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Cold storage for Iowa grown apples.

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COLD STORAGE FOR IOWA GROWN APPLES

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IOWA STATE COLLEGE OF AGRICULTURE AND
THE MECHANIC ARTS

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COLD STORAGE FOR IOWA GROWN APPLES.

BY LAURENZ GREENE

In continuing its investigation of cold storage for Iowa grown apples, upon which a partial report was made in September, 1909*, the horticultural section of the Iowa Agricultural Experiment Station has found further evidence that the principal commercial varieties of apples grown in the state may be handled with profit. The four years’ work with many different varieties all gives support to the value of this practice to Iowa apple men.

Since 1909 the Station has also developed many other new facts of importance to Iowa apple growers, not the least of them pertaining to the freezing of apples and their storage value when frozen. Careful tests indicate that apples which are frozen upon the trees in the fall can be safely placed in cold storage if allowed to thaw out gradually on the tree before picking, unless the fruit is broken down by the freeze. Apples which are frozen in cold or common storage will not be seriously injured if thawed out below freezing temperature.

OTHER RESULTS OF EXPERIMENTS.

Passing in brief review the other important results of the past four years’ work, they may be stated as follows:

To keep well in cold storage, the fruit should be thoroughly ripened, well colored and carefully handled.

In comparing cold storage early and cellar storage later with continued cold storage, it was found that Grimes Golden and Sheriff could be kept in this way until February 1st. Jonathan, Winesap and Northwestern Greening could be kept in the cellar storage until May 1st with but little more loss than where kept in the cold storage continuously.

Cellar storage in comparison with cold storage, kept such varieties as Winesap and Mammoth Black Twig until May 1st in excellent condition. Grimes Golden and Jonathan in cellar storage should be marketed before January 1st.

Delaying the storage of fruit after packing for a short time may prove beneficial if the fruit has not been properly ripened and the weather remains cool. For well matured specimens immediate storage is preferable.

Wrapping the fruit with paper retards the ripening process, prevents bruising in shipment and delays the appearance of scald. Wrapped fruit will keep longer in cold storage than when packed without wrappers.

Where fruit is properly ripened, carefully handled and stored immediately, the package in which it is stored has but little influence on its keeping qualities.

But little difference in the keeping qualities of fruit from cultivated and sod orchards could be seen.

*Iowa Agricultural Experiment Station Bulletin No. 108.
In selecting fruit for cold storage only the medium sized fruits should be selected for the extreme storage limit of the variety. Overgrown specimens do not keep as well as the smaller ones.

Apple scald attacks immature, poorly colored fruit first. The temperature at which the fruit is stored may influence scald. If the temperature is high enough to allow the fruit to continue the ripening processes, it may delay the appearance of scald.

The investigations of the past four years with a large number of varieties of apples indicate that the principal commercial varieties in Iowa can nearly all be handled profitably in cold storage.

**EFFECT OF FREEZING UPON THE KEEPING QUALITIES OF APPLES IN COLD STORAGE.**

On October 12 and 13, 1909, there occurred a heavy freeze all over the state of Iowa which found many apples still unpicked. It seriously injured the fruit crop of the state as a whole and interfered with the experiments which it had been planned to undertake. However, it offered an opportunity for studying the effects of freezing upon the keeping qualities of the apple.

After the freeze, many growers, buyers and packers as well as commission and cold storage men who were handling fruit questioned the advisability of using frozen fruit for cold storage purposes. Much discussion arose and quite naturally buyers everywhere discounted the value of this fruit. To obtain definite data relative to the keeping qualities of fruit which had been frozen on the trees and later thawed out gradually, two boxes each of Winesaps, Ben Davis and Gano, one box of each frozen and one not frozen, were placed in cold storage. These were secured from the state institution at Glenwood, Iowa, and were picked from the same trees and were treated alike except that those picked before the freeze were stored in a cellar for about two weeks while those picked after the freeze were stored for about one week. These fruits were inspected at irregular intervals during the winter and summer.

The Gano apples picked before the freeze showed very little decay, with only two apples decayed at all on June 1, 1910. Those picked after the freeze on the same date had only one decayed apple removed on June 1. However, on April 13, one apple had been removed because of decay.

Of Winesap picked before the freeze, one apple was removed on account of decay on April 13. On June 1, all were in good condition. These apples were also badly scabbed. Winesap picked after the freeze, were very scabby and not good cold storage stock. On March 3rd, six of these apples were removed.
There was one bushel in each lot of the above apples when stored; the piles shown were the apples remaining when photographed January 21, 1911.

because of decay. It was noted at that time that five of these were probably injured by the freeze.

Of the Ben Davis picked before the freeze, on February 24 and 25, six apples were removed on account of decay. On June 1 seven apples were removed on account of decay. Of the Ben Davis picked after the freeze, on April 13, it was noted that several inspections had been made at which all apples were found in good condition. On April 13 four were removed due to decay and the remainder were reported in good condition. On June 1st, one apple was removed which was badly decayed.

All of the above lots of apples were inspected at intervals during the fall and winter months of 1910. On December 1, 1910, the following counts were made:

Of the Winesap picked before the freeze, 62 were found in good condition and 130 decayed. Of those picked after the freeze, 69 were found good and 160 removed on account of
decay. This shows a very slight difference in the keeping qualities of the Winesap. However, on account of the large amount of scab on these apples, it could not be considered a fair test. On December 1, it was noted also that all apples picked before the freeze showed more scald. The apples picked after the freeze were evidently more mature and better colored, therefore reducing their susceptibility to scald.

Of the Gano picked before the freeze, 70 were found good on December 1, and 31 decayed. Of the Gano picked after the freeze, 96 were found good and 41 removed on account of decay.

Of the Ben Davis picked before the freeze, 59 were found good December 1 and 64 removed on account of decay. Of the Ben Davis picked after the freeze, 96 were found to be good on December 1 and 16 were removed because of decay. It is of interest to note also that at the last inspection which was made on January 21, 1911, the keeping qualities did not seem to be impaired by the October freeze of 1909.

These apples were held at a temperature of 31 degrees, or as near that temperature as possible throughout the entire fifteen months of their storage term. This fruit had been subjected to a temperature of 19° above zero on October 11 and 12, 1909. The conditions after the freeze were slightly better at Glenwood than other parts of the state, the weather having been cool and cloudy for a short period of time.

The above tests would indicate that if the freeze is not too severe, and is followed by favorable weather conditions, and if the frozen fruit is allowed to thaw out gradually on the tree, it can be stored safely. By noting carefully the records given below, there seems to be a slight advantage in favor of frozen fruit. It is believed that this advantage is entirely due to maturity at picking time and also due to the fact that the apples picked before the freeze were stored in a comparatively warm cellar for a longer period of time than those picked after the freeze.

<table>
<thead>
<tr>
<th>Date of Inspection</th>
<th>Picked Before Freeze of October, 1909</th>
<th>Picked After Freeze of October, 1909</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total No. of Apples</td>
<td>In Good Condition</td>
</tr>
<tr>
<td>Dec. 20, 1909</td>
<td>195</td>
<td>100%</td>
</tr>
<tr>
<td>Feb. 26, 1910</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>March 3, 1910</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>April 13, 1910</td>
<td>96.6%</td>
<td>33.3%</td>
</tr>
<tr>
<td>June 1, 1910</td>
<td>96.6%</td>
<td>33.3%</td>
</tr>
<tr>
<td>Dec. 1, 1910</td>
<td>96.6%</td>
<td>33.3%</td>
</tr>
</tbody>
</table>
Because of the results secured and recorded in the storage test of apples frozen on the tree, experiments were planned to test the temperature at which apples may be frozen and still remain in good condition if properly thawed out. In 1909, lower layers of apples in boxes stored immediately above the room called a “sharp freezer” were frozen. These boxes were later raised away from the floor to thaw out gradually at a room temperature of 31°. With Jonathan and Winesap no injury could be noted later in the season from this freezing. Wealthy, however, at the last inspection in June, showed a much larger per cent of decay on the frozen specimens.

The experiments in 1910 and 1911 were planned for the purpose of determining whether frost or freezing temperatures will seriously injure apples in cold storage if the frost is gradually drawn out, and if injurious, whether the injury will show so long as the fruit remains in storage temperatures.

**THE FIRST EXPERIMENT**

In the first experiment, one box each of Ben Davis and Jonathan were placed in a room at a temperature of 19° at 5 P. M.
November 30, 1910. These apples were taken from a room held at 31°. As they had been stored here for some time, the temperature of the fruit must have been very nearly that degree. On December 1, the following notes were taken:

<table>
<thead>
<tr>
<th>Time</th>
<th>Room</th>
<th>Box</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:30 A. M.</td>
<td>18°</td>
<td>26°</td>
</tr>
<tr>
<td>11:20 A. M.</td>
<td>18°</td>
<td>24°</td>
</tr>
<tr>
<td>2:00 P. M.</td>
<td>18°</td>
<td>24°</td>
</tr>
</tbody>
</table>

At 2 P. M., December 1, these boxes were removed to a room which stood at 30° and were allowed to remain there until the morning of December 2, when they were taken to the apple storage room at a temperature of 31°. The center of the box showed a temperature of 30° at the time it was removed to the cold storage room. On January 3, 1911, no apparent injury except where specimens were bruised near the outside of the box could be detected and these bruised specimens were not seriously injured.

On February 9, Jonathan showed no apparent injury from the freezing. The Ben Davis were in pretty good condition; 39 specimens were removed on account of decay. The check box of Ben Davis which had not been frozen showed practically the same conditions with 26 specimens out. Both boxes contained 150 apples each.

**THE SECOND EXPERIMENT**

Because of the results secured in the first experiment, it was thought advisable to make a second test and subject apples to even lower temperatures in order to determine what temperatures could be undergone without serious injury. Another box each of Ben Davis and Jonathan were taken from the cold storage room at a temperature of 31° and placed in a sharp freezer room at 3° below zero. One-half box of the Jonathans were left wrapped and the wrappers removed from the other half. The Ben Davis were not wrapped. These apples were placed in the room at 3° below zero at 2:45 P. M., December 1, 1910.

The following notes were taken to show the box temperatures at different periods of time:

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Jonathon Center of Box</th>
<th>Ben Davis Center of Box</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-2</td>
<td>4:30 P. M.</td>
<td>29°</td>
<td>26°</td>
</tr>
<tr>
<td></td>
<td>9:30 A. M.</td>
<td>26°</td>
<td>26°</td>
</tr>
<tr>
<td></td>
<td>11:30 A. M.</td>
<td>24°</td>
<td>24°</td>
</tr>
<tr>
<td></td>
<td>4:30 P. M.</td>
<td>20°</td>
<td>13°</td>
</tr>
<tr>
<td>12-3</td>
<td>11:30 A. M.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is of interest to note that the wrappers and liners in the Jonathan box prevented the rapid fall of temperature which occurred in the unwrapped Ben Davis, a difference of 7°. It required 43 hours to lower the temperature in a wrapped box.
of apples from 31° to 20°, while in the same time in an un­wrapped box the temperature fell from 31° to 13°. These apples were removed to a room which stood at 24° at 11:30 but no perceptible rise in temperature could be detected at 2:00 P. M. This shows that the apples were warming up slowly. These apples were then removed to a room at 32°.

At 4:30 P. M. (same date), the Jonathan box temperature had risen 2° and the temperature of the Ben Davis had risen 3°. On January 3rd, the following notes were made:

Of the unwrapped Jonathan, all were soft and broken down. Of the wrapped Jonathan, practically all specimens were still frozen but showed the frost injury to such an extent and the cell walls were so badly broken that they would have gone down even though gradually thawed out.

The Ben Davis were all broken down. From the above experience, it would seem that there must be a temperature between 20° and 24° at which apples can be frozen and still remain in good condition if thawed out gradually.

THE THIRD EXPERIMENT

In order to test this question further, 2 boxes of Jonathan—one wrapped and one unwrapped—were placed in a room at 20° on January 4, 1910. A box of Ben Davis, unwrapped, was also included in the lot. A small centigrade thermometer was placed in the center apple of each box with the bulb close to the core. Fahrenheit thermometers were used for room temperatures and the temperature on top of the boxes. The boxes and thermometers came from a room where the temperature was 29°. These apples were placed in a room at 20° at 9 A. M., January 4, and the following table shows the record secured:

RATE OF COOLING OF APPLES IN COLD STORAGE.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 4</td>
<td>11:45 A.M.</td>
<td>19°</td>
<td>211°</td>
<td>29°</td>
<td>29°</td>
<td>29°</td>
</tr>
<tr>
<td></td>
<td>12:45 P.M.</td>
<td>19°</td>
<td>212°</td>
<td>28.5°</td>
<td>28.1°</td>
<td>28.1°</td>
</tr>
<tr>
<td></td>
<td>4:45 P.M.</td>
<td>19°</td>
<td>28.1°</td>
<td>28.1°</td>
<td>28.1°</td>
<td>28.1°</td>
</tr>
<tr>
<td>Jan. 5</td>
<td>8:45 A.M.</td>
<td>19°</td>
<td>22°</td>
<td>27.2°</td>
<td>28.1°</td>
<td>28.1°</td>
</tr>
<tr>
<td></td>
<td>11:45 A.M.</td>
<td>19°</td>
<td>27.2°</td>
<td>28.1°</td>
<td>28.1°</td>
<td>28.1°</td>
</tr>
<tr>
<td></td>
<td>5:00 P.M.</td>
<td>19°</td>
<td>26.7°</td>
<td>27.2°</td>
<td>27.2°</td>
<td>27.2°</td>
</tr>
<tr>
<td></td>
<td>A.M.</td>
<td>19°</td>
<td>26.3°</td>
<td>27.2°</td>
<td>27.2°</td>
<td>26.3°</td>
</tr>
<tr>
<td></td>
<td>P.M.</td>
<td>19°</td>
<td>21.8°</td>
<td>25.4°</td>
<td>25.4°</td>
<td>22.7°</td>
</tr>
<tr>
<td>Jan. 6</td>
<td>A.M.</td>
<td>19°</td>
<td>**</td>
<td>21.8°</td>
<td>25.4°</td>
<td>22.7°</td>
</tr>
<tr>
<td></td>
<td>P.M.</td>
<td>19°</td>
<td>**</td>
<td>21.8°</td>
<td>25.4°</td>
<td>22.7°</td>
</tr>
<tr>
<td>Total</td>
<td>About 55 hours</td>
<td>Drop 9°</td>
<td>Drop 7.2°</td>
<td>Drop 4.6°</td>
<td>Drop 6.2°</td>
<td></td>
</tr>
</tbody>
</table>

*Thermometers had been removed from apples so that no reading was possible.

**Outside apple at the core and temperature of the room was 19°.
These apples were placed in a room which stood 29° F. On
March 9, 1911, the following counts were made: Jonathan un-
wrapped, 150 box, 23 removed with more or less injury, 78 were
free from injury. The apples near the sides of the box showed
greatest injury. Forty-nine apples were removed by visitors to
the Cold Storage Plant. Jonathan wrapped showed no apparent
injury.

The Ben Davis showed considerable injury. Seventy-seven
removed on account of injury. This box contained 163 apples.
Injured 46.1%.

The results of the above experiments would indicate that
apples which are frozen in cold storage at temperatures of 24°
or above would remain uninjured if thawed out gradually at
a temperature below freezing—29° to 31°. If proper care is
given to fruit accidentally frozen, less claims for damage against
the storage men will be collected.

**Maturity**

The first maturity test of apples in storage was made in 1909-
1910. In this test immature apples could be secured for only
three varieties; namely, Jonathan, Wealthy and Northwestern
Greening. Little difference could be noted in the keeping qual-
ities of these different lots except that the Northwestern Green-
ings which were immature showed considerably more scald than
those which were from other sources and ripe.

A second maturity test was made in 1912-1913. The fall of
1912, a few trees of Jonathan with more dense foliage and
perhaps more favorable locations were found that had fruits
which were not properly matured at picking time both as regards
color and condition of flesh. A few boxes of these were placed
in storage to compare with those which had properly ripened.
On May 31, these were inspected for the last time when there
was practically only 4% loss. Not much more than in the case
of the mature Jonathan. This test, however, is not a fair one
because the Jonathan in these lots were nearly ready for storage
purposes though poorly colored.

Tests with several varieties, and numerous inspections of com-
mmercial lots of apples in cold storage offer further evidence that
well matured or "hard ripe" apples keep best in cold storage.

**Methods of Storage**

In order to secure data relative to the keeping qualities of
apples under different methods of storage, three lines of investi-
gation were undertaken.

1st. Cold storage for the entire season in comparison with cold
storage early and cellar storage later.
2nd. Cellar storage throughout the entire season.
3rd. Immediate storage as compared with delayed storage.

EARLY VS. CONTINUED COLD STORAGE.

1909-1910 Tests:—Two boxes each of Wealthy, Grimes Golden, Jonathan and Colorado Orange, were placed in storage and removed about November 22. With the Jonathans the apples which were stored in this manner kept in excellent condition until the first of March. They seemed to be in as good condition as those which were kept in cold storage.

Grimes Golden began to show scald on all of the specimens although they retained their firmness until the first of March, while those in cold storage scalded fully as early and as badly as those in common storage.

The Wealthy scalded as early as would that fruit in cold storage. This fruit was frozen in the cellar, after it was removed from cold storage and is not comparable with that in storage.

The Colorado Orange apples kept in cellar storage very well until the first of April when they were removed. These, however, rotted earlier than those which were kept in cold storage.

1912-1913 Tests:—In this series of tests, five varieties were included—Winesap, Sheriff, Grimes Golden, Northwestern Greening and Jonathan.

Winesap: The Winesap were picked and packed during the first week of October and were immediately stored. Those which were removed to the cellar were shipped from cold storage December 24, making the storage period about two and one-half months. With the Winesap, those which were stored in the cellar late in the season showed by the first of June less than 3% of rot. These apples kept in excellent condition with the exception of scald which was no worse than on the apples in continuous cold storage. There was practically no difference in these lots of apples in regard to keeping qualities, there having been more variations due to size and color than to methods of storage.

Sheriff: The Sheriff apples were picked the first week of September and stored until December 24, when four boxes were removed to cellar storage. These were last inspected about the middle of April, having been inspected several times previously. At the above date, the two lots, both those continuously in cold storage and those which had been removed to cellar storage, showed about 74% decay although there was a wide variation between different boxes. This variety began to scald, as noted under "Variety Test," in February. It should not be held in cold storage after February 15.

Grimes Golden: The Grimes Golden apples were picked the last week of September, immediately stored, and four boxes removed December 24 to common cellar storage. These were inspected about the middle of April and at that time a large percentage of them were decayed, 65.7% were unmarketable with only 34.3% marketable of those in cellar storage. Very little difference could be detected at this time between the early and continued cold storage. Grimes Golden should be removed from storage before the first week of March, as noted under "Variety Test."
Northwestern Greening: Northwestern Greening were picked about September 25. These were immediately stored and four boxes removed December 24. The final inspection was made May 24, May 27 and May 31, at which time those which had been removed to the cellar showed a 27% loss. While those which had been in continuous cold storage showed a loss of only 9%. This difference, however, was partly due to the fact that the cellar, in which the apples were stored, was flooded owing to defective drainage and the apples had to be removed in order to dry the cellar, they thus became warm and deteriorated rapidly. About the first of May, there was practically no difference between the two lots.

Jonathan: The Jonathans were picked the last week in September, immediately stored, and 4 boxes removed December 24. These were inspected from May 27 to June 4, at which time those which had been removed from cellar storage showed an average loss of about 7%. The remaining apples were in excellent condition. As the Jonathan season should not be extended beyond May 1 as the latest extreme, this method of storage should prove economical with Jonathan.

As a result of the above tests, it would seem that where cold storage can be had close at hand, it would be economical to store fruit for one or two months at a monthly rate until the cellar storage could be cooled to proper temperatures and then the fruit removed to the cellar. The season rate per box is 15 cents. The monthly rate per box is 5 cents for the first month and 4 cents for the second month. This method would also give opportunity for keeping the supply on hand through December for the local demand.

**CELLAR VS. COLD STORAGE.**

1909-1910 Tests:—In order to compare cellar storage with cold storage, one box of Northwestern Greenings was shipped from Mr. Deur's place when the other fruit was put in cold storage.

One box of Grimes Golden and Jonathan were placed in J. M. Bechtel's cellar on September 23 and at the same time the fruit of those varieties were shipped to cold storage.

The Northwestern Greenings kept in good condition until the first of March but showed more scald and wilt than those kept in cold storage.

The Grimes Golden which were placed in cellar storage were shipped to Ames on March 14. These were badly scalded and largely decayed, and sound specimens had lost much of their flavor.

The Jonathans were shipped to Ames on March 14 and were in fair condition, their quality being but slightly impaired. The fruit showed some shriveling but no decay or scald.

1912-1913 Tests:—Only two varieties were included in this test in 1912 and 1913: Winesap and Grimes Golden.

Winesap: The Winesap stored in the cellar throughout the entire season began to decay much earlier than those kept in continuous
cold storage or those which were removed from cold storage in December. On April 14 about 12% had begun to decay. On June 4 to 6, two boxes showed about 17% decay. This variety in cellar storage gave much better results as regards scald but there was a larger amount of shriveling. Where Winesaps are to be placed on the market by the first of April, they can be safely stored in cellar storage unless the weather at harvest time is exceptionally warm. As a rule, Winesap can remain on the trees until there is danger of freezing, after which time, by proper methods of ventilation, the cellar storage can be kept at good temperatures.

Grimes Golden: The Grimes Golden in cellar storage showed very much less scald than where stored in cold storage for the entire season. However, they began to decay earlier and shrivel badly by the middle of April. About 10% of this lot were decayed on April 14. Grimes Golden would not be safe in cellar storage in ordinary seasons because at their time of ripening the weather is usually quite warm and they would be apt to shrivel and go down rapidly in cellar storage unless they could be placed on the market before the holiday season.

DELAYED STORAGE.

1912-1913 Tests:—In order to test the desirability of placing the fruit in storage immediately rather than allowing it to remain in the packing sheds for some time after it is packed, several boxes of Winesap, Sheriff and Grimes Golden were picked and packed the last of September and early in October. Some of these remained in the shed for nearly a month while the Winesap and Sheriff remained for only about three weeks. They were all stored on October 29. On April 14, the Grimes Golden showed nearly 50% decay and a large percentage shriveled. However, the scald was noticeably much less than on those which were stored immediately after picking. The apples in the shed had opportunity to mature better than those which were stored immediately. The same results could not have been secured had the fruit been properly matured on the trees before being picked.

The Winesap showed very little advantage in immediate storage over those which were delayed from three to four weeks. Very little decay was found even as late as June 4, and 6. There was noticeably less scald than among those in cold storage but more than in cellar storage.

The Sheriff, which were picked and packed October 2 and stored October 29, began to decay and shrivel earlier than those which were stored immediately but gave better results so far as scald was concerned. Had these been placed on the market early in February, those which were delayed before being stored would have given best results. The Sheriff, like Grimes Golden, were picked too early for cold storage.

From the above tests, it would seem that delay in placing fruit in storage would not prove injurious and in some cases bene-
ficial. While such a conclusion is natural it is probably erroneous because these fruits were not properly ripened before being packed. If fruit has not properly colored at the time when there is danger of freezing then it may prove beneficial to pack and delay the storage for some little time before placing in the cold storage room for the winter. It should be remembered that the fall of 1912 was very cool and an excellent harvest season for most varieties of late apples. Warmer harvest weather would doubtless give different results.

**WRAPPERS.**

1909-1910 Tests:—One barrel of Wealthy was packed at Mr. Kyle’s place without wrapping. The others were wrapped. These were shipped to storage and not opened until June 1. At that time there was very little difference between the two lots of fruit; the wrapped barrel showing a slight advantage but not sufficient to make it profitable to wrap Wealthy provided they are going to be placed in storage soon after being picked. There was less than ten per cent loss of the fruit in either of these two barrels.

Grimes Golden wrapped kept with a very small amount of scald until March 14. They were taken out at this time and would have gone on the market in fairly good condition, while those not wrapped began to scald by the 22nd of February and were rather badly scalded at that time.

Wrapping Colorado Orange did not seem to affect the variety at all as it keeps in excellent condition until late in the season.

1912-1913 Tests:—During the fall of 1912, several varieties of apples, including Jonathan, Winesap, Grimes Golden, Sheriff and Mammoth Black Twig, were packed with and without wrappers.

With Grime Golden, especially, the wrapper delayed injury from scald to a very marked degree. It also prevented scald to a limited extent with Sheriff, Winesap and Mammoth Black Twig. The Jonathan stock kept excellently in cold storage regardless of the method of packing but the wrapped boxes by June 1 were in better condition than those which were not wrapped. In general, the wrappers will extend the cold storage season from two weeks to several months, according to variety.

The effect of wrappers on the keeping qualities of stored fruits was noted with several different varieties during the past four years of work. Apple wrappers tend to delay apple scald on most varieties with which they have been used. They also prevent the breaking down of fruits at as early a date as otherwise occurs. In addition, wrapped fruits which do decay are prevented from causing the decay of those specimens immediately.
surrounding them. Wrappers, however, are out of the question excepting where apples are packed in boxes or where packed for special purposes in barrels. The cost of wrappers amounts to from 3 to 4c per bushel in addition to the expense of wrapping. With fancy fruits for boxing the wrapper is of considerable value in preserving fruits in cold storage.

**PACKAGE TEST.**

1909-1910 Tests:—Fruit for the package test was secured from H. J. Kyle at Aredale and a portion of the fruit was placed in boxes and a part in barrels. The Wealthy was used for this test. These were picked and packed September 6 and stored September 11. The fruit was placed in storage very soon after it was picked. There was practically no difference in the results with the different packages.

**CULTIVATION VS. SOD.**

1909-1910 Tests:—Wealthy apples were secured from H. J. Kyle at Aredale from two orchards about one mile apart, one of which is under cultivation and the other in sod.

Those taken from the sod orchard were much better colored but apparently no riper than those in the cultivated block. Those from the sod block were slightly affected with scab and had some codling moth injury. In one box of this lot the apples on the lower layer, 23 in number, were next to the floor and were frozen early in December. These showed the effects of the frost at later inspections but did not decay badly while in storage. By May 28, the layer was badly decayed.

On March 13 the apples from the sod block were not nearly so firm as those from the cultivated block, but otherwise were in equally good condition.

The decay was slightly larger in the lot from the sod orchard. It is possible that those from the sod orchard might have been over-ripe as would be indicated by their action in storage.

1912-1913 Tests:—No apparent difference could be noted between lots grown on sod and in cultivated areas.

**INFLUENCE OF SIZE UPON THE KEEPING QUALITIES OF APPLES.**

Good cold storage stock should not be over-grown fruit. In a number of varieties the larger apples were noticeably shorter lived in storage than medium sized fruits of the same variety.

A box of Rome Beauty containing 111 apples showed 82.8% in good condition and 17.2% decayed on May 27, while a box
of 74 apples of the same variety contained only 46% in good condition and 54% decayed, on the same date.

Jonathan, 200 to the box, contained only about 1% decayed fruits while 120 to the box contained as high as 9% and 10% decayed fruits, when inspected May 27.

Differences could be noted in boxes where the size varied only 40 or 50 apples to the box. In almost every variety the larger apples will not keep as long as the smaller ones. They also lose their flavor earlier. Just why this is true is a matter of discussion. Doubtless, the flesh is coarser and will break down more quickly than in the smaller fruits. Further investigation along this line is contemplated.

IMPORTANCE OF AN UNBROKEN SKIN ON APPLES FOR COLD STORAGE

The importance of having fruits which are entirely sound was demonstrated in numerous instances during the past four years' work. Apples which were sound but were russeted with spray mixture, by frost or by limb rubbing were noted to shrivel much earlier than those which had a smooth, clear skin. Any break in the skin allows the cell sap to evaporate more rapidly. The Salome and Ralls Genet both have a tendency to crack. There is also a natural roughening of the skin of these varieties. In seasons when the cracking is bad, it will not be well to include them in cold storage stock as they will shrivel before the end of the season. This only emphasizes the importance of having strictly first grade stock for cold storage purposes. Providing the fruit has been burned by spray mixture or scarred in any other way it should not be included in storage stock that is to be held after February 1.

APPLE SCALD.

As noted in Bulletin 108 of this Station, a common trouble of apples in cold storage is one known as "scald." This is a brownish discoloration of the surface not extending into the flesh of the apple, though scalded fruit will break down earlier than unaffected fruits. The greatest damage from the trouble is the lessening of the market value of the fruit due to unattractive appearance. The trouble is not well understood.

The interest in apple scald among growers and shippers was keen during the season 1912-1913. Much loss from this trouble was experienced in all parts of the state. There is a wide variation in varieties in regard to their susceptibility to this trouble. The facts in a study of apple scald are interesting as they indi-
cate methods of handling fruit in storage which might decrease loss from this trouble. From the investigations and observations during the past season, it would seem that maturity is one of the main factors of influence with this trouble. Well matured, well colored specimens scald very little while those immature and poorly colored specimens suffer greatly.

A lot of Grimes Golden apples were picked October 2, packed the same date and stored October 29. They were shipped to Ames January 25 and stored in common cellar at a temperature of from 32 to 34 degrees. Owing to the fact that these were delayed before placing in cold storage the fruits were mature and well colored. On February 7, the better color had prevented scald to a limited extent. However, this lot had shriveled and decayed more than those stored immediately after packing.

On March 19, it was noted that a box of 200 well colored Grimes Golden showed practically no scald. Apples suffering most show greatest decline in quality.

By February 26, frequent complaint had been made that the cold storage companies had not properly cared for the temperatures at which the fruit was held. Certain cold storage men expressed the belief that the scald was due to immaturity at time of harvesting. Others have advanced the opinion that apples which naturally scald should be held at higher temperature than those which are not susceptible to the trouble.

One grower had Mammoth Black Twig in storage in two different towns. Those in one lot were not so badly scalded as those in the other. The scalded lot were picked and packed first although the harvesting operations were not interrupted. The temperature of both storage houses is reported to have been practically the same—at or near 33°. A cold storage or refrigeration engineer expressed the opinion that low temperatures influenced the amount of scald. He held that apples which were susceptible to scald should be stored at higher temperatures than 33°. Some dealers were of the opinion that the degree of maturity had the greater influence, others that the temperature in which the fruit was held increased or decreased the trouble.

There is a difference of opinion as to how much scald injures the apples. Some dealers claim that it does not injure the sale of the fruit to any appreciable extent. others, however, discount scalded fruits a certain amount. Scalded fruits may find a ready market at bakeries, restaurants and hotels for culinary use.

On April 2, it was noted that continued reports of loss from scald with Mammoth Black Twig were received. One grower reported that he had but little scald on Mammoth Black Twig except those which were picked early in the season. All of this lot of fruit was held in common storage. Another grower
reported badly scalded fruit in common storage but could give no data relative to the time of picking. Apples from the Experiment Station orchard which had been kept in cellar storage, showed no signs of scald a few days previous to April 2, and though no record of picking date was kept, there was a marked difference between the cellar stored fruits and those kept in cold storage from the same orchard. These observations seem to indicate that apples like Mammoth Black Twig, Winesap, and others from which loss is sustained because of scald, might well be stored in well constructed cellars, and if placed in cold storage they should be thoroughly matured and, possibly, kept at higher temperatures.

The Sheriff apple scalded very badly in cold storage during 1912-13. Several instances were noted where cellar stored fruit kept in good condition without scald until after March 1, whereas, those in cold storage scalded badly. Certain lots of this variety were held in the packing shed at the Experiment Station orchard for nearly four weeks before being placed in cold storage. These apples colored up well during that time and but little loss resulted from scald. Cool weather favorable to the keeping of these fruits prevailed during this period.
As shown in the discussion under the wrapper tests, wrapping may delay scald for some time with certain varieties.

It is probable that maturity had more to do with scald than did the cellar temperatures at which the fruit was held, but owing to the fact that the cellars were comparatively warm, the fruit had an opportunity to mature after having been picked.

With the information at hand at this time, it is recommended that such varieties as Grimes Golden, Sheriff, Winesap, Mammoth Black Twig, and others which scald badly be picked as late as possible to prevent heavy dropping or to prevent being frozen on the tree, thus securing well matured specimens. If good storage facilities are at hand in the way of cellars or caves, varieties of good keeping qualities like Winesap and Mammoth Black Twig can be handled profitably in common storage.

This question is an important one and the Experiment Station has outlined experiments rather extensive in character for the coming season and solicits correspondence in regard to it. Those growers who have good cellars for storage purposes are requested to test out varieties and report to the Experiment Station.

**COLD STORAGE VARIETY TESTS.**

The cold storage variety testing carried on during the seasons of 1909, 1910, 1912 and 1913, was for the most part to secure confirmatory evidence on the same line of investigation as reported in Bulletin 108 of this Station. Descriptions of varieties will be found in the above bulletin unless otherwise noted.

**Ben Davis:** 1909-1910—Grown by the State Hospital at Glenwood, picked October 5 to October 20, stored on October 30. This fruit was secured primarily for the purpose of testing the effect of freezing upon its keeping qualities. This fruit was in excellent condition, both frozen and that which was not frozen on July 6 when it was last inspected. Its behavior is reported under “Effect of Freezing.”

**Ben Davis:** 1912-1913—Three boxes were included in this lot; picked and packed October 7, stored October 29. These apples kept in excellent condition throughout the season. Final inspection was made on June 6, having been shipped from storage on May 17. At the last inspection in 2 boxes of 268, 56 were found to be in poor condition. While these kept well early in the season they did not seem to be in as good condition at this time. However, Ben Davis has proven itself to be, as reported before, an excellent keeper for late spring storage.

**Colorado Orange:** 1909-1910—Grown by H. J. Kyle, Aredale, Iowa, picked October 18 or 19, stored October 20. These apples varied in degree of ripeness when placed in storage. Some were over-ripe and others not quite mature. Both showed some wilt early in the season but this did not seem to increase to any great extent. This variety when taken from storage on June 16 and allowed to stand upon the open market was in excellent condition and later showed very few signs of decay. Some of the fruit was kept until January 21, 1911, and was in fair condition though it had shriveled and had lost considerable in quality by that date.
Because this apple is reported to keep very successfully in common cellar storage, further investigation is needed to determine whether cold storage is an advantage in handling the variety or not. It makes an excellent cold storage variety.

*Charlamoff:* 1909-1910—Grown by J. D. Day, Castana, Iowa. Picked August 28, shipped August 30 and stored September 3. This variety resembles the Duchess of Oldenburg very much in appearance and quality. September 28, these apples were in excellent condition. October 21, very little decay was shown. November 19, about 12% were thrown out due to decay and physical break-down. It was thought that the variety had passed the date of profitable storage but the remainder of the fruit kept in excellent condition until March 15 when it was removed from storage. This fruit was over-ripe when placed in storage and had it not been for this, the variety would have made a better showing.

*Delicious:* One of the newer commercial varieties which is receiving considerable attention by Iowa planters. It originated at Peru, Madison County, Iowa. An attractive red apple, rather bright to dark red over yellow ground color. It is of good size and somewhat the form of Yellow Belleflower. The flesh is firm, very juicy, rather coarse, rich and slightly aromatic and of excellent quality. While it has not been thoroughly tested for hardiness in Northern Iowa, the fact that the original tree is still bearing would indicate that it was hardy as far north as Peru. If, as noted below, the apple is carefully handled it should make a profitable commercial apple for southern Iowa and it may possibly prove hardy for northern Iowa when topworked.

The Delicious apples tested in cold storage during the winter of 1912 and 1913 were grown by F. O. Harrington of Williamsburg, Iowa. These apples were carefully graded free from insect and disease injuries. These apples were picked October 11 to 14, packed October 24, shipped by express October 25 and stored in Council Bluffs October 26. Four barrels of these were included in the shipment. It was thought best to retain these in the original packages until after opening for inspection at later dates. The inspection was made for the most part by shipping the fruit to Ames from Council Bluffs. The first shipment was made January 3 and was inspected at Ames on January 15. The barrel was stored during the interim in a storage cellar at a temperature of from 32° to 34°. A count of apples on January 15 showed the following for one barrel: 266 apples or 74.5% in good condition; 28 or 7.8% badly bruised, starting to decay; 63 or 17.7% unmarketable on account of decay; total, 357. The decay was largely caused by mechanical injury followed by soft rot. These apples were in many cases sound and hard except in the injured portion. The sound apples were in excellent condition. Many of these fruits were injured before packing and others were bruised in packing and shipping. It would seem that by careful methods of handling and shipping, these apples would have kept perfectly to this date.

A portion of the fruit from the above lot was stored in boxes in the cellar mentioned above. On February 14, these apples had lost in flavor to some extent though they were still firm.

The second shipment was made February 10, arriving in Ames February 13 and were inspected on February 14. The counts were as follows: In good condition 275 or 79.2%. Seconds, 27 or 7.8% bruised and decaying. Decayed 45 or 13%; total 347. The grading in this case was not quite so severe so that several bruised apples were included among the firsts. The decayed apples were in the main worse decayed than the barrel inspected January 15. There was no
shriveling and the condition of the fruit was good but in quality and flavor there seemed to be a slight deterioration.

On February 8, the remaining barrels were reported by the Cold Storage firm as leaking and in bad condition. Under date of February 14, the remaining two barrels were inspected in cold storage and the following conditions noted: Seconds, bruised and decaying 29% or 4.1%; decayed 41 or 5.8%. The total number was not counted in either of these barrels and the percentages given above are taken from the average count of the two barrels inspected January 15 and February 14. Inspection very evidently was not as close as in above cases. The remaining apples were packed in boxes and inspected as noted below. On May 16 the following counts were made of the boxes still remaining in storage, many apples having been removed. These are considered as a part of the barrels above and are not recorded as to each box, the entire lot being considered as one. At this date, there were in good condition 267 or 66.5%; of decayed apples, in unmarketable condition there were 134 or 32.5%. Those reported as being in good condition had lost in quality to a certain extent. However, had these apples been as carefully handled as this variety should have been, the fruit would have been in excellent condition for the market at this date. From the above record, certain points are of interest. First, Delicious is a tender variety, and where shipped long distances, should be carefully handled and should never be packed in barrels. The shape of the apples with the five prominent points at the blossom end make it impossible to pack in barrels without bruising other specimens. It would seem also that where packed in boxes it would be preferable to place layer boards between each tier. Where handled in this manner, Delicious should prove a profitable variety for cold storage purposes even into the month of May.

To those growers and shippers of Delicious, it is recommended that the greatest possible care should be given the handling of this variety. Bruised specimens will not carry well in cold storage and the flesh, as with some other varieties, breaks down rapidly where the fruit is bruised or injured in any way.

Gano: 1909-1910—Grown by the State Hospital at Glenwood. Report of the fruit will be found under "Effect of Freezing."

Gano: 1911-1912—Two boxes were picked and packed October 7, stored October 29. These were inspected at frequent intervals during the year and kept in good condition. At the final inspection June 6, about 12% were found to be decayed. A portion of one box was wrapped, but very little advantage if any, could be seen in favor of the wrapping. Gano like Ben Davis still holds its place as a good, long keeping apple.


Grimes Golden: 1912-1913—Grimes Golden kept in excellent condition until January 24. They were not again inspected until February 26. On that date, several boxes had begun to scald although most of them were still in marketable condition. Several boxes were inspected and from one or two apples up to twenty were found with scald. Very little decay was showing at this date. By March 15 scald had increased so that as high as 50% of the fruits in each box were scalded. In some cases, however, where better color had been obtained before picking but little scald resulted. The wrappers with Grimes Golden were quite noticeably of value as there was much less scald and less decay in the case of the wrapped apples. In many cases the flavor at
this date in the wrapped boxes was very nearly normal. It was also noted that those apples which showed the most scald showed the greatest decline in quality.

Grimes Golden is not recommended as a storage apple to be held after February 1. Until this time it can be kept in very good marketable condition.

Hutchins Red: An attractive red apple somewhat flattened in shape, good quality, the type of Fameuse or Snow. This apple originated in western Iowa and is slowly growing in favor though not much grown as yet. It ripens a little ahead of Jonathan and, as noted below, makes a good a variety for storage.

1909-1910—Grown by E. A. Hess of Council Bluffs, picked and stored September 22. This fruit was unsprayed so that worm and scab free specimens were hard to secure. None of this fruit was removed on account of decay until May 28 when three specimens were taken out of the box which contained 164 apples. Fruit of this variety which was left in storage in a mixed box scalded by July 21 but most of it retained its fine flavor until that date.

Jonathan: 1909-1910—Grown by J. M. Bechtel of Hamburg, Iowa. Picked October 23 and stored October 24. Some of the apples were frozen due to the fact that they were stored in a room immediately above a "sharp freezer" room and were placed next the floor. These were, however, later raised from the floor and showed no signs of injury from the freezing at the time they were removed from storage. These apples showed no signs of decay except those which were mechanically injured. They were in excellent condition at the last inspection March 14th.

Jonathan: 1912-1913—Several boxes of these apples were kept in cold storage until May 17 at which time there was less than 2% decay except in the larger sizes of apples. Apples which pack from 165 to 200 apples to the box will keep in excellent condition where properly matured and carefully handled, until June 1. Jonathan is an excellent storage variety.

Mammoth Black Twig: [Arkansas] 1912-1913—Mammoth Black Twig apples kept in good condition until after January 24. Some few specimens were beginning to show scald on that date. By February 26 this variety had scalded badly. A discussion of the behavior of this variety is given under "Apple Scald." However, there was very little decay at the last inspection which was given May 27. Mature specimens which were well colored were in prime condition on that date. On account of scald this variety should not be stored after February 15.

Minkler: 1912-1913—Minkler grown by J. M. Bechtel of Hamburg, Iowa. Picked on October 18, stored October 19. The apples of this variety were not well colored specimens but were free from insect injury. These apples were in excellent condition the first of June when the last inspection was made. An excellent variety for cold storage purposes. Does not scald badly nor does it shrivel.

Newell Winter: 1909-1910—Grown by Clarence Wedge, Albert Lea, Minnesota. This fruit was very poor grade and badly affected with scab and codling moth, consequently, it showed much decay from injury but they stood the test well until May 13 when they began to break down even where not injured. This variety made a poor showing but the fruit was not of a class to make the results valuable.

Northwestern Greening: 1909-1910—Grown by C. H. Deur, Missouri Valley, Iowa. Picked and stored September 22. First class fruit for the test was very difficult to secure. Nearly all fruit in the test was slightly affected with scab but no codling moth injured fruit was included. On April 13, this fruit was in good condition and decay
was just beginning to show at points other than those due to injury. On May 28, about 10% were decayed and the remainder were in excellent condition.

**Northwestern Greening:** 1912-1913—Contrary to the reports formerly sent out, Northwestern Greening proved to be one of the best keepers in the test. These apples were grown at the Exepriment Station orchard near Council Bluffs. Were picked and packed late in September and stored immediately. They were in prime condition as noted under “Early vs. Continued Cold Storage,” when they were last inspected May 24. The flesh of this variety is somewhat tender and breaks down rapidly when decay once starts but if properly handled it will make an excellent storage apple.

**Okoboji:** Grown by H. N. Antisdel of Milford. This fruit was badly affected with codling moth and scab and the packing was very slack, consequently bruising in shipment resulted. These were stored early in October. On April 13 a few were decayed but the rest were hard and in good condition. On the 2d of June about 6% were decayed and the rest were in good condition although some showed scald. The variety keeps well but is practically worthless so far as quality and color is concerned.

**Baits Genet:** This variety kept well in storage until late in May. At the last inspection May 27, nearly 40% were either decayed or shriveled. Were it not for the shriveling of this variety, which is doubtless due to the cracking of the skin, a common trouble with the variety, it would make an excellent cold storage fruit. For use up to May 1, it makes a good storage variety. Its color, however, is against it for market purposes.

**Ramsdell’s Sweet:** 1909-1910—Grown by F. O. Harrington of Williamsburg, Iowa. Stored October 6 and had been picked for several days. A few specimens were injured by codling moth but all were free from disease. Packing was slack, however, and bruising in shipment resulted. Much of this bruised fruit had to be removed during the season but the remaining specimens kept fairly well. February 22, about 30% was removed on account of decay. The remainder of the fruit was in good marketable condition. Should keep in cold storage until March 1.

**Rome Beauty:** 1909-1910—Grown by F. O. Harrington, Williamsburg, Iowa. The exact date of picking was not recorded. Fruit was stored October 30 and was picked and packed ten days or two weeks before. Fruit of excellent quality, showing but little injury. Packing was loose so that some bruising occurred in shipment. These kept well until April 13 when they began to lose firmness. On June 1 when they were removed from storage about 10% had decayed and the remainder suffered but little from wilt and were in fairly good condition. These apples were frozen on the trees in October and after thawing out were picked and placed in the cellar for some time before they were shipped to Council Bluffs.

**Rome Beauty:** 1911-1912—Two lots of Rome Beauty were included in this test. Two boxes grown by A. A. Simmons of Hamburg, Iowa. These apples kept in good condition until May 1. May 27, when the last inspection was given, out of a box of 112 about 18% were decayed. Out of a box of 72 about 55% were decayed or scalded. As with other varieties, the larger sizes did not keep as well as smaller sizes. Further testing of Rome Beauty in cold storage is desirable but evidence shows that it should prove a good storage variety until May 1.

**Sheriff:** 1912-1913—Sheriff was in good condition January 24. By February 26 scald had started in to such an extent as to make those specimens not well colored unmarketable. Aside from scald the condi-
tion was excellent. Sheriff, especially if not well colored, should not be held in storage after February 1. This does not make a valuable storage variety as it has a tendency to develop a bitterness of the skin in storage.

**Stayman (Stayman Winesap):** 1909-1910—Grown by F. O. Harrington, Williamsburg, Iowa. Were frozen upon the trees October 11 and 12. After thawing were picked and placed in a cellar ten days or two weeks before being shipped to cold storage. They were stored October 20. Some bruising occurred owing to loose packing. Otherwise, the fruit was of excellent quality. The lower layer of fruit in one box was again frozen in cold storage due to the fact that it was placed next to the floor over a "sharp freezer." This was noted December 20. No injury seemed to result from this freezing as when thawed out after having been raised from the floor no difference could be noted between those frozen and those not frozen. February 26 they were in excellent condition and by April 13 they had begun to scald. On May 28 a large percentage had scalded but the condition of fruit was fairly good at that time. A valuable storage variety if well colored. Should be marketed by March 1.

**Wealthy:** 1909-1910—Grown by C. E. Mincer, Hamburg, Iowa. These were picked the last of August and stored immediately. These apples were in first-class condition so far as codling moth and scab injury were concerned but were not quite as mature as storage stock should be. Only a few specimens were highly colored. Unfortunately, these apples were removed for exhibition purposes in November and were repacked and re-stored later. On February 21 about 10% showed scald. On March 14 practically the whole box were showing scald. On April 13 many had begun to decay and by the end of May they were practically all showing decay. Wealthy from other sources made a better showing as reported under "Packages."

**Wealthy:** 1912-1913—Contrary to previous experience Wealthy did not prove to be a valuable storage variety after December. An average of nearly 20% was decaying by January 24. This was partly due to rough handling of the fruit and doubtless partly due to the fact that the apples were grown on trees which produced a very small crop which would tend to make them over-grown specimens.

Wealthy, especially from northern and central Iowa, makes a good cold storage variety. If properly ripened, carefully handled and immediately stored, it can be kept in good condition until May.

**Windsor:** 1909-1910—Grown by E. H. Graves, Ames, Iowa. Picked September 28, stored September 30. A few specimens decayed during the season largely due to insects, scab and mechanical injury. These were in first-class condition on the 28th of May when they were removed from cold storage.

**Winesap:** 1909-1910—Grown by C. E. Mincer, Hamburg, Iowa. This fruit was secured after the freeze of October 11 and 12 and intended for comparison with fruit which had not been frozen but it was impossible to secure unfrozen fruit from the same orchard. This fruit was picked during the last week of October and stored November 6. Was removed from storage on May 28 and there was practically no decay at that time.

**Winesap:** 1912-1913—Winesap was grown in the Experiment Station orchard near Council Bluffs. While these apples were well colored when harvested they were evidently not well matured. They were picked early in October and were stored immediately in cold storage. Scalded badly before June 1. Where Winesap is properly matured, it makes a valuable storage apple whether intended for cold storage or common storage.