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Electrical Resistance of Pear Tissue as an Index of Maturity

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SUMMARY

(1) Owing to the severe drought which prevailed during the period of this investigation, the results are presented as a preliminary report.

(2) Indications are that the degree of maturity in pears may be measured by their resistance to an electrical current.

(3) A portable device for the determination of electrical resistance which is adaptable for either field or laboratory use is developed and described.

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Electrical Resistance of Pear Tissue as an Index of Maturity

By

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INTRODUCTION—HISTORICAL

THIS report deals with the development and testing of a new device for studying changes which occur during harvesting and storage of pears. Murneek[5] began in 1917, a series of investigations relative to the physiological changes that occur in pears prior to maturity. The results of these investigations led him to believe that the degree of maturity could be correlated with the resistance offered to pressure by the epidermal and cortex cells. This led to the development of the "Oregon pressure tester." Hartman[1, 2] and others have continued the work of Murneek and have substantiated his findings. The pressure test as developed by Murneek is still used for determining time of picking pears within the state of Oregon. Magness[3] modified the original form, however, and called it the Federal tester. This form has found wide favor in other states as it is simple of operation and offers the additional advantage of portability.

Both the Oregon and the Federal testers are quite satisfactory in the hands of skillful operators, although in the hands of different workers the pressure test may fluctuate through wide limits. This apparent error has caused considerable criticism of the method as well as financial loss to growers and shippers. The pressure test is of little or no value in following the changes that occur during storage of the fruit. The resistance of the fruit to crushing by pressure appears to remain fairly constant once the fruit is removed from the tree and placed in storage. With the foregoing in mind and at the insistence of a group of Rogue River Valley growers the writer in 1930 attacked the problem from a new angle.

In 1899 Smith[8] reported that there were significant changes in the electrical conductivity of pure culture media during the growth and development of bacteria. This is apparently the first report of an investigation wherein the electrical properties of a medium have been correlated with biological activity. Plowman[7] in 1903 demonstrated that the functional activity of white lupine caused a potential difference in various regions. He concluded that the intensity of these potential differences depended upon the physiological condition of the plant. Mameli[4] in 1905 buried platinum electrodes in plant tissue and made periodic readings of the electrical conductivity of such tissue. She concludes that the specific conductivity of a plant decreases with age.

Nicolosi-Roncata[6] in 1907 reported his observations on the conductivity of certain fruit juices. His data indicated that the conductivity of the

*This investigation, begun while on leave of absence from the U. S. Department of Agriculture, Bureau of Plant Industry, in the employ of the Southern Oregon Sales, was completed at the Oregon Agricultural Experiment Station, Corvallis.

juice decreased during the ripening process. From the foregoing it appears that the physio-chemical changes that take place during the various developmental stages in the growth cycle of an organism, especially in the storage tissue of most fruits and vegetables, may be correlated with changes in their electrical properties.

METHOD

Preliminary observations on the resistance of pear tissue to the passage of an electrical current with a type "S" Leeds and Northrup testing set, indicated that the electrical resistance of such tissue was a fair index of its degree of maturity. The time required to balance this instrument and secure a reading, however, permitted polarization of the electrodes to proceed to such a point that reliable results could not be obtained. At the suggestion of Dr. E. M. Harvey* and with his close cooperation the writer undertook to correlate the potential, as measured with a Leeds and Northrup wall-type suspension galvanometer, with the maturity of several fruits and vegetables. This proved impractical, however, because concordant readings could not be obtained on similar specimens.

Since the conventional type of conductivity apparatus available for this type of work did not lend itself to portability for field use and is much too expensive to be practical, the following apparatus was designed and used throughout the experiments herein reported.

Materials used:

One Weston 301 milliameter graduated in .02MA
Range 0-1 MA.
One Weston 301 Voltmeter graduated in .2 volt.
Range 0-6 volts.
One Yaxley 400-Ohm potentiometer.
One 4-5-volt Radio "C" battery.
One pair copper electrodes 5 mm. square, set 5 mm. apart—connected with about 3 feet of copper wire.

This material was assembled as an ohm-meter. The potentiometer is used to adjust the voltage to any desired strength up to 4.5 volts.

Figure 1 shows a diagrammatic sketch of the modified form.

The modified ohm-meter has several advantages over the original in that it is (1) less expensive, a suitable resistance coil being substituted for the voltmeter; (2) more compact, size approximately 8" x 4" x 2", capable of being carried in an ordinary coat pocket; and (3) very durable, the frame being made of pressed brass.

To balance the instrument, open the small door at the base of MA. This releases the potentiometer lock. Press switch "C" with the left thumb, at the same time rotating knob "A" until indicator hand of the

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milliameter reaches 0.6 MA; then release switch "C" which connects a 5000-ohm fixed resistance in the circuit. According to Ohm's law—which expressed mathematically is $I = \frac{E}{R}$ when I equals amperes, E equals volts and R equals resistance—when 0.6 MA flows through 5000 ohms a potential difference of 3 volts exists across the electrodes.

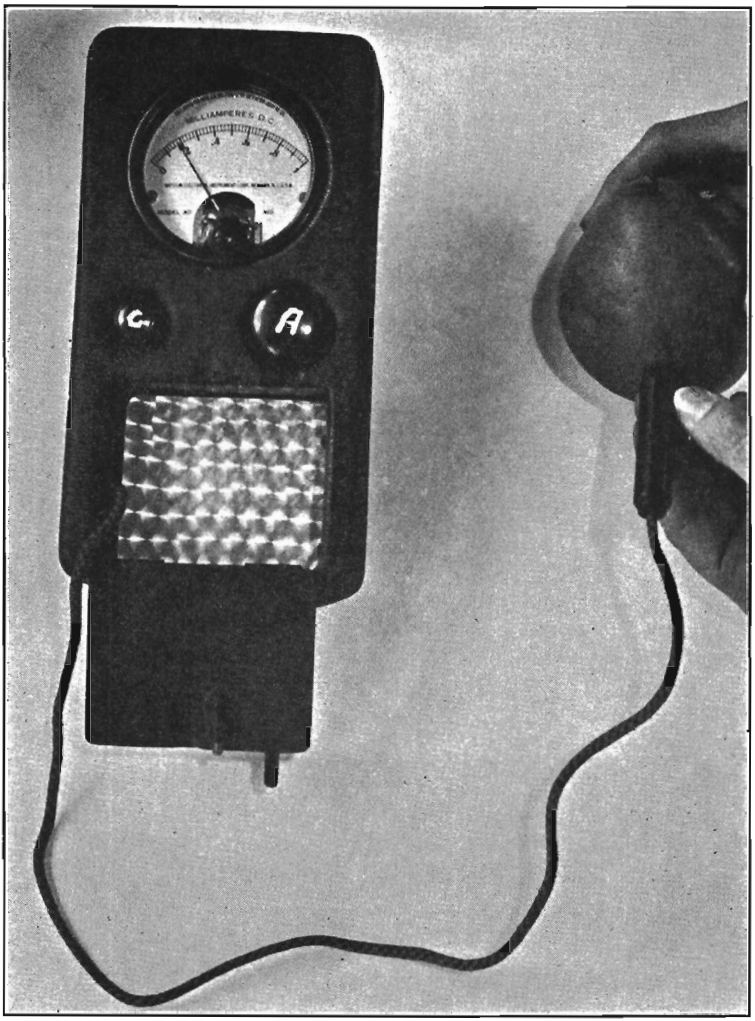

Figure 1. Electrical maturity tester. (*Courtesy of* SOUTHERN OREGON SALES, INC. Pat. app. for.)

Since the voltage is fixed, the unknown may be connected across the electrodes and its resistance determined by use of the foregoing formula. The resistance varies inversely with the current strength in amperes. As resistance increases, current strength decreases, with a constant potential of 3 volts. 0.78 MA is equivalent to 3846.1 ohms resistance and 0.07 MA is equivalent to 42857.1 ohms. Conductivity is the reciprocal of resistance and can be calculated from the foregoing. The readings herein reported were made by inserting the electrodes to their full depth in the region of greatest circumference and at the same time noting the deflection of the milliameter.

The Bartlett, Anjou, and Bosc varieties were selected for detailed study. For the Bartlett and Anjou varieties two healthy vigorous trees were selected—one each in orchards C and F—and all fruit tested from these orchards came from these selected trees. Two trees of the Bosc variety were selected in orchards A and G. For the other orchards reported herein the samples were taken at random usually from several different trees. Ten specimens were used for each test. Two readings were taken on each specimen, making a total of twenty readings. Preliminary readings made on several lots of one hundred indicated that ten specimens would be sufficient. The average orchardist cannot determine the optimum picking maturity of his fruit by so few tests, as there will be considerable variation from tree to tree in different portions of the orchard.

Electrical tests were made immediately after the fruit was removed from the tree and the same specimens were tested with the Oregon pressure tester upon return to the laboratory. The maximum time elapsing after fruit was removed from the tree until the pressure tests were made was less than three hours.

Preliminary readings were made on the Bartlett and Anjou varieties May 7 and May 27. Beginning with June 1 regular tests were made at seven-day intervals up to and including July 28, after which time the readings were taken twice each week. Regular readings on the Bosc were

TABLE I. LOCATION AND SOIL TYPES OF THE ORCHARDS STUDIED

Orchard	Location	Soil types and remarks
A	N. Central Bottom	Salem clay loam. Very sticky clay. 18 inches to 6 feet in depth. Compact showing tendency to adobe structure. Water limited. Trees fair to poor in thriftiness.
B	S. E. Hillside	Phoenix Clay adobe. Pronounced adobe structure. Water limited. Trees fairly thrifty.
C	N. E. Bottom	Sams loam 2-6 feet depth. Drainage poor. Water ample. Trees thrifty and vigorous.
D	N. W. Hillside	Siskiyou coarse sandy loam underlaid by red clay resting on granite. Trees fair. Water very limited.
E	South Central Bottom	Medford gravelly clay loam. Black sticky. Water limited, trees fairly thrifty.
F	N. Central Bottom	Salem clay loam. Slight tendency toward adobe structure. Water ample. Trees very thrifty showing vigorous growth.
G	S. Central Bottom	Meyers clay adobe, pronounced tendency toward adobe structure. Intensely cultivated and fertilized. Trees fairly thrifty. Water limited.

begun July 7. These were made at seven-day intervals up to and including August 11, after which time the readings were made twice each week. Seven orchards, selected as fairly representative of the different soils, cultural practices and exposures, were used for the tests. The location, soil type and condition of orchards studied are shown in Table I.

Owing to the unusual drought which prevailed during 1930 and 1931 only two of the seven orchards selected had ample water supply. These conditions probably necessitated picking most varieties much earlier than is customary in this section.

PRESENTATION OF FIELD DATA

To simplify the data herein presented, all readings in milliamperes are presented as whole numbers—i.e., 0.07 milliampere is presented as 7.0, thus eliminating the decimal point. To convert to the original readings, divide by one hundred.

The average electrical resistance for Bartlett pears in milliamperes is presented in Table II.

TABLE II. ELECTRICAL RESISTANCE OF BARTLETT PEARS IN MILLIAMPERES

Date tested	Orchards						
	A	B	C	D	E	F	Average
June 1	.....	.....	66.9	.....	.....	.....	.....
9	.....	.....	58.0	.....	.....	.....	.....
23	.....	.....	44.1	48.0	.....	44.8	45.6
30	.....	.....	42.2	.....	.....	.....	42.2
July 7	.....	.....	42.1	41.6	36.2	31.6	37.9
14	.....	35.6	34.1	34.5	35.2	36.1	33.0
21	30.2	32.6	31.3	30.9	31.8	33.6	31.6
28	32.1	31.8	28.8	28.6	31.5	28.3	30.2
31	23.9	29.8	29.2	30.0	31.3	28.4	28.7
Aug. 4	.....	28.8	21.8	27.0	27.1	23.0	25.4
7	22.1	23.3	22.6	23.5	26.3	20.4	23.0
11	22.8	.....	*20.7	25.2	.....	*20.6	22.2
14	23.7	.....	21.5	.....	.....	22.7	22.3
18	*20.0	.....	19.1	.....	.....	20.6	19.6
21	20.2	.....	20.0	.....	.....	19.9	20.0
25	.....	.....	18.1	.....	.....	18.1	18.1
28	.....	.....	17.1	.....	.....	.....	17.1
Sept. 1	.....	.....	20.6	.....	.....	.....	20.6
4	.....	.....	19.2	.....	.....	.....	19.2

*Optimum maturity.

All specimens from orchards C and F were from the same tree. The others were from three to four trees, selected at random.

The data in Table II show that rapid changes in the electrical resistance of pear tissue occur just prior to the optimum picking maturity. It is interesting to note that orchards C and F which were the only ones with ample moisture were the first to reach optimum picking maturity. Note the increase in resistance as shown by the decreased current density occurring between July 31 and August 4 in these orchards. The fruit from orchards B, D, and E was removed from the trees prior to optimum maturity. Compare with Table III.

Table III shows the average pressure tests for the Bartletts shown in Table II. The pressure tests were taken on the same specimens as used for the electrical tests and were made within three hours after removal from tree.

TABLE III. AVERAGE PRESSURE TESTS FOR BARTLETT PEARS BEFORE AND AFTER OPTIMUM MATURITY

Date tested	Orchards					
	A	B	C	D	E	F
July 28	.....	31.6	30.5	32.7	33.6	28.9
31	.....	30.8	31.8	33.8	33.3	29.9
Aug. 4	32.9	30.0	31.5	36.3	33.7	31.1
7	33.6	30.5	31.9	32.7	31.4	31.2
11	30.7	.....	*28.2	29.9	.....	*28.8
14	29.9	.....	27.3	.....	.....	27.8
18	29.2	.....	25.9	.....	.....	27.7
21	*28.1	.....	26.3	.....	.....	25.3
25	.....	.....	24.6	.....	.....	24.1
28	.....	.....	24.3	.....	.....	.....
31	.....	.....	24.1	.....	.....	.....

*Optimum maturity.

According to Hartman,[2] the optimum picking range for Bartlett occurs between 33 and 26 pounds pressure. On this basis the data in Table III indicate that the majority of the Bartletts grown in the Rogue River Valley in 1931 were ready to pick prior to July 28. Fruit picked as late as August 25, however, developed excellent quality on ripening and failed to show abnormal amounts of physiological breakdown after 40 to 45 days' storage.

A study of Tables II and III brings to light several interesting facts. The resistance of the tissue to electrical pressure increases quite rapidly between July 31 and August 4. Ripening and storage tests showed that this rapid change indicated the approach of ideal maturity. On the other hand, the resistance to physical pressure made a rapid change between August 7 and 11. This leads to an important point. The electrical test is much more sensitive than the physical test to changes that occur within the tissues. Chemical changes precede physical changes. The electrical properties are primarily chemical in character.

Electrical resistance and pressure-test data for Anjous are presented in Tables IV and V.

TABLE IV. AVERAGE ELECTRICAL RESISTANCE IN MILLIAMPERES FOR ANJOU PEARS

Date tested	Orchards						
	A	B	C	D	E	F	Average
June 1	.....	.....	56.7	.....	.....	.....	56.7
9	.....	.....	47.7	.....	.....	.....	47.7
23	41.4	.....	43.3	47.5	.....	44.5	44.0
30	.....	.....	42.8	.....	.....	.....	42.8
July 7	38.8	.....	39.8	32.6	33.8	30.3	35.0
14	30.6	.....	34.5	30.7	33.8	33.4	32.6
21	.....	.....	31.0	25.9	30.0	31.1	29.5
28	.....	.....	27.4	25.5	30.8	27.9	27.9
Aug. 4	.....	.....	21.7	21.5	24.6	21.8	22.4
11	20.1	.....	20.3	19.4	20.8	21.0	20.3
14	19.0	.....	22.9	18.0	22.5	20.9	20.7
18	18.5	21.9	19.9	18.8	20.9	20.0	19.8
21	16.7	20.2	18.0	17.7	20.2	18.8	18.5
25	17.5	20.3	15.2	18.2	21.0	17.9	18.3
28	.....	21.4	17.2	.....	17.3	15.7	17.9
Sept. 1	.....	18.1	20.0	.....	.....	17.7	18.3
4	.....	19.4	18.8	.....	.....	.....	19.1
8	.....	.....	19.5	.....	.....	.....	19.5
11	.....	.....	17.0	.....	.....	.....	17.0
15	.....	.....	17.5	.....	.....	.....	17.5
18	.....	.....	18.4	.....	.....	.....	18.4

TABLE V. AVERAGE PRESSURE TESTS FOR ANJOU PEARS

Date tested	Orchards					
	A	B	C	D	E	F
Aug. 1	28.1	.....	27.8	28.1	26.5	28.3
14	27.0	.....	25.9	28.6	26.0	26.3
18	25.8	28.0	26.2	29.6	27.2	25.9
21	24.4	26.2	25.0	29.1	25.8	24.9
25	24.2	24.4	23.9	28.7	25.6	24.0
28	.....	25.9	22.7	.....	22.4	22.8
Sept. 1	.....	23.7	22.0	.....	.....	23.0
4	.....	24.4	22.5	.....	.....	22.6
8	.....	.....	22.4	.....	.....	.....
11	.....	.....	22.0	.....	.....	.....
15	.....	.....	23.0	.....	.....	.....
18	.....	.....	21.2	.....	.....	.....

Tables IV and V indicate that the average grower harvested his crop prior to optimum maturity in spite of the work that has been done to ascertain the time of picking.

According to Hartman[2] the optimum pressure for Anjou pears ranges between 24 and 19 pounds. Table V shows that the pressure test for orchard C on August 25 was 23.9 and on September 18, 21.2 pounds, a decrease of 2.7 pounds over a period of 24 days. The electrical test shows 15.2 MA on August 25 and 18.4 on September 18 with an uneven fluctuation between these dates. Orchard D, according to the pressure test, showed no appreciable change in maturity during the period August 11-25. Compare this with the electrical test from 19.4 to 17.7 MA during this period.

The electrical resistance and pressure-test data for Boscs are presented in Tables VI and VII.

Bosc pears should be harvested at a pressure test ranging from 28 to 24 pounds. Table VII shows that most of the crops of this variety were ready to harvest August 21. The pears in orchard G on August 21 showed a

TABLE VI. ELECTRICAL RESISTANCE IN MILLIAMPERES FOR BOSC PEARS

Date tested	Orchards					
	A	B	D	E	G	Average
June 23	51.6	.....	50.0	.....	.....	50.8
July 7	34.2	.....	.....	33.1	32.1	33.1
14	.....	.....	35.4	38.8	35.0	36.4
21	.....	29.8	30.6	35.5	38.4	33.5
28	.....	27.7	.....	26.8	32.7	29.1
Aug. 4	.....	23.4	20.6	23.5	26.6	23.5
11	20.6	22.6	19.0	21.1	22.6	21.2
14	20.5	22.9	18.8	21.3	21.7	21.0
18	17.4	18.5	18.2	18.4	20.1	18.4
21	17.1	18.5	16.6	20.3	20.5	18.6
25	16.6	19.8	17.8	19.4	20.3	18.8
28	16.3	17.0	17.7	20.0	19.5	18.1
Sept. 1	15.9	17.7	17.7	.....	18.6	17.5
4	18.6	17.8	17.3	.....	18.7	18.1
8	18.9	16.5	16.0	.....	18.2	17.4
11	18.0	.....	14.9	.....	17.2	16.7
15	17.5	.....	.....	.....	15.3	16.4
18	17.0	.....	.....	.....	16.5	16.7
22	.....	.....	.....	.....	14.7	14.7
25	.....	.....	.....	.....	14.9	14.9

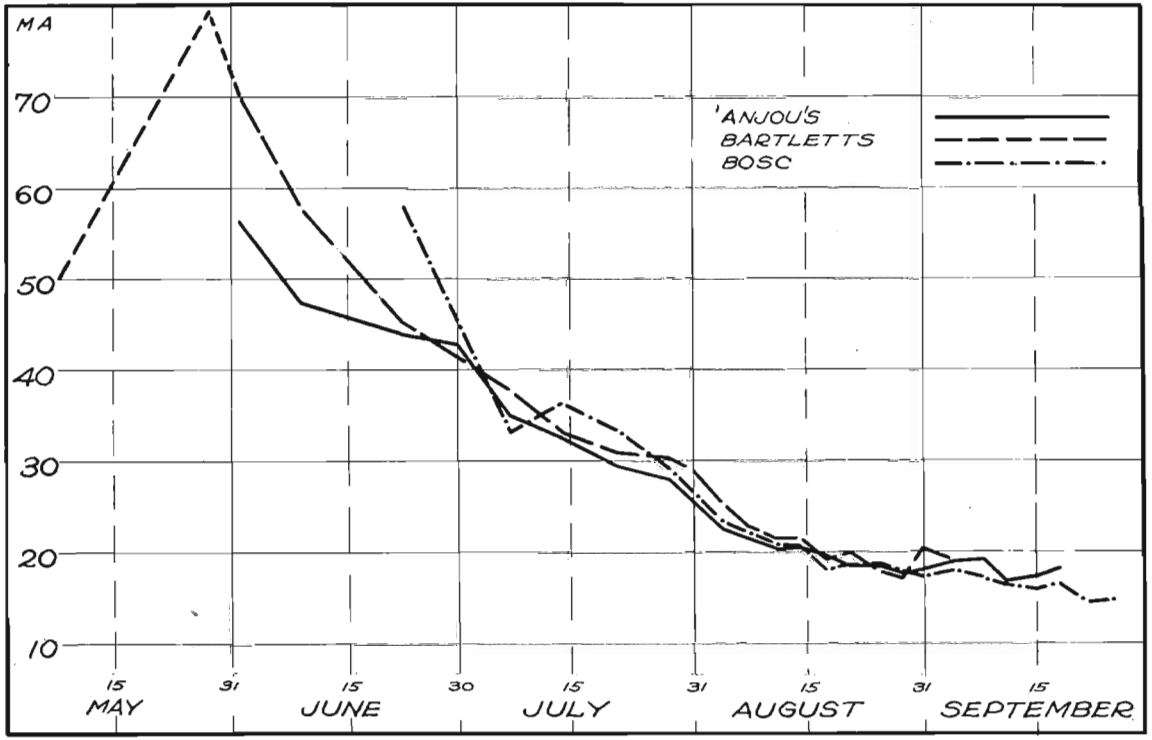

Figure 2. Average electrical resistance in milliamperes during growth and maturity of Bartlett, Anjou, and Bosc pears.

TABLE VII. PRESSURE TEST DATA FOR BOSC PEARS

Date tested	Orchards				
	A	B	D	E	G
Aug. 11	30.7	30.1	29.2	30.6	31.7
14	30.9	29.4	31.2	27.5	30.3
18	31.5	25.6	29.3	27.0	28.3
21	29.6	25.7	28.0	25.0	28.2
25	28.8	25.9	28.2	26.8	27.3
28	26.0	25.3	27.1	26.3	27.6
Sept. 1	27.0	25.2	25.7	27.0	27.5
4	27.7	25.2	26.1	.....	26.0
8	27.6	23.2	24.9	.....	26.2
11	27.0	.....	26.9	.....	26.6
15	.....	.....	.....	.....	26.7
18	.....	.....	.....	.....	25.4
22	.....	.....	.....	.....	24.8
25	.....	.....	.....	.....	24.5

pressure test of 28.2, decreasing to 24.5 on September 25, a drop of only 4 pounds in 35 days. During the same period the electrical resistance in milliamperes decreased from 20.5 to 14.9, a change of 5.6 MA, or an increase in resistance of 5500 ohms.

DISCUSSION OF FIELD DATA

For clarity of discussion, the averages from the data presented in Tables II, IV, and VI are presented graphically in Figure 2. The pressure-test data, presented in Tables III, V, and VII, using orchards C for Anjou and Bartlett and F for Bosc, are presented graphically in Figure 3.

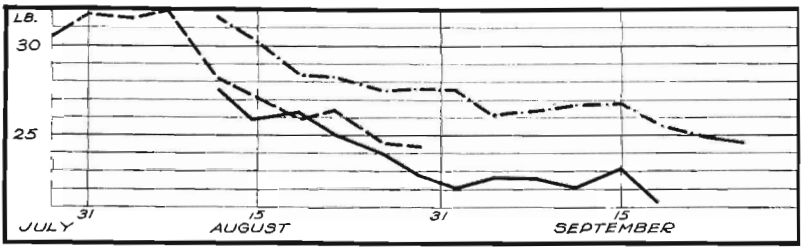

Figure 3. Average pressure in pounds during growth and maturity of Bartlett, Anjou, and Bosc pears.

A study of Figure 2 reveals a striking similarity between the three varieties studied. Between June 1 and July 7 the electrical resistance of all three varieties changed rapidly.

On July 7 the electrical properties of the fruit changed as shown by the decreased rate of change in electrical resistance. The slower rate continued up to July 28. Again the rate of change in resistance increased rapidly. The curve breaks abruptly, which probably indicates that the simpler inorganic constituents were being combined with organic components making complex compounds which are very poor conductors. By August 4 the rate of change in resistance had again slowed up and no further radical change took place until the fruit was ready to be moved from storage. This will be considered later.

The curve for Bartlett, plotted from the averages, gives a rather smooth line indicating no radical changes, but on examining the individual averages from any one of the orchards represented it is found that several radical changes occurred during the growth and maturity of this fruit. On May 7 the resistance in MA is 50. A very sharp rise occurs before May 27 to about 78. This is the peak and evidently coincides with the maximum amount of inorganic materials which are laid down for further growth. As carbohydrates were manufactured and laid down within this storage tissue the resistance gradually increased until July 31, when in the case of Bartlett from Orchard C a very striking change in resistance was shown. This evidently indicates the approach of ideal maturity as there was very little further change in this variety even though left on the tree for several weeks. Storage and ripening experiments conducted in conjunction with the foregoing indicated that fruit picked within two weeks after this sharp increase in resistance of the tissue kept well and developed excellent quality upon ripening.

The optimum picking range varies with the location, type of soil and cultural practices; e.g., orchards C and F were ready to pick about August 11, while orchard A was not ready until August 18. This is a fortunate condition for the orchardist and packing-house as it would be next to impossible to handle the crop with the present facilities should it all mature at the same time.

Two different minima for Anjou occur; namely, 17.0 on August 11, and 17.9 on August 26. By examining the individual components of this curve, it is apparent that a minimum for each orchard was reached as follows: A, August 21; B, September 1; C, August 25; D, August 21; E, August 28; and F, August 28. As in the case of Bartletts, a different period of maturity is found for the different soils and orchards. The ripening experiments indicate that this variety should be harvested from ten days to two weeks after the minimum is reached.

Factors other than resistance to electrical or physical pressure may prevent the development of quality in pears. Bosc harvested from Orchard A on August 28, September 4, 11, 18, and 25, failed to develop quality on ripening, although both the electrical resistance and the pressure tests indicated that these pears were ready to harvest September 1. The fruit from Orchard G picked September 18, 25, and October 2 developed excellent quality, especially the Bosc of the last picking. According to the pressure-test data, these pears were ready to pick August 25, while the electrical-resistance data indicated September 15. From the foregoing it appears that other factors may nullify both tests.

COLD-STORAGE DATA

The changes in resistance shown by Bartlett pears during storage are presented in Table VIII.

The changes during the first month of storage are of slight importance. A very significant change does take place between the 30th and 45th day after the fruit is placed in storage. At the end of 45 days a rather sharp

TABLE VIII. RESISTANCE OF BARTLETT DURING STORAGE

Date tested	Orchards		
	F	C	Average
Aug. 18	20.6	19.1	19.85 at time of picking
28	7.6	7.6	7.6 in storage
Sept. 15	9.6	9.7	9.7 in storage
30	13.9	16.4	15.1 in storage
Oct. 17	16.3	16.0	16.1 in storage
31	15.4	17.0	16.2 in storage
Nov. 16	16.2	17.0	16.6 in storage

decrease occurs in the resistance of pears to the passage of an electrical current. Within 20 to 30 days after this change has taken place, similar specimens when removed to a conditioning room develop on ripening considerable scald and core breakdown.

TABLE IX. ELECTRICAL RESISTANCE OF ANJOU PEARS DURING COLD STORAGE
Orchard C

Date tested	Date picked					
	Aug. 21	Aug. 28	Sept. 4	Sept. 11	Sept. 18	Average
Sept. 14	8.6	7.9	9.0	9.8	.....	8.8
28	9.0	8.6	9.0	9.0	9.6	9.0
Oct. 12	9.6	9.3	9.5	9.6	10.0	9.6
26	12.0	11.9	12.0	12.5	11.6	12.0
Nov. 9	14.0	14.2	14.8	13.6	14.5	14.2
23	13.5	13.2	13.2	12.4	13.6	13.2
Dec. 9	13.3	13.6	14.3	14.8	12.0	13.6
21	14.1	14.1	13.6	14.0	12.6	13.7
Aug. 30	7.8	7.0	.....	.....	.....	7.4
Jan. 4	14.7	16.9	15.7	15.2	14.7	15.4

The first significant change in the metabolism of the Anjou begins approximately 60 days after the fruit is stored. The Anjou, having a long storage season, is famous as a late keeper. The length of time required for a marked change in resistance of the tissue after storage at 30° F. is notable.

TABLE X. ELECTRICAL RESISTANCE OF BOSC PEARS DURING STORAGE

Date tested	Date picked							
	Orchard A					Orchard G		
	Aug. 28	Sept. 4	Sept. 11	Sept. 18	Sept. 25	Sept. 18	Sept. 25	Oct. 2
Aug. 30	7.5	.....	.....	.....	.....	.....	.....	.....
Sept. 14	7.6	7.5	7.8	.....	.....	.....	.....	.....
28	9.3	8.0	8.0	8.5	9.4	9.0	9.3	.....
Oct. 12	8.6	8.5	8.8	8.9	9.6	9.8	9.6	9.9
26	9.8	11.0	11.6	13.0	13.3	10.6	9.5	10.0
Nov. 9	11.9	11.5	12.3	13.8	12.9	11.5	11.3	11.4
23	12.3	12.0	12.7	13.2	13.1	12.5	11.1	11.5
Dec. 7	11.9	11.4	12.9	14.3	14.0	12.5	13.7	13.7
21	12.9	12.6	15.8	15.0	16.2	13.3	12.6	13.0
Jan. 4	.....	.....	16.1	15.6	.....	14.1	12.5	12.8

The data presented in Tables VIII, IX, and X are shown graphically in Figure 4.

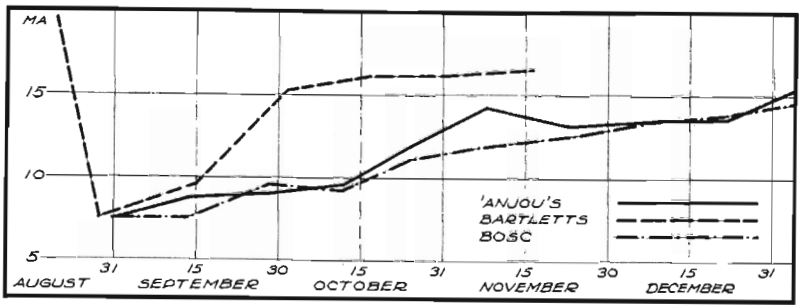

Figure 4. Electrical resistance of Bartlett, Anjou, and Bosc pears during storage.

DISCUSSION OF COLD-STORAGE DATA

The electrical resistance of the pear tissue increases rapidly to about 7.8 MA when stored at 30° F. This increase in resistance is due almost entirely to a change in the temperature of the tissue. Referring back to Figure 4, the resistance of Bartlett is shown as 7.6 on August 28. Eighteen days later, the resistance had decreased to 9.7, while during the ensuing 15 days the resistance decreased to 15.1—a change of 56.2 percent. Thereafter only a slight change in resistance occurred until complete breakdown became apparent. All specimens ripened prior to October 31 developed excellent quality. Specimens held later showed considerable core breakdown, scald, and other physiological disturbances.

The curves for the Anjou and Bosc are very similar, each showing a gradual decrease in resistance during the first 42 days, a marked change during the next 28 days, and thereafter a gradual change up to January 4, when the experiments were discontinued.

The explanation for these phenomena probably rests with the enzyme activity of the organism in question. Fruit removed from the tree and placed in storage immediately would have very little, if any, enzyme activity. After several weeks of storage, however, the enzymes have adapted themselves to the temperature of the surrounding media and respiration increases. The products of respiration are quite soluble at storage temperatures. Thus carbon dioxide is accumulated within the tissue until a maximum concentration for that temperature is reached. This maximum probably coincides with the rapid change of electrical resistance occurring after 42 days' storage. After this time carbon dioxide within the tissue is fairly constant and hence no further changes take place in the electrical resistance of the tissue until further physiological or physical conditions change to increase the respiration rate. In connection with the foregoing, other factors must enter which are very important in the measurement of electrical conductivity. During anabolism, the cell walls are being continually built up, the wall becoming thicker and less permeable. Therefore, during anabolism the electrical resistance of the tissue should increase. Figure 2 indicates that such is the case. When katabolism starts, the opposite effect, a gradual disintegration of the cell walls, is noted, and this in turn decreases the resistance of the tissue to the passage of an electrical current.

Owing to the fact that severe drought prevailed throughout the Rogue River Valley during the winter and growing seasons of 1930 and 1931 and that the limited time available did not permit the making of certain chemical determinations which might have enlarged the investigation, it is hoped that this investigation may be continued during the coming growing, harvesting, and storage season, permitting complete chemical analyses of the tissue when critical changes occur during the life cycle.

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