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Relation of Bruising and Other Factors to Blue Mold Decay of Delicious Apples

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Contents

Introduction

The blue mold fungus (*Penicillium expansum* Lk. emend. Thom.) is the most important decay organism of apples from the Pacific Northwest. Estimates indicate that 65 to 75 percent of the total rot in stored apples is caused by this fungus (*3, 13*).[1] From these data together with crop production and valuation statistics (*11*), it is estimated that there has been an average annual loss of $1,134,112 in Washington apples from blue mold since 1939.

The existence of a relationship between bruising and the decay of apples has long been recognized because of the obvious association of decay with badly bruised fruits. However, little work has been done to show the relation between the amount of bruising and subsequent decay development. Most studies of the bruising problem have been concerned with the relative numbers and severity of bruises occurring in the various stages of handling from tree to table (*6, 7, 8, 9, 10, 12*) and with the direct economic effects of this damage. Fisher (*5*)

[1] Italic numbers in parentheses refer to Literature Cited, p. 14.

stressed avoidance of bruising. Baker and Heald (*1, pp. 26–27*) stated:

During the past 2 years occasional apples have been seen that had one to many lenticel infections on the margins of bruises and of flattened areas produced by contact with the box or with other fruit. It is thought that localized pressure may rupture the layer of cutinized cells in the lenticel basins and thus increase susceptibility.

The same authors in a later publication mentioned that the number of infectible lenticels was increased by bruising (*2*), and English and his coworkers (*4*) noted that many lenticel infections were found in bruised areas.

Preliminary tests (*14*) that demonstrated bruised areas of Delicious apples were much more susceptible to blue mold decay than nonbruised tissue, and contemporary investigations (*7*) that disclosed the large numbers of bruises that occur in the harvesting and packing operations, emphasized the need for further research on the relation of bruising to subsequent decay. These investigations were made during 1947, 1948, and 1949.

Materials and Methods

In order to study the influence of maturity on severity of bruising and on the consequent blue mold infection in 1947, the required numbers of Delicious apples were picked from 1 tree in each of 3 orchards. The early-maturity fruits were harvested at Monitor, Wash., on September 19, the medium-maturity apples at Wenatchee on September 22, and the advanced-maturity apples at Orondo on September 29.

The 1948 tests were designed to determine the influence of maturity and ripeness on bruising damage and subsequent decay of apples removed from storage at intervals during the storage season. The apples for these investigations were harvested from one tree in the Wenatchee area on September 21 and again on October 16.

The 1949 studies of decay susceptibility of bruised tissue at various intervals after bruising, and of the effect of cooling rate and storage temperature on retardation of infection at bruises, were made on apples of optimum maturity picked from one tree in the Wenatchee area on September 26.

Throughout the investigations the apples were carefully picked by the writers to avoid the bruising incidental to commercial picking. All fruits were placed in storage at 31° F. on the day picked. The apples were then composited into separate lots for bruising or for puncturing, inoculation, and pressure testing.

Apple bruises are of various types, including small deep indentations caused by contact with picking-bag frames, numerous sharply defined nicks or dents caused by the washing and packing equipment, or flattened surfaces with varying depths of injured tissue that result from rough dumping of boxes or pressure against the walls of the package. Since it was not feasible to duplicate all types of bruises, standardized bruises were produced throughout these experiments by pressing a cheek of each apple by hand on the platform of scales that had been preset either at 40 pounds for a slight bruise or at 75 pounds for a severe bruise. When the pressure exerted on the platform deflected the weight arm, the pressure was released. In this manner, uniform flat-surface bruises were made that did not visibly rupture the skin.

Two bruises were produced on each apple in all of the experiments. A few minutes after bruising, two measurements of the bruise diameter were taken at right angles to each other, and the average of the two was considered the bruise diameter. Only severe bruises were produced on the test fruit in 1948 and 1949.

Inoculating was done by dipping fruit for 10 seconds in a blue mold suspension prepared by stirring 3 to 5 (constant number for each experiment) 1-week-old petri plate cultures of blue mold in a Waring blender with a little tapwater. This mixture was made up to 16 liters with tapwater in the dip tank. Unless specifically stated otherwise, the test fruit was inoculated within 1 hour after it was bruised. In 1947 inoculated fruits were held 24 hours at ordinary room temperature before they were returned to cold storage at 31° F., but in 1948 and 1949 the holding period at room temperature was 48 hours. Inspections of bruised and inoculated apples began after a 30-day cold-storage period and were repeated at 4 biweekly intervals.

To study the rate of enlargement of decaying areas, apples were punctured with a blunt instrument that made uniform injuries ⅛ inch deep and 1/16 inch in diameter. As soon as each lot of fruits was punctured, it was inoculated as previously described, held at room temperature for a period to allow infection to occur, and then placed in storage at 31° F. In 1947 the period at room temperature was 24 hours, and decay diameters were measured after 15, 25, and 55 days of storage. In 1948 the incubation period was 48 hours, and decayed areas were measured at weekly intervals after the first 10 days of storage. Decay diameters were measured in the same manner as bruise diameters.

Fruit firmness was determined with a Magness-Taylor pressure tester, using a 7/16-inch plunger. Readings were taken on 3 pared surfaces of each apple in 10 fruit samples.

The influence of cooling rate and cold-storage temperature on decay infection at bruises was studied in 1949 by bruising and inoculating about half the fruits in each of three packed boxes of Delicious apples (size 72). The unbruised, uninoculated fruits in each box constituted the checks. A Ryan thermograph was placed in the center of each box of fruit. One box was placed in storage at 31° F. at the laboratory and the remaining two were put in commercial apple-storage plants within 3 hours. All boxes were placed in exposed locations to insure maximum cooling. After 29 days the boxes were removed from the commercial plants and brought to the laboratory, where all three were inspected for decay. All the boxes were then held in the laboratory cold storage for 8 weeks, during which period they were reinspected at biweekly intervals.

Factors Related to Bruising

Maturity

Firmness decreased with advancing maturity (tables 1 and 2), and bruising, whether severe or slight, produced damaged areas of greater size on apples of advanced maturity than on less mature fruit.

TABLE 1.—*Firmness of Delicious apples at time of bruising and average diameter of bruises, harvest of 1947*

Maturity [1]	Average firmness	Slight bruises [2]		Severe bruises [3]	
		Fruits tested	Average diameter	Fruits tested	Average diameter
	Pounds	*Number*	*Centimeters*	*Number*	*Centimeters*
Early	14. 9±0. 19	120	2. 31±0. 02	128	3. 18±0. 03
Medium	14. 3±0. 18	124	2. 41±0. 02	122	3. 26±0. 08
Advanced	12. 6±0. 38	150	2. 45±0. 05	144	3. 40±0. 05

[1] Early-, medium-, and advanced-maturity fruits, respectively, were harvested at Monitor, Wash., on September 19, at Wenatchee on Sept. 22, and at Orondo on Sept. 29.
[2] Slight bruises produced by pressure of 40 pounds.
[3] Severe bruises produced by pressure of 75 pounds.

TABLE 2.—*Relation of maturity and firmness of Delicious apples at time of bruising to diameter of bruises, harvest of 1948*

Date of bruising	Immature fruits [1]		Overmature fruits [3]	
	Average firmness	Average diameter of bruises [2]	Average firmness	Average diameter of bruises [2]
	Pounds	*Centimeters*	*Pounds*	*Centimeters*
At harvest	16. 1±0. 19	2. 90±0. 02	15. 3±0. 16	3. 04±0. 02
Dec. 1	15. 8±0. 15	3. 13±0. 03	14. 8±0. 13	3. 21±0. 04
Feb. 1	14. 0±0. 13	3. 19±0. 02	13. 0±0. 13	3. 60±0. 04
Mar. 21	13. 0±0. 14	3. 20±0. 02	11. 5±0. 12	3. 54±0. 03

[1] Picked Sept. 21.
[2] A total of 36 bruises was produced on each lot at time of bruising.
[3] Picked Oct. 16.

Ripeness During Storage

In 1948 the effect of maturity and ripeness on severity of bruising was studied. The apples were bruised at intervals during the storage season.

Pressure-test data were obtained (table 2) to indicate the differences in firmness of the immature and overmature fruits. The pressures dropped significantly during storage, as shown by readings taken in December, February, and March, but the differences in firmness at harvesttime were maintained as ripening progressed in cold storage.

Bruise diameters were increasingly large on lots of apples bruised as the storage season advanced. Bruises on the overmature fruits were consistently larger throughout the storage period than those on immature fruits.

The results of this investigation show that in the commercial handling of overmature and ripened apples, extra care should be taken to avoid additional bruise damage.

Factors Related to Infection

Bruising

A comparison of decay at bruised areas with that at nonbruised areas of the same fruits following inoculation with blue mold indicated that many times more decay develops in bruised tissue than in nonbruised tissue, the amount of decay being dependent upon the severity of bruising. In 1947 comparatively little decay developed even on bruised fruit, when it was not inoculated, and no decay was found in the apples that were neither bruised nor inoculated. (See table 3.)

Increased decay susceptibility caused by bruising was demonstrated again in 1948 (table 4). All the overmature apples bruised and inoculated, after they had been held in cold storage until February and March, developed decay in the bruises, whereas only 17.6 and 15 percent of these apples, respectively, decayed in nonbruised areas.

Bruising of apples with the blue mold fungus present occurs throughout the commercial preparation of this commodity for consumption. Extremely favorable conditions for inoculation are provided, however, when wet apples are handled roughly. Such conditions occur in handling apples that have been exposed to rain in the orchard after picking, and in handling sweating fruit after its removal from cold storage, or during the washing and packing operations.

Maturity

Maturity of the fruit markedly influenced bruise damage in 1947 (table 1) and in 1948 (table 2). The results of inoculation studies for those years are summarized (tables 3 and 4).

TABLE 3.—*Relation of maturity and severity of bruising to blue mold decay infections of Delicious apples, harvest of 1947*

SEVERE BRUISES [1]

Kind and time of treatment: Bruising	Kind and time of treatment: Inoculation	Maturity at harvest	Fruits tested [2]	Bruised areas infected	Fruits infected: At bruised areas	Fruits infected: At non-bruised areas
			Number	*Percent*	*Percent*	*Percent*
Harvest	Harvest	Early	31	17. 7	35. 5	3. 2
		Medium	30	36. 6	66. 6	0
		Advanced	33	77. 2	96. 9	12. 1
Average				43. 8	66. 3	5. 1
Harvest		Early	33	0	0	0
		Medium	31	1. 6	3. 2	0
		Advanced	37	1. 3	2. 7	2. 7
Average				1. 0	2. 0	. 9

SLIGHT BRUISES [3]

Kind and time of treatment: Bruising	Kind and time of treatment: Inoculation	Maturity at harvest	Fruits tested [2]	Bruised areas infected	Fruits infected: At bruised areas	Fruits infected: At non-bruised areas
Harvest	Harvest	Early	30	10. 0	20. 0	0
		Medium	32	15. 6	31. 2	3. 1
		Advanced	37	25. 7	40. 5	24. 4
Average				17. 1	30. 6	13. 8
Harvest		Early	30	0	0	0
		Medium	30	0	0	0
		Advanced	38	0	0	0
Average				0	0	0
	Harvest	Early	27			0
		Medium	25			8. 0
		Advanced	31			19. 4
Average						9. 1
Untreated	Untreated	Early	28			0
		Medium	24			0
		Advanced	31			0
Average						0

[1] Severe bruises produced by pressure of 75 pounds.
[2] 2 bruises were produced on each apple bruised.
[3] Slight bruises produced by pressure of 40 pounds.

Table 4.—*Relation of maturity and ripeness of Delicious apples to blue mold infection after bruising at intervals during storage season, harvest of 1948*

Kind and time of treatment: Bruising	Kind and time of treatment: Inoculation	Maturity at harvest	Fruits tested [1]	Bruised areas infected	Fruits infected: At bruised areas	Fruits infected: At nonbruised areas
			Number	*Percent*	*Percent*	*Percent*
Harvest	Harvest	Immature	20	20	30.0	0
		Overmature	20	28	40.0	0
	Harvest	Immature	20			0
		Overmature	20			5.0
Harvest	Dec. 1	Immature	20	0	0	0
		Overmature	20	5	10.0	10.0
Dec. 1	Dec. 1	Immature	20	35	60.0	0
		Overmature	19	52	71.0	5.3
	Dec. 1	Immature	20			0
		Overmature	20			15.0
Harvest	Feb. 1	Immature	20	0	0	5.0
		Overmature	15	7	11.1	33.3
Feb. 1	Feb. 1	Immature	20	30	60.0	5.0
		Overmature	17	68	100.0	17.6
	Feb. 1	Immature	20			0
		Overmature	20			0
Harvest	Mar. 21	Immature	20	0	0	0
		Overmature	16	7	12.2	18.8
Mar. 21	Mar. 21	Immature	20	45	75.0	0
		Overmature	20	70	100.0	15.0
	Mar. 21	Immature	20			0
		Overmature	20			0
Harvest		Immature	20	0	0	0
		Overmature	20	0	0	0

[1] 2 bruises were produced on each apple bruised.

The more mature fruits were much more susceptible to fungus invasion than fruits of early harvest maturity (tables 3 and 4). Bruising greatly increased the incidence of decay, and the overmature fruits continued to be more susceptible than the immature ones.

Immature and overmature apples in 1948 (table 4) showed little difference in amount of decay after bruising and inoculation at harvesttime. However, the effect of overmaturity at time of harvest became clearly evident as the apples were bruised and inoculated after intervals in storage. Ripening during storage accentuated the greater susceptibility of the overmature fruits to bruising damage and resultant decay.

Ripeness During Storage

Susceptibility to bruising damage increased with ripening of apples (table 2), and the number of bruises that decayed after inoculation increased with maturity and ripeness of the fruit (table 4). Infected bruises on overmature apples increased from 28 percent at harvest to 70 percent on apples that were bruised and inoculated late in March.

The increasing susceptibility of bruised apples to decay with advancing ripeness is an important consideration for the shipper who is planning spring shipments of freshly packed apples. When late packing is necessary, every precaution should be taken to prevent bruising; exposure to decay fungi in packing-house operations should be kept at a minimum; and the packing operation should be so timed that packed fruit can be shipped and marketed in the shortest possible time after packing.

Time of Inoculation After Bruising

During the 1948 study of the effect of ripeness on bruising damage and decay, many of the bruises produced at harvesttime lost their susceptibility to decay invasion when inoculated later in the storage season (table 4). Since the reduction of susceptibility to decay occurred prior to December 1, a study was made in 1949 to find how soon after bruising the damaged tissue became resistant to decay infection.

In the experiment, one lot of apples was bruised and inoculated at harvesttime and compared with other lots so treated after 3, 10, 17, 31, 45, and 75 days of storage at 31° F. Additional lots were bruised at harvest, then inoculated after these same intervals of storage for comparison with those freshly bruised and inoculated. Pressure tests performed at harvesttime showed an average firmness of 15.3 ± 0.19 pounds, whereas the same tests at the end of the 75-day storage period on apples comparable to those bruised and inoculated at harvesttime, showed an average firmness of only 12.9 ± 0.15 pounds. This indicated that a significant softening of the apples had taken place during the storage period. No statistically significant variation in size of bruises was noted on fruits bruised at intervals up to and including 45 days after harvest. Bruises produced 30 days later (or at the end of the 75-day test period, which terminated approximately December 10) were significantly larger, indicating that there was a marked correlation between loss of firmness of the apples and bruise damage (table 5).

Delayed inoculation after bruising resulted in less infection than inoculation at the time of bruising (table 5). Twenty percent of the bruises produced at harvesttime and inoculated with blue mold immediately became infected, whereas only 2.5 percent of the bruises made at harvest and inoculated after 3 days in storage decayed. On the other hand, 57.6 percent of the bruises produced after 3 days in storage and inoculated immediately became infected. No decay occurred on fruit bruised at harvesttime and inoculated after intervals in storage of more than 3 days, except in the lot inoculated after 31 days. In this lot, 10 percent of the inoculated bruises decayed.

The loss of susceptibility of bruises to decay within the 3-day period was probably caused by changes occurring in the injured tissue of the bruised area that rendered this substratum less favorable to fungus infection. Desiccation of the injured tissue may have been a factor in bringing about such a change.

Table 5.—*Relation of time interval between bruising and inoculation of Delicious apples to average diameter of bruises and the development of blue mold infections, harvest of 1949*

Kind and time of treatment (days after harvest)[1]		Average diameter of bruises [2]	Bruised areas infected	Fruits infected at nonbruised areas
Bruising	Inoculation			
		Centimeters	*Percent*	*Percent*
0	0	3. 20±0. 04	20. 0	0
0			0	0
	0			30. 0
0	3		2. 5	0
3	3	3. 18±0. 03	57. 6	20. 0
3			0	5. 0
	3			10. 0
0	10		0	5. 0
10	10	3. 19±0. 02	47. 4	7. 9
10			0	0
	10			15. 0
0	17		0	10. 0
17	17	3. 24±0. 03	30. 0	5. 0
17			0	0
	17			20. 0
0	31		10. 0	25. 0
31	31	3. 18±0. 03	45. 0	5. 0
31			0	0
	31			10. 0
0	45		0	10. 0
45	45	3. 22±0. 02	37. 5	10. 0
45			0	0
	45			10. 0
0	75		0	5. 0
75	75	3. 50±0. 07	22. 5	5. 0
75			0	0
	75			5. 0
Untreated	Untreated			0

[1] 20 apples were used in each lot.
[2] 2 bruises were produced on each apple bruised.

Factors Related to Decay Development After Infection

Maturity

To determine the effect of maturity and ripeness of apples on the rate of growth of the blue mold fungus in apple tissue, tests were made of the rate of decay enlargement in punctured and inoculated fruits harvested in 1947 and 1948 (tables 6 and 7). The apples used for these studies were a part of those harvested for the bruising investigations.

TABLE 6.—*Average diameter of blue mold decay lesions on punctured* [1] *and inoculated Delicious apples at intervals of 15, 25, and 55 days in 31° F. storage, harvest of 1947*

Maturity	Average firmness	Average diameter of decay lesions after—		
		15 days	25 days	55 days
	Pounds	*Centimeters*	*Centimeters*	*Centimeters*
Early	14. 9±0. 19	1. 62±0. 04	2. 38±0. 05	4. 64±0. 04
Medium	14. 3±0. 18	1. 61±0. 05	2. 40±0. 05	4. 77±0. 05
Advanced	12. 6±0. 38	1. 55±0. 05	2. 31±0. 04	4. 55±0. 06

[1] 21 punctures were measured except on fruits of advanced maturity, on which 19 were measured.

In 1948 immature and overmature apples from one tree were punctured and inoculated at harvest and at intervals until March 21. Measurements of diameters of the decayed areas were begun 10 days after puncturing and inoculating (table 7). The immature apples were held in storage until October 18 so that they could be punctured and inoculated at the same time as the first of the overmature fruits.

There was no relationship between the maturity of apples and the rate of decay enlargement, once infection was established (tables 6 and 7).

These findings are not in complete agreement with similar investigations by Baker and Heald (*2*). Their data indicated that the rate of growth of blue mold was greater in Delicious apples of prime maturity than in apples of early maturity. They stated, however, that the difference, although statistically significant, was slight, and they were of the opinion that maturity was of small importance in determining the internal resistance to decay expansion.

Ripeness During Storage

The rate of decay expansion remained the same throughout the storage period regardless of the progressive ripening of the apples (table 7). These results are in agreement with those of Baker and Heald (*2*) for a storage period of 180 days. However, in their study of decay-expansion rate in punctured and inoculated Delicious apples during the storage period, they found that a marked advance of decay enlargement rate occurred after a storage period of 180 days (approximately April 1). The increase in rate of expansion continued until the end of the test period of 240 days. The present studies were terminated with the March 21 series.

TABLE 7.—*Average diameter of blue mold decay lesions on Delicious apples of 2 maturities harvested from 1 tree, punctured and inoculated at intervals in storage at 31° F., harvest of 1948*

Date punctured and inoculated	Average firmness	Average diameter of decay lesions [2] after—					
		1st week	2d week	3d week	4th week	5th week	6th week
IMMATURE FRUITS [1]							
	Pounds	*Centimeters*	*Centimeters*	*Centimeters*	*Centimeters*	*Centimeters*	*Centimeters*
Oct. 18	16. 1±0. 19	1. 58±0. 03	2. 17±0. 03	2. 81±0. 04	3. 46±0. 04	3. 96±0. 03	4. 42±0. 03
Dec. 1	15. 8±0. 15	1. 78±0. 03	2. 39±0. 04	2. 99±0. 04	3. 57±0. 04	4. 18±0. 04	4. 68±0. 04
Feb. 1	14. 0±0. 13	1. 83±0. 03	2. 51±0. 03	3. 32±0. 04	3. 60±0. 03	4. 47±0. 05	----------
Mar. 21	13. 0±0. 14	1. 77±0. 02	2. 40±0. 03	3. 03±0. 03	3. 42±0. 03	4. 01±0. 03	4. 39±0. 04
OVERMATURE FRUITS [3]							
Oct. 18	15. 3±0. 16	1. 69±0. 03	2. 29±0. 02	2. 94±0. 03	3. 60±0. 04	4. 13±0. 04	4. 66±0. 03
Dec. 1	14. 8±0. 13	1. 54±0. 03	2. 04±0. 04	2. 63±0. 05	3. 19±0. 06	3. 92±0. 06	4. 41±0. 06
Feb. 1	13. 0±0. 13	1. 55±0. 02	2. 06±0. 03	2. 84±0. 05	3. 08±0. 05	4. 05±0. 05	----------
Mar. 21	11. 5±0. 12	1. 77±0. 02	2. 30±0. 03	2. 93±0. 03	3. 32±0. 04	3. 90±0. 04	4. 21±0. 04

[1] Harvested Sept. 21.
[2] Readings begun after 10-day incubation in storage.
[3] Harvested Oct. 16.

Cooling Rate and Storage Temperature

It is generally known that rapid cooling after harvest and maintenance of fruit temperature at approximately 31° F. add considerably to the storage life of apples.

The air temperatures at the center of the packed boxes of apples were recorded by using Ryan thermographs (fig. 1). In these tests,

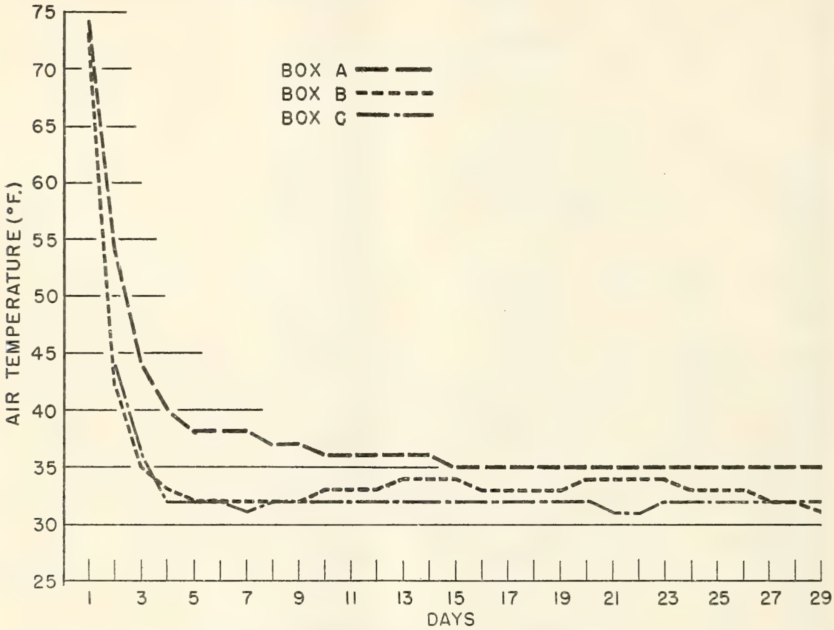

FIGURE 1.—Air-temperature records at center of packed boxes of bruised and inoculated Delicious apples harvested in 1949: Box A cooled slowly and reached 35° F. the 15th day; boxes B and C cooled rapidly and reached 32° the 5th and 4th days, respectively.

box B was held in the laboratory cold storage during the entire test, while boxes A and C were stored in commercial apple storage rooms for the first 29 days of the test and were then transferred to the laboratory storage for the rest of the storage period.

Boxes B and C cooled rapidly at similar rates (fig. 1), but the temperature in box C held uniformly at 32° F. during most of the 29-day storage period, dropping in two instances to a minimum of 31°; whereas that for box B fluctuated generally between 32° and 34°, dropping once to a minimum of 31°. Box A, in contrast, cooled much more slowly and reached a 35° minimum temperature on the 15th day, while boxes B and C reached a 32° temperature after 5 and 4 days, respectively.

These temperature differences strikingly affected inception of blue mold decay on the bruised areas of the apples (table 8). At the first inspection, 33 percent of the bruises in box A were decayed in contrast to 8 and 1 percent, respectively, of those in boxes B and C. At the second inspection, 2 weeks later, 51 percent of the bruises in box A and 22 percent of those in boxes B and C were decaying. The fifth (and final) inspection, at the end of 8 weeks, showed the decay in boxes B and C to be nearly as great as that in box A.

TABLE 8.—*Blue mold decay of Delicious apples that had been bruised, inoculated, and held in storage for 29 days at different temperatures, then placed in laboratory cold storage from which inspections were made at biweekly intervals, harvest of 1949*

Inspection	Box A		Box B		Box C	
	Decay at bruised areas	Decay at non-bruised areas	Decay at bruised areas	Decay at non-bruised areas	Decay at bruised areas	Decay at non-bruised areas
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1st (29th day of storage)	33. 4	5. 6	8. 3	0	1. 4	0
2d	51. 4	5. 6	22. 2	0	22. 2	0
3d	52. 8	8. 3	38. 9	8. 3	38. 9	0
4th	55. 6	8. 3	47. 3	8. 3	47. 3	0
5th	55. 6	8. 3	50. 0	8. 3	47. 3	5. 6

A similar relation existed on the unbruised portions of the apples. The apples in box A had 5.6 percent decay at the first inspection; this increased to 8.3 percent during the subsequent inspections. No decay on unbruised portions of the fruits appeared in box B until the third inspection, when 8.3 percent was found, whereas in box C no decay of the unbruised areas occurred until the final inspection, when 5.6 percent was found.

No decay occurred in the apples that had been neither bruised nor inoculated.

These results reemphasize the importance of rapid cooling of apples and of maintaining adequate cold-storage temperatures during their entire handling, to prevent decay at bruises during the storage period and to retard decay after removal of the fruits from cold storage.

Summary

An association between bruising and susceptibility to decay has long been observed, but there has been little experimental data on the relation between them. The present studies illustrate the susceptibility of bruised tissue to blue mold decay, the influence and relative importance of such factors as maturity and ripeness of apples on bruising damage and subsequent decay, and the effects of handling methods on decay development in bruised fruits.

Bruising damage, measured by the diameter of the bruised area, was found to relate directly to the firmness of the apples and, consequently, to increase with advanced maturity and ripeness.

Decay after inoculation of freshly made bruises increased with bruising damage and with softening of the fruits as a result of maturation and ripening.

Susceptibility of bruises to decay decreased during storage of the bruised fruit; this reduction was marked after only 3 days.

The amount of infection increased with advance in maturity and ripeness of the fruit, but these factors did not influence the rate of enlargement of the decaying areas once infection had occurred.

Rapid cooling and subsequent storage temperatures of 31° to 32° F. during a 1-month period after bruising and inoculation, greatly retarded the development of decay in bruised tissue.

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