance between the pared and the unpared fruit became less and less as the season progressed, being 4.5 pounds at the time of the first picking, and 2.2 pounds at the time of the last picking. The epidermal region, in other words, shows a greater amount of seasonal decrease in resistance than does the cortex, and since the efficiency of the pressure test is dependent primarily upon the range of resistance manifested, unpared fruit should give a more indicative test when the above condition obtains.

GENERAL INDICATORS OF MATURITY IN PEARS

The general indicators of maturity in pears again received attention during the present investigations, and a brief digest of the observations is given here.

Ease of separation from the spur. Ease of separation from the spur does not seem to be a reliable indicator of maturity in pears. This

factor, seemingly, is associated with the moisture conditions of the tree and fruit. When moisture is abundant and turgidity is high, most pears separate quite readily from the spurs though they may be comparatively green. But when the moisture is limiting and turgidity is below normal, the fruit tends to cling regardless of maturity. This is especially true during the early part of the harvest season.

Size of the fruit. Though often resorted to in actual practice, size of fruit is not an indicator of maturity according to findings in these investigations. The larger specimens are usually no riper than are the smaller ones; in fact, as already pointed out, there are instances where the smaller specimens in the same orchard are actually much riper than are the larger ones.

Ripening of imperfect specimens. With most varieties of pears, wormy or otherwise imperfect specimens often fall to the ground and ripen considerably in advance of the normal crop. This has proved to be a fairly reliable indicator of maturity. So long as the imperfect specimens fall to the ground and merely shrivel up without ripening, it is safe to assume that the normal fruit has not reached picking maturity, but as soon as these specimens are observed to turn yellow and soften up without undue shriveling the bulk of the crop can generally be picked without danger of sacrifice in quality.

Color of the seeds. In some of the fruit districts of eastern United States the color of the seed is often employed as an indicator of maturity. In Oregon, however, this factor has proved to be extremely unreliable, the color of the seeds varying widely with the season, moisture conditions, and age of the trees.

Changes of the ground color. Two distinct color elements may be associated with the pear. First, there is the blush or "overcolor" which seemingly is brought on by factors other than those associated with ripening and which has, therefore, no value as an indicator of maturity. Second, there is the ground or "undercolor," which, during the period of maturity usually changes from a dull green to a light green or yellow, and which may be of considerable value in determining time of picking, especially in the clear skinned varieties such as Clapp's Favorite, Bartlett, Howell, Anjou, and Comice. The change in ground color in most pears takes place in a rather characteristic manner. The surface for the most part becomes lighter in color with the exception of a small area immediately surrounding each lenticel or breathing pore. This gives the pear a more or less speckled or dotted appearance. In the case of Bartlett, the speckling usually occurs when the pressure test registers around 38 pounds. This would mean that the first picking of pears for eastern shipment may be made ordinarily from 5 to 8 days following the appearance of the green dots.

Nature of the bloom. Most of the deciduous fruits during the period of growth and maturity are covered with whitish "bloom" which gives the fruit a characteristic bluish or gray tinge. In the case of pears, the bloom is usually more or less insignificant yet may be of some value as an indicator of maturity. During the period of growth, pears of the clear skinned type have a rather dull appearance because of this bloom, but as the fruit approaches maturity, a portion of the bloom disappears and the pear takes on a brighter and waxier finish. This is noticeable especially in the case of Bartlett.

RELATION OF TIME OF PICKING TO QUALITY AND TIME OF RIPENING

Representative lots of Anjou, Comice, Winter Nelis, and Bartlett were gathered at intervals of 3 to 5 days during the season of 1923. Pressure test readings were made of each lot and the lots were all placed in storage at a temperature of 66° F. and a relative humidity of 52 to 56 percent. The specimens were wrapped in common fruit tissue and packed in open containers. Careful observations were made from time to time with the aim of ascertaining, so far as possible, (1) the effects of time of picking on quality and time of ripening, and (2) the proper time of harvesting as indicated by the pressure tester.

Anjou. As shown in Table XV, ten separate pickings of Anjou were made during the season of 1923, the first on August 29 and the final on October 5. It will be noted that a considerable difference was registered in the time required for the fruit of the various pickings to reach prime eating condition, that of the first requiring 54 days, and that of the last, only 26 days. This is a rather significant observation. As Table XV shows, the pears from the early pickings developed inferior quality in storage. They were undersized for the variety, and displayed more or less wilt. They were somewhat astringent, lacked in sweetness, and tended to ripen unevenly. Those picked late in the season lacked a little in juiciness, but in the main were of good quality. It appears from these data that Anjou has a comparatively long picking season, since all the fruit gathered between September 4 and September 28 developed full Anjou characteristics and held up remarkably well. Obviously, there was a gradual reduction in resistance throughout the harvest season, the pears of the first picking registering a pressure test of 33.0 pounds and all subsequent pickings showing an average daily decrease of 0.4 pound. So far as these results indicate, Anjou in the Willamette Valley may be safely picked when the pressure test readings are between 24 and 19 pounds.

Comice. Beginning with September 17, and ending with October 19, nine separate pickings of Comice were made. These were handled as indicated in the case of Anjou. The data on Comice, which in general corroborate those obtained with Anjou, are given in Table XVI. As before, the fruit of the early pickings was inferior in quality, showed considerable wilt, and was undersized.[12] Fruit of these pickings required considerably longer to reach edible maturity in storage. Late picked fruit lacked somewhat in juiciness and went down rapidly due to core rot. Comice, unlike Anjou, seems to have a rather short harvesting period. Only the pears picked between October 1 and October 9 developed real Comice quality. Comice, like other varieties, shows a gradual decrease in resistance during the season, the pressure test reading at the time of the first picking being 25.7 pounds and only 16.5 pounds at the time of the last picking. Indications are that Willamette Valley Comice should be gathered when the pressure test registers between 20 and 18 pounds.

Winter Nelis. Eight separate pickings of Winter Nelis were made. These were handled in the same manner as were Anjou and Comice. The picking dates and the complete data obtained are given in Table

TABLE XV. THE RELATION OF TIME OF PICKING TO THE QUALITY AND TIME OF RIPENING OF ANJOU PEARS

Lot No.	Date of picking and storing	Pressure test	Temperature of storage room (Fahr.)	Relative humidity of storage room	Date of prime eating condition	No. of days to attain prime eating condition	Condition at maturity
		lbs.					
1	8/29	33.0	66°	80-86	10/22	54	Considerably undersized. Considerably wilted. Juicy but more or less astringent. Lacking in sweetness and character. No aroma. Tendency to ripen unevenly. No core rot. No scald.
2	9/7	29.6	66°	80-86	10/25	48	Considerably undersized. More or less wilted. Not waxy. Juicy but lacking in sweetness and character. No aroma. No core rot. No scald.
3	9/11	27.2	66°	80-86	10/29	48	More or less undersized. Slightly wilted. Not waxy. Juicy but lacking somewhat in sweetness and character. Quality better than that of Lots 1 and 2. Slightly aromatic. No core rot. No scald.
4	9/14	25.0	66°	80-86	10/30	46	Slightly undersized. Not wilted. More or less waxy. Juicy and fairly sweet. Quality better than that of Lot 3. Aromatic. No core rot. No scald.
5	9/17	23.2	66°	80-86	10/31	44	Practically full sized. Not wilted. Juicy and sweet with full Anjou quality. Good waxy appearance. Ripened evenly. Aromatic. No core rot. No scald.
6	9/21	21.1	66°	80-86	10/31	40	Practically full sized. Not wilted. Juicy and sweet with full Anjou quality. Good waxy appearance. Ripened evenly. Aromatic. No core rot. No scald.
7	9/25	19.1	66°	80-86	10/31	36	Full sized. Not wilted. Juicy and sweet with full Anjou quality. Good waxy appearance. Ripened evenly. Aromatic. No core rot. No scald.
8	9/28	18.6	66°	80-86	10/31	33	Full sized. Not wilted. Juicy and sweet with full Anjou quality. Good waxy appearance. Ripened evenly. Aromatic. No core rot. No scald.
9	10/1	18.0	66°	80-86	10/31	30	Full sized. Not wilted. Juicy and sweet with full Anjou quality. Good waxy appearance. Ripened evenly. Aromatic. No core rot. No scald.
10	10/5	17.2	66°	80-86	10/31	26	Full sized. Not wilted. Slightly less juicy than previous lots, but sweet and of good quality. Good waxy appearance. Ripened evenly. Aromatic. No core rot. No scald.

XVII. Here again the results in general are very similar to those of other varieties. Fruit of the early pickings required much more time to ripen and was inferior in quality and other respects. That of the very late pickings lacked somewhat in juiciness. As in the case of Anjou, this variety seems to have a long picking season, excellent quality resulting from all pears picked between October 1 and October 20. Though of a

less indicative nature, Winter Nelis showed the usual decrease in resistance during the season, registering 35.8 pounds on September 22 and 26.4 pounds on October 27. The results of this test indicate that Winter Nelis should be gathered when the pressure tester indicates a resistance of 33 to 29 pounds. This is assuming that fairly clear skinned specimens are used in making the test. When russeted fruit has to be used and the specimens are pared, the test should read between 28 and 24 pounds.

Bartlett. Table XVIII gives the results obtained with nine pickings of Bartlett, the first being made on August 18 and the last on September 18. The data given here correspond very closely with those previously given for this variety in other reports. In general, fruit gathered at

TABLE XVI. THE RELATION OF TIME OF PICKING TO THE QUALITY AND TIME OF RIPENING OF COMICE PEARS

Lot No.	Date of picking and storing	Pressure test	Temperature of storage room (Fahr.)	Relative humidity of storage room	Date of prime eating condition	No. of days to attain prime eating condition	Condition at maturity
		lbs.					
1	9/17	25.7	66°	80-86	11/9	53	Considerably undersized. Considerably wilted. Juicy but astringent and lacking in sweetness. Unmarketable. Not waxy. Not aromatic. No core rot. No scald. Tendency to ripen unevenly.
2	9/21	24.3	66°	80-86	11/8	46	Considerably undersized. Considerably wilted. Juicy but astringent, and lacking in sweetness. Unmarketable. Not waxy. Not aromatic. No core rot. No scald. Tendency to ripen unevenly.
3	9/25	23.0	66°	80-86	11/7	43	More or less undersized. Slightly wilted. Juicy but somewhat astringent and lacking in sweetness. Quality somewhat better than that of previous lots. Unmarketable. Not waxy. Not aromatic. No core rot. No scald.
4	9/28	21.6	66°	80-86	11/7	41	Slightly undersized. Slightly wilted. Juicy but lacking somewhat in sweetness. Quality fairly good. Marketable. Not very waxy. Slightly aromatic. No core rot. No scald.
5	10/1	19.1	66°	80-86	11/4	35	Slightly undersized. Slightly shriveled. Juicy, sweet and of good quality. Not very waxy. Slightly aromatic. No core rot. No scald.
6	10/5	18.2	66°	80-86	11/3	28	Full sized. Not wilted. Juicy and sweet with full Comice quality. Good waxy appearance. Aromatic. No core rot. No scald.
7	10/9	18.2	66°	80-86	11/3	25	Full sized. Not wilted. Juicy and sweet with full Comice quality. Good waxy appearance. Aromatic. No core rot. No scald.
8	10/13	17.3	66°	80-86	11/2	20	Full sized. Not wilted. Less juicy than previous lots, but sweet and of good quality. Good waxy appearance. Aromatic. About 31 percent core rot. No scald.
9	10/19	16.5	66°	80-86	11/1	13	Full sized. Not wilted. Much less juicy than previous lots. Sweet but more or less insipid. Good waxy appearance. Aromatic. Tendency to go down rapidly. One hundred percent core rot. No scald.

mid-season develops the highest quality. Late picked fruit, while suitable for drying and canning, does not hold up sufficiently long for distant shipment in the fresh state. Fruit picked very late in the season develops more or less core rot. The average reduction in resistance of approximately 0.5 pound per day was maintained throughout the season of 1923. The recommendation of Murneek to the effect that Bartlett pears should be picked when the pressure test registers between 35 and 25 pounds was sustained by this test.

TABLE XVII. THE RELATION OF TIME OF PICKING TO THE QUALITY AND TIME OF RIPENING OF WINTER NELIS PEARS

Lot No.	Date of picking and storing	Pressure test	Temperature of storage room (Fahr.)	Relative humidity of storage room	Date of prime eating condition	No. of days to attain prime eating condition	Condition at maturity
		lbs.					
1	9/22	35.8	66°	80-86	11/1	41	Considerably undersized. Slightly wilted. Juicy but more or less puckery. Only fair in quality. No core rot. No scald.
2	9/25	34.9	66°	80-86	11/2	38	More or less undersized. Slightly wilted. Juicy but more or less insipid and slightly puckery. Quality slightly better than that of Lot 1. No core rot. No scald.
3	9/29	33.7	66°	80-86	11/3	35	Slightly undersized. Not wilted. Juicy and fairly sweet. Quality good. No core rot. No scald.
4	10/2	33.0	66°	80-86	11/5	32	Slightly undersized. Not wilted. Juicy and sweet with full Winter Nelis quality. No core rot. No scald.
5	10/6	32.6	66°	80-86	11/7	31	Full sized. Not wilted. Juicy and sweet with full Winter Nelis quality. No core rot. No scald.
6	10/13	30.0	66°	80-86	11/10	28	Full sized. Not wilted. Juicy and sweet with full Winter Nelis quality. No core rot. No scald.
7	10/20	28.8	66°	80-86	11/13	24	Full sized. Not wilted. Slightly less juicy than previous lots. Sweet and of very good quality. No core rot. No scald.
8	10/27	26.4	66°	80-86	11/16	20	Full sized. Not wilted. Slightly less juicy than previous lots. Sweet and of very good quality. No core rot. No scald.

PRESENT STATUS OF THE PRESSURE TEST

The pressure tester has been in use for several seasons in the pear districts of Oregon and elsewhere and in general has given satisfactory results, not only as an indicator of picking maturity but as an index of the condition of fruit in storage. There is but little doubt that the pressure test intelligently administered would prevent many of the losses incident to the harvesting and handling of pears. It is now clear, however, that the pressure tester can be efficient only when operated by someone with more or less technical training and who is willing to make a study of the factors involved. Promiscuous use of this apparatus can but lead to erroneous conclusions.

TABLE XVIII. THE RELATION OF TIME OF PICKING TO THE QUALITY AND TIME OF RIPENING IN BARTLETT PEARS

Lot No.	Date of picking and storing	Pressure test	Temperature of storage room (Fahr.)	Relative humidity of storage room	Date of prime eating condition	No. of days to attain prime eating condition	Condition at maturity
		lbs.					
1	8/18	38.3	66°	80-86	9/2	15	Somewhat undersized. Not wilted. Juicy but slightly astringent and lacking in sweetness. Waxy. Aromatic. No core rot. No scald. Slight tendency to go down after ripening.
2	8/20	37.2	66°	80-86	9/3	14	Somewhat undersized. Not wilted. Juicy but slightly astringent and lacking in sweetness. Waxy. Aromatic. No core rot. No scald. Slight tendency to go down after ripening.
3	8/24	35.5	66°	80-86	9/6	13	Somewhat undersized. Not wilted. Juicy and fairly sweet. Quality somewhat better than that of previous lots. Good waxy appearance. Aromatic. No core rot. No scald. Slight tendency to go down after ripening.
4	8/29	33.0	66°	80-86	9/8	10	Slightly undersized. Not wilted. Juicy and sweet. Quality better than that of previous lots. Good waxy appearance. Aromatic. No core rot. No scald.
5	9/1	31.5	66°	80-86	9/10	9	Apparently full sized. Not wilted. Juicy and sweet with full Bartlett quality. Good waxy appearance. Aromatic. No core rot. No scald.
6	9/7	28.1	66°	80-86	9/15	8	Full sized. Not wilted. Juicy and sweet with full Bartlett quality. Good waxy appearance. Aromatic. No core rot. No scald.
7	9/11	26.0	66°	80-86	9/19	7	Full sized. Not wilted. Slightly less juicy than previous lots but of good quality. Good waxy appearance. Aromatic. No core rot. No scald.
8	9/14	24.8	66°	80-86	9/20	6	Full size. Not wilted. Less juicy than previous lots. Sweet but more or less insipid. Flesh slightly granular. Good waxy appearance. Aromatic. About 5 percent core rot. No scald. Tendency to ripen unevenly.
9	9/18	23.1	66°	80-86	9/22	4	Full sized. Not wilted. More or less dry and insipid. Flesh granular. Good waxy appearance. Aromatic. About 60 percent core rot. No scald. Tendency to ripen unevenly.

As already indicated, temperature of the fruit may affect the pressure test. The variation between day and night temperatures may be sufficient to make a difference in resistance of 2 to 3 pounds. This difficulty can be eliminated for practical purposes by picking the fruit for testing early in the morning. So far as possible only turgid specimens should be used in making the test. After picking, the fruit should be kept in a closed container or should be covered over with a moist cloth until the test can be made. Allowance must be made for lessened turgidity during periods of drought. It was found that specimens from the larger branches on the inside of the tree are usually more turgid than those from the outer portions. Specimens which are blemished, wormy, or over-colored should be eliminated. After a goodly portion of the

crop has been removed, the theoretical rather than the actual resistance, as already explained, should be used as the index of maturity.

If these factors are taken into account, the pressure test should be even more reliable than it has been in the past and many of the irregularities formerly encountered will be alleviated.

NUMBER OF PICKINGS IN RELATION TO SIZE AND TONNAGE

It is a rather common belief among growers of pears that the size of the fruit and the total tonnage are influenced more or less by the number of pickings made. Even in cases where pears are sold to canneries some growers prefer to dispose of their crop in two or three pickings, thinking that this practice results in better size and consequently in greater tonnage. Preliminary observations during previous tests, however, had indicated that this factor is of less importance than is commonly supposed.

The data obtained in 1923 on this phase of the subject were furnished by twelve Bartlett trees of bearing age in the Oaco orchard at Monroe. Care was taken to select, so far as possible, trees of equal size, vigor, and amount of crop. The trees selected were divided into two lots of six trees each. The crop from the trees of Lot 1 was disposed of in three separate pickings, one-third of the crop being removed on August 15, one-third on August 24 and the remainder on September 14. The crop from the trees of Lot 2 was gathered in a single picking on August 24. The fruit from each picking was counted and weighed, and measurements of the transverse diameter of each specimen were made. Table XIX gives the data appertaining to both size and tonnage.

TABLE XIX. NUMBER OF PICKINGS IN RELATION TO SIZE AND TONNAGE IN BARTLETT PEARS

Lot No.	No. of trees	No. of pickings	No. of specimens	Total weight of specimens	Average weight of specimens	Percentage of specimens between 2⅜ and 2¾ inches in diameter
				lbs.	*lbs.*	%
1	6	3	3301	1210.3	.366	84.2
2	6	1	3885	1374.0	.353	65.7

From this test it appears that the number of pickings has but little bearing upon total tonnage. This is indicated by the fact that the average weight of the specimens is practically the same whether the crop be disposed of in one or three pickings. There is indication, however, that when several pickings are made, a better distribution of size is obtained. As Table XIX shows, 84 percent of the specimens of Lot 1 are between 2⅜ and 2¾ inches in diameter, while in Lot 2, but 65.7 percent came within these dimensions. It would appear, then, that the disposal of the crop in more than one picking is justified only when uniformity of size is of prime importance. When total tonnage regardless of size is the object in view, this practice does not seem warranted, at least so far as this experiment shows.

UTILIZATION OF NIGHT TEMPERATURES

Cool night temperatures are characteristic of the climate in the fruit sections of the Pacific Northwest. This is true not only during the fall, but also during the summer months. It is not uncommon for the temperature in the orchard to vary 50° F. between night and day. Cool night temperatures are an asset to the fruit grower if he would only utilize them. Fruit harvested during the hot part of the day will give up much of its heat if left out in the orchard where air circulation is abundant. Bartlett pears at Corvallis registered a temperature of 104° F. when gathered in the middle of the afternoon on August 20, but when left under the trees during the night their temperature went down to 63° F., a reduction of 41.° Had these pears been stacked together in piles in a warm packing shed or warehouse, most of the heat would have been retained. It is safe to say that half the cost and burden of precooling can be eliminated by proper utilization of night temperatures at harvest time.

RED COLOR AS AN INDICATOR OF KEEPING QUALITY

Some fruit districts in Oregon are noted for the amount of blush or red color which develops on pears. This is especially true in the case of Bartlett and Comice. Experiments show that such pears hold up considerably better than those which are uncolored. Invariably these are firmer in texture and show less wilting and "leathering." They require somewhat longer to reach prime condition and remain firm for a longer time after ripening. They are especially desirable for long distance shipment, and growers who habitually produce such pears might profit by capitalizing this advantage.

CORE ROT OF PEARS

Core rot, evidently, is a physiological disease, occasionally found in apples and frequently in pears. It is primarily a storage trouble although not infrequently core-rotted fruit is present on the trees. It is characterized by breakdown of the core area and surrounding portion of the fleshy torus. A foul odor is generally present in the advanced stages. In most cases, the fruit is sound to outward appearance. The disease usually makes most progress as the fruit approaches prime eating condition. All varieties of pears seem to be more or less susceptible to core rot, but of the common sorts, Bosc and Comice are most frequently affected.

Though at this time not a great deal is known concerning the nature of core rot, the trouble appears to be associated with over-maturity. Of the various lots of pears under observation during these tests it was only in the cases of late picked fruit that core rot developed to any extent. The various lots of Bartlett picked between August 18 and September 11 showed no evidence of the disease, but those picked on September 14 developed 5 percent core rot and those picked on September 18, only three days later, developed over 60 percent core rot. Comice picked between September 17 and October 10 showed no core rot in storage. Comice pears picked on October 13, on the other hand, developed 31 percent core rot, while those picked on October 19, developed 100 percent core rot.

Drain, 1923, found that specimens of Le Conte, Anjou, and Bosc core-rotted less after the calyx ends had been sealed with melted paraffin.[9] This is in keeping with the idea that core rot is linked with over-maturity, since the author found that the use of paraffin wax in the basin tends to retard the life activities of the fruit.

EXPERIMENTAL—PART II. APPLES

THE PRESSURE TEST AS APPLIED TO THE APPLE

The pressure test as an indicator of picking maturity in the apple has met with varying success. Murneek, 1921, found that in general apples show a gradual decrease in resistance to pressure prior to the time of harvesting.[4] Burroughs, 1922, found a total decrease in resistance in Wagener of only three-fourths of a pound during a period of three weeks and infers that so far as this variety is concerned the test is not sufficiently indicative to be of value as a guide to time of picking. Magness and Diehl, 1924, on the other hand, observed a rather rapid decrease in resistance at the close of the growing period in Winesap, Rome, Ben Davis, and Delicious.[2]

Table XX gives the results of the pressure test determinations made in 1923 on Grimes, Jonathan, and Ortley. These tests were rather comprehensive and the data from them may be taken as representative of the general conditions existing throughout the harvest season. Determinations were made upon both pared and unpared surfaces, but since only a constant difference appeared between the two sets of readings, only the results obtained with the unpared fruit are given.

TABLE XX. DECREASE IN THE RESISTANCE TO PRESSURE IN APPLES AS INDICATED BY THE PRESSURE TESTER

Dates	9/17	9/26	10/2	10/8	10/13	10/20
Grimes, 1923—Willamette Valley.						
Pressure test	28.0	25.0	24.2	23.2	24.8	24.2
Jonathan, 1923—Willamette Valley.						
Pressure test	21.6	20.2	19.1	19.7	18.8	18.5
Ortley, 1923—Willamette Valley.						
Pressure test	.....	23.9	23.9	22.5	23.3	22.7

Although a gradual decrease in resistance took place during the season, it is apparent that this is not sufficiently indicative to act as a guide of picking maturity. Grimes, for example, shows a total decrease of only 3.8 pounds in 33 days. Jonathan for the same period shows a decrease of only 3.1 pounds in spite of the fact that during this time this variety passed from a stage of immaturity to one far beyond the optimum condition for picking. Ortley shows a decrease in resistance of only 1.2 pounds in 22 days.

There are several factors that tend to render the pressure test inefficient as an indicator of picking maturity in apples. First, cultural conditions are known to produce wide differences in the texture of the fruit. Second, differences in resistance occasioned by color intensity are more pronounced in apples than in pears. Third, the proper harvest season of many varieties of apples is considerably shorter than that of pears in general. And fourth, as already indicated, the amount of de-

crease in resistance throughout the season is too small to make the test indicative. Most of the softening that occurs in apples takes place following the proper time of picking.

As an indicator of the condition of apples after harvest, however, the pressure test gives considerable promise. Experimental work thus far conducted shows that the degree of maturity of apples in storage can be ascertained rather accurately by means of the pressure tester.[6]

TIME OF PICKING IN RELATION TO SIZE

Six separate pickings of Grimes were made during the picking season of 1923. The fruit in each case was picked from six trees which had been set aside for this test. Size was determined by weighing the specimens and measuring their transverse diameters. Lots from each picking were placed in storage. Table XXI gives the figures obtained at the time of picking.

TABLE XXI. TIME OF PICKING IN RELATION TO INCREASE IN SIZE IN GRIMES APPLES

Lot No.	Date	Pressure test	Average transverse diameter	Average weight of specimens	Percent increase in weight
		lbs.	*in.*	*lbs.*	%
1	9/17	28.0	2.75	.35	.....
2	9/26	25.0	2.83	.40	14.3
3	10/2	24.2	2.92	.42	20.0
4	10/8	23.9	2.95	.44	25.7
5	10/13	24.8	3.01	.45	28.8
6	10/20	24.2	3.13	.46	31.4

Obviously, Grimes in this case shows a considerable increase in size from time to time during the harvest season. The storage tests from this fruit indicate that nothing was lost in either eating or keeping quality by leaving the fruit longer on the trees. In fact, the fruit from the later pickings, aside from being much larger in size, showed less wilt and developed more of the characteristic Grimes flavor. This observation is corroborated by recent work at the Iowa Experiment Station.[11]

In 1923, the bulk of the Grimes crop in the Willamette Valley was gathered between September 10 and 18. So far as the above test indicates, picking at this time resulted in a considerable loss of tonnage and a sacrifice of quality. The Grimes apple in the Willamette Valley clings to the trees remarkably well during the season of maturity, and the loss from wind has been a negligible factor in recent years.

TIME OF PICKING IN RELATION TO KEEPING QUALITY

Table XXII gives the results obtained with six separate pickings of Jonathan made during the season and stored under identical conditions. These pickings cover a period of 33 days. At the time of the first picking the fruit was still somewhat undersized and considerably undercolored for the variety, while at the time of the last picking the fruit was full sized and highly colored. Three examinations of the fruit were made during the storage period, the fruit being listed as "unmarketable" when it showed unmistakable evidence of internal breakdown.

TABLE XXII. TIME OF PICKING IN RELATION TO KEEPING QUALITY OF JONATHAN APPLES

Lot No.	Date of picking and storing	Pressure test	Condition at time of picking	Temperature of storage room (Fahr.)	Relative humidity of storage room	Percent unmarketable Nov. 7	Percent unmarketable Nov. 17	Percent unmarketable Jan. 3
		lbs.				%	%	%
1	9/17	21.0	Somewhat undersized, undercolored	66°	80-86	0.0	4.1	5.0
2	9/26	20.2	Somewhat undersized, undercolored	66°	80-86	4.3	4.3	8.8
3	10/2	19.1	Full sized, medium color	66°	80-86	5.2	5.2	25.0
4	10/8	19.7	Full sized, good color	66°	80-86	8.3	8.3	24.0
5	10/13	18.8	Full sized, good color	66°	80-86	18.1	21.7	45.9
6	10/20	18.5	Full sized, high color	66°	80-86	41.6	70.8	79.2

Time of picking, obviously, had considerable effect upon the amount of internal breakdown which occurred. Internal breakdown in storage is a factor of considerable importance in Willamette Valley Jonathans during some years, and there is little doubt that this trouble is essentially a matter of overmaturity. In order to attain high color growers are inclined to leave Jonathan on the trees far beyond the time of its proper picking maturity. Internal breakdown in Jonathan seems to be associated, also, with the type of the apple. The smaller, oblong, and brightly colored specimens usually show much less breakdown than those which are larger, more blocky in type, and of dull brown color.

Experiments show, further, that much less Jonathan Spot develops on fruit of the early pickings. Jonathan apples picked on September 24 developed 36.5 percent spot, while those picked on October 10 showed 78.1 percent spot at the close of the storage period.

BLOOM IN RELATION TO LOSS OF WEIGHT AND KEEPING QUALITY

The epidermis of the apple and other fruits is naturally covered with small wax particles which give the characteristic whitish or bluish tinge known as the "bloom." The true function of the bloom is not definitely known, save that it affords protection and seems to be associated with certain of the life processes. With the modern practices of handling apples, a great deal of the bloom is usually lost. The action of the fingers and the use of canvas bags and other utensils by the pickers result in a considerable loss of bloom. In many cases the sorters wear cotton gloves and practically polish the apples before they are packed. This is especially true since in certain quarters the trade objects to the presence of spray material on the fruit. Growers and dealers are naturally interested in whatever effect removal of the bloom may have upon the subsequent keeping quality. The following experiment gave some interesting data relative to loss of bloom.

Specimens of Rome were gathered on October 11, and divided into two lots of equal number. Care was taken to select apples of the same degree of maturity and color intensity so far as possible. The fruit ap-

peared to be fully matured at this time. The specimens of Lot 1 were polished; i.e., the bloom was removed by rubbing with a piece of cloth. Lot 2 was left unpolished. Weighings of the two lots were made and the specimens were placed in storage under identical conditions, the temperature being 66° F. and the relative humidity 52 to 56 percent. Other weighings and observations were made on November 5, March 20, December 12, and January 2. Table XXIII gives the data relative to loss of weight by the specimens of both lots.

TABLE XXIII. BLOOM IN RELATION TO LOSS OF WEIGHT IN ROME APPLES

Date	Weight	Loss of weight	Loss of weight in per-cents
	grams	*grams*	%
Polished.			
October 11	2106.90	.....	.....
November 5	1956.10	150.80	7.1
November 20	1888.15	218.75	10.3
December 12	1788.50	318.60	15.1
January 2	1701.50	405.40	19.2
Unpolished.			
October 11	2432.00	.....	.....
November 5	2324.30	107.70	4.4
November 20	2274.10	157.90	6.5
December 12	2208.50	223.50	9.2
January 2	2148.90	283.10	11.6

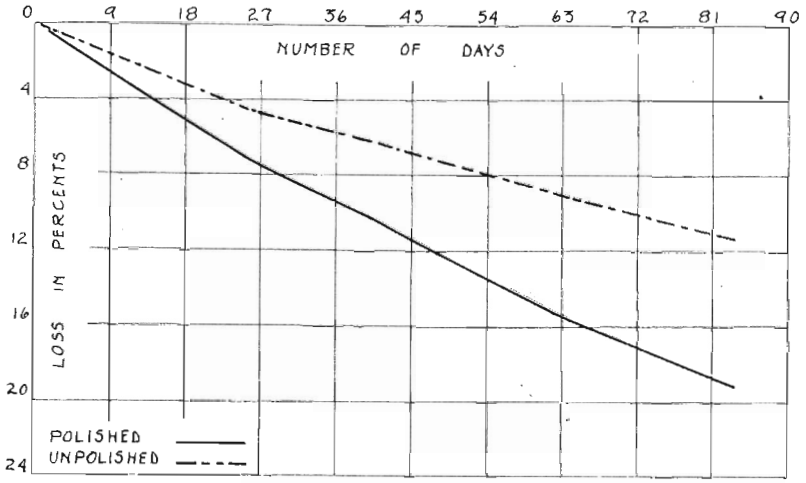

Fig. 2. The relation of bloom to loss of weight in apples.

Certain rather significant conclusions seem apparent from this experiment. Not only does the polished fruit show a greater total loss of weight, but it shows, also, a uniformly greater rate of loss of weight for the period (Fig. 2). The difference in loss of weight, in other words, is constant throughout the season, and there is no indication that the heavy loss by polished fruit early in the period will eventually be equalized by the loss of the unpolished specimens.

In the course of this test it was obvious that the polished fruit was going down more rapidly than the other. By December 12, the unpolished apples had so wilted that they were practically unmarketable. The unpolished apples at this time showed some evidence of wilt but were still marketable. On January 2, thirty-four percent of the polished lot showed internal breakdown. The fruit from the unpolished lot, on the other hand, was all sound at this time, although it showed considerable wilt.

SUMMARY

1. Loss of weight after harvest may be a considerable factor in the handling of pears. Excessive loss of weight not only results in decreased tonnage but causes wilting which seriously impairs the appearance of the fruit. Wilted pears are usually dull and unattractive and do not become aromatic. A loss of 3 to 4 percent is usually sufficient to cause noticeable wilt.

2. Though several factors may contribute to loss of weight in pears insufficient humidity appears to be its chief causal agent. Storing at a relative humidity of 80 to 85 percent practically prevents loss of weight in all cases.

3. Time of picking apparently has bearing upon loss of weight. Bartlett pears picked on August 14 lost 9.7 percent of their weight during 264 hours of storage, while those picked on September 14 lost only 5.8 percent of their weight during this time.

4. The use of common fruit wraps and commercial oiled papers does not seem to be effective in preventing loss of weight in pears.

5. The rate of loss of weight in pears seems to be constant throughout the storage period.

6. Apparently every loss of weight is accompanied by a corresponding loss in volume.

7. Pears from heavily loaded trees are usually more advanced in maturity than those from lightly loaded trees in the same orchard. As indicated by the pressure tester the time of picking pears on heavily loaded trees may be from 8 to 12 days earlier than that of pears on lightly loaded trees.

8. The pressure tester may be materially influenced by several factors, chief among which are (1) temperature of the fruit, (2) turgidity, (3) removal of a portion of the crop, (4) amount of russeting, and (5) intensity of the "over" color.

9. Such general indicators of maturity as (1) ripening of imperfect specimens, (2) changes of the "ground" color, and (3) loss of bloom were found to be valuable in determining time of picking in pears. Such factors as (1) ease of separation from the spur, (2) color of the seeds, and (3) size of the fruit were found to be unreliable as indicators of maturity.

10. Time of picking has considerable bearing upon the time required for pears to reach prime condition. When held at 66° F., Anjous of the first picking required 54 days to ripen, while those of the last picking were ready for eating in 26 days. This seems to be true of all varieties.

11. Anjou seems to have a rather long picking season. All fruit of this variety harvested between September 4 and 28 developed good quality. The average decrease in resistance for the season was 0.4 pound per day. Apparently it is safe to pick Anjou when the pressure tester registers between 24 and 19 pounds. When picked prematurely this variety wilts badly in storage, becomes dull in appearance, and remains more or less astringent. When picked too late, it lacks considerably in juiciness.

12. Comice, unlike Anjou, seems to have a fairly short picking season. Real Comice quality was developed only by the fruit gathered between October 1 and 9. The average decrease in resistance for the season was 0.3 pound per day. Seemingly this variety should be picked when the pressure tester registers between 20 and 18 pounds. When picked too green Comice wilts badly in storage and develops only inferior quality. When picked too late it lacks in juiciness and goes down rapidly, due chiefly to rotting at the core.

13. Winter Nelis gathered between October 1 and 20 developed good quality. This variety appears to be ready for picking when the pressure tester registers between 33 and 29 pounds on clear skinned specimens. Winter Nelis pears of the very early pickings wilted more or less, lacked in sweetness, and were undersized. Those picked very late in the season lacked in juiciness.

14. The results obtained with Bartlett corroborate rather closely those of the previous investigations. Pears suitable for one purpose or another were harvested between August 20 and September 14. The entire crop, however, should be disposed of when the pressure tester registers between 35 and 25 pounds.

15. Total tonnage does not seem to be materially affected by the number of pickings made. When the crop is disposed of in several pickings, however, a better distribution of sizes is obtained.

16. Cool night temperatures may be utilized to advantage in the handling of pears. The temperature of Bartlett specimens picked during the warm part of the day dropped from 104° F. to 63° F. when left outdoors during the night.

17. Pears with a red cheek or blush hold up best during long distance shipment.

18. Core rot in pears seems to be associated with overmaturity. No evidence of this trouble was noted in Bartlett and Comice except in the lots that were picked comparatively late in the season.

19. Apples, in the main, show a decrease in resistance prior to the time of picking. In most cases, however, the decrease is not sufficiently indicative to be a reliable guide to time of picking.

20. Grimes shows a material increase in size toward the end of the growth period. From September 17 to October 20, an increase in size of 31.4 percent was noted in this variety. Indications are that Grimes is commonly picked prematurely in the Willamette Valley.

21. Time of picking seemingly has bearing upon the development of internal breakdown in Jonathan. Fruit of this variety gathered on September 17 developed only 5 percent breakdown during the storage period, while that picked on October 20 became affected to the extent of

79 percent. It is apparent that growers commonly sacrifice keeping and dessert quality in this variety in order to obtain high color.

22. Loss of "bloom" seemingly increases the rate at which apples lose weight in storage and shortens the life of the fruit.

ACKNOWLEDGMENTS

The author wishes to express his appreciation to Professor W. S. Brown and Dr. E. M. Harvey for valuable suggestions and to Mr. B. W. Johnson and Dean G. A. Covell for their cooperation in carrying on these experiments.

LITERATURE CITED

[1]Murneek, A. E.
1923. Studies of physical and morphological changes in Bartlett pears.
Am. Jour. of Bot. X: 310-324. June, 1923.

[2]Magness, J. R., and Diehl, H. C.
1924. Physiological studies on apples in storage.
Jour. of Ag. Research, Vol. XXVII, No. 1, G. 347.

[3]Magness, J. R.
1922. The handling, shipping, and cold storage of Bartlett pears in the Pacific Northwest.
U. S. Dept. of Agric. Bul. 1072; pp. 3-5.

[4]Murneek, A. E.
1921. A new test for the maturity of the pear.
Ore. Sta. Bul. 186.

[5]Hawkins, L. A., and Sando, C. E.
1922. Effect of temperature on the resistance to wounding of certain small fruits and cherries.
U. S. Dept. of Agric. Bul. 830.

[6]Magness, J. R., and Burroughs, A. M.
1924. Storage investigation, 1921-1922.
The Marble Laboratory, Inc.

[7]Chandler, W. H.
1914. Sap studies with horticultural plants.
Missouri Sta. Research Bul. 14; pp. 491-552.

[8]Zschokke, A.
1897. Uber den bau der haut und die urachen der verschiedenen haltbarkeit unserer kernobsfrii chte.
In Landw. Jahrb. Schweiz. Bd. 11, pp. 153-197, 2 pl.

[9]Drain, B. D.
1923. Oxidase activity in varieties of apples.
Pro. of Am. So. for Hort. Sci., 1923, pp. 25-30.

[10]Burroughs, A. M.
1922. Changes in the respiration rate of ripening apples.
Pro. of Am. So. for Hort. Sci., 1922, pp. 225-235.

[11]Results of apple storage investigations.
Annual report, Iowa Station, 1922.

[12]Overholser, E. L.
1923. Effect of premature harvest of plums and pears.
Pro. Am. Soc. for Hort. Sci., 1923, pp. 101-108.