KEEPING QUALITY OF APPLES.

F. H. HALL, S. A. BEACH AND V. A. CLARK.

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Problem worth study.

Apple storage has become one of the most important features of the fruit industry. The demand for apples has increased greatly, and to meet the demand large areas have been devoted to orchards in sections where conditions do not favor ease in holding or length of keeping. The necessity of disposing of this fruit quickly tends to overstock the market in the fall and early winter and frequently to reduce prices far below the limit of profitable handling. Accordingly the ability to hold part of the crop until the perishable surplus has been disposed of often means higher prices, easier sales and better accommodation to the public. Consumers are also gradually but surely learning discrimination and demanding not only good apples but an ample supply of them throughout nearly the entire year. It is possible, by some system of storage, to avoid the glutted markets and to hold the crops with little loss for sale late in the season, and make good profits from the practice; but like all farm and orchard operations of the present time, apple storage must receive careful attention to insure success. The grower or buyer must learn what varieties are suitable for storage, what conditions must be provided to secure the best and most economical

*This is a brief review of Bulletin No. 248 of this Station, on New York Apples in Storage, by S. A. Beach and V. A. Clark. Any one especially interested in the detailed account of the investigation will be furnished, on application, with a copy of the complete bulletin. The names of those who so request will be placed on our mailing list to receive future bulletins, popular or complete edition as desired. Bulletins are issued at irregular intervals as investigations are completed, not monthly.
management of the stored fruit, and at what time and under what conditions the different varieties must be put on the market. Apples are exceedingly variable in length of keeping: Early Harvest often becomes too ripe and mealy for choice eating while still upon the tree; while Schodack, in ordinary storage, may keep well until midsummer of the next year. They also vary in behavior in storage, some varieties scalding, shrinking, losing flavor and becoming dull colored and unattractive, while others, after six months keeping, come out smooth, bright, fragrant and crisp. These variations in behavior are to a great extent varietal characteristics; yet the same variety grown upon sand or upon clay, grown in the North or in the South, grown in a wet season or a dry one, may show very striking differences. The problem of selecting varieties and storing them properly is, therefore, a complex one; and requires careful study.

To secure information on some of these points, the Station, in constructing a fruit house, provided tests. a large room, well insulated and so arranged that many varieties could be stored under uniform conditions and examined easily at any time during their holding. No artificial refrigeration was used, but when the temperature in the room was higher than desired and it was cooler outside, the windows were opened. The tests were continued for four years, 1895 to 1898 inclusive. During this time 165 varieties of apples were stored, most of them being under observation all four seasons, the others for one, two or three seasons. These apples were all from the Station orchards, consequently grown on heavy clay loam soil.

In 1901 and 1902 the Station coöperated with the U. S. Department of Agriculture by furnishing, from its orchards, 100 varieties of apples for study in a cold storage house in Buffalo. The results of these Department tests are included in "Notes on Varieties" given in Bulletin No. 248, of which this is a "popular edition."

To supplement the information thus secured, the Station has also corresponded with more than a dozen cold storage men of wide experience, and includes the data and opinions thus secured in the "Notes on Varieties" in Bulletin No. 248, and in the
general discussion in that bulletin. The topics there discussed are arranged under the following heads:

Conditions affecting the keeping quality of apples.
Comparative efficiency of different kinds of storage as applied to different varieties.
At what temperature should different varieties be held?
Relation between seasonal differences and keeping quality.
Kinds of deterioration that may precede rotting in storage, and varieties liable to each:

1. Scald. 2. Loss in quality. 3. Change in color. 4. Loss in firmness. 5. Becoming bitter. 6. Shriveling. 7. Becoming mealy. 8. Bursting. 9. Rapidity of going down. (a) List of those that go down gradually. (b) List of those that go down quickly. 10. Endurance of heat after picking and before going into storage. (a) List of those enduring heat comparatively well. (b) List of those not enduring heat well.

As a general index to the keeping quality of apples the following lists have been prepared from the notes on the varieties grown in the Station orchards and stored in the Station fruit room mentioned above. The average life of the variety is taken as a basis, rather than either the time when the fruit was half gone or the commercial limit of storage.

Apple varieties arranged in order of average life in storage:

**October 1-31:**

- Gracie, Keswick, Parry,
- Strode.

**November 1-15:**

- English Pippin, Alexander, Pound Sweet,
- Chenango, Pomona, Stump.

**November 16-30:**

- Boskoop, Elgin, Pumpkin Russet,
- Jersey Sweet, Krimtartar, Haskell,
- Longfield.

**December 1-15:**

- Ohio Pippin, Heidorn, Gravenstein,
- Longworth, Tufts.

**December 16-31:**

- Haas, Ostrakoff, St. Lawrence,
- Tobias, Washington Strawberry, Romna,
- Ginnie.
JANUARY 1-15:
Admirable,
Aucuba,

Tobias Pippin,
Gideon,

Magog,
Disharoon.

JANUARY 16-31:
Jefferies,
Twenty Ounce,
Wolf River,
Henniker,

McMahon,
Blenheim,
Fameuse,
Jewett Red,

Stanard,
Mother,
Crots,
McIntosh.

FEBRUARY 1-15:
Pomme Grise,
Hurlbut,
Pumpkin Sweet,
Peter,
Fall Pippin.

Clarke,
Kalkidon,
Barbel,
Jacobs Sweet,

Victoria,
Rhodes,
Wealthy,
Flory,

FEBRUARY 16-28:
Milligen,
Felix,
Maiden Blush,
Grimes,
Jonathan Buler,
Borsdorf.

Pewaukee,
Brownlee,
Etowah,
Fall Wine,
Celestia,

Northern Spy,
Greenville,
Cogswell,
Landsberg,
Dickinson,

MARCH 1-15:
Sharp,
Smith Cider,
Duke of Devonshire
Yellow Bellflower,
Northwestern Greening,
Domine,
Canada Baldwin,

Peach,
Milden,
Reinette Pippin,
Tolman Sweet,
Swenker,
Dumelow,
Ornament.

Hubbardston,
Tompkins King,
Marigold,
Buckingham,
Melon,
Rambo,

MARCH 16-31:
Canada Reineke,
Monmouth,
Red Russet,
Peck Pleasant,
Rhode Island Greening,
Wallace Howard.

Esopus Spitzenburg,
Moon,
Golden Russet,
Sutton,
Washington Royal,

Farris,
Scott,
Golden Medal,
Coon,
Ronk,

APRIL 1-15:
White Pippin,
Holland,
Olive,
White Doctor,
Streaked Pippin,
Kittagesee,

Kansas Greening,
Mann,
Swaar,
Ewalt,
Arkansas,
Walbridge.

Menagère,
Jonathan,
Caux,
Salome,
Duncan,
April 16-30:
Moore Sweet, Lankford, Yellow Forest,
Newtown Spitzenburg, Occident, Ontario,
Fallawater, Roxbury, Rome,
Lady Sweet, Vanhoy.

May 1-15:
Kansas Keeper, Gideon Sweet, Cooper Market,
Lawyer, Chase, Wagener,
York Imperial, Newman, Texas,
Large Lady, Baldwin.

May 16-31:
Jones, Edwards, Stark,
Kirtland, Ralls, Winesap,
Ben Davis, Zurdel, Nelson.

June 1-15:
Green Newtown, Pifer, Andrews,
Red Canada.

July 18, Schodack.

Effect of kinds of storage.
The efficiency of the different systems of storage differs greatly with different varieties; but, in general, storage with low temperature secured by the use of ice extends the keeping period from one to four months beyond the limit in ordinary storage, and chemical cold storage prolongs the life of the variety at least half a month—often much longer—beyond the life under ice.

The comparative efficiency of the various forms of storage is shown by the following varieties selected from a longer table in the complete bulletin.
### Seasons of Certain Varieties of Apples in Various Storages

<table>
<thead>
<tr>
<th>Variety</th>
<th>Season in</th>
<th>Difference in season between</th>
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<tbody>
<tr>
<td></td>
<td>Chemical cold storage</td>
<td>Ice storage</td>
</tr>
<tr>
<td>Baldwin</td>
<td>June 15</td>
<td>May 1</td>
</tr>
<tr>
<td>Esopus Spitzenburg</td>
<td>May</td>
<td>Apr.</td>
</tr>
<tr>
<td>Fallwater</td>
<td>June 15</td>
<td>June 1</td>
</tr>
<tr>
<td>Mch.</td>
<td>Jan.</td>
<td>Jan.</td>
</tr>
<tr>
<td>Fall Pippin.</td>
<td>Nov.</td>
<td>No.</td>
</tr>
<tr>
<td>Hubbardston</td>
<td>Apr. 1</td>
<td>Feb. 15</td>
</tr>
<tr>
<td>Mch.</td>
<td>Mch.</td>
<td>Feb.</td>
</tr>
<tr>
<td>Jonathan</td>
<td>Mch.</td>
<td>Mch.</td>
</tr>
<tr>
<td>Maiden Blush</td>
<td>Nov.</td>
<td>Nov.</td>
</tr>
<tr>
<td>McIntosh</td>
<td>Jan.</td>
<td>Jan.</td>
</tr>
<tr>
<td>Northern Spy</td>
<td>Apr.</td>
<td>Mch.</td>
</tr>
<tr>
<td>Rhode Island Greening</td>
<td>Feb.</td>
<td>Feb.</td>
</tr>
<tr>
<td></td>
<td>Apr.</td>
<td>Mch.</td>
</tr>
</tbody>
</table>

1 Reported by Benj. Newhall, Chicago, Ill.
2 Reported by W. D. Graham, Minneapolis, Minn.
3 Reported by W. H. Hart, Poughkeepsie, N. Y.

Ice storage has several disadvantages, and storage houses employing that system are no longer built for commercial purposes. With ice, the temperature cannot be held as low as with chemical refrigeration; so that warm fruit requires longer to cool off when first stored and therefore ripens more before reaching the point of slow change. The space required for ice also lessens by nearly one-third the storage capacity of the building.

Different warehouse men hold apples at slightly different temperatures, but the range is only 5° temperature or 6°. From 32° to 34° is the favorite temperature with most storage men; and many of them hold all varieties as near as possible to some selected temperature within these limits. Others vary the tem-
perature according to the variety and may store some varieties in rooms as low as $31^\circ$ or as high as $35^\circ$. The tendency is toward the lower temperatures.

If any general rule for these variations exist, among practices widely different, it is that long-keeping varieties that go down slowly are held at lower temperatures, while early-ripening varieties and those that go down quickly are held one or two degrees higher. The early apple may be held for a longer time at a low temperature, but goes down much more rapidly when taken from such storage than when held at the higher temperature. Some fruit like Twenty Ounce cannot be held as low as $32^\circ$ since it freezes at a higher temperature than other apples like Baldwin. Very large fruit does not keep as well as smaller specimens of the same variety, hence some storage men put large apples of a variety at $33^\circ$ while the ordinary crop is held at $32^\circ$.

Many conditions aside from varietal characteristics affecting keeping influence the keeping quality of apples, among which are the soil of the orchard, whether it be in sod or cultivated, weather of growing season, especially of latter part of it, presence or absence of fungi, degree of coloration of fruit, size, ripeness, manner of handling, and kind of storage.

Baldwins grown on sandy or gravelly soil ripen earlier, must be picked earlier and have a higher color than those grown on clay, but they do not keep so well. Apples grown in sod attain a higher color and keep longer than those grown under clean culture. Ordinarily, apples keep better when the season has been dry rather than when wet, and when the month of October has been cool rather than warm. The character of the weather has much to do with the next factor, presence of fungi, for a warm, moist season is favorable to nearly all the fungous diseases of the apple; and a scabby apple or one infected with any of the rots is a very poor investment for the storage man. Indeed, only prime fruit ordinarily should be stored; for No. 2 fruit not only yields small profit from storage but it hurts the sale of No. 1 fruit. Overgrown specimens do not keep so well as fruit of ordinary size. Well colored fruit usually keeps best, but it should not be allowed to remain on the tree so long for the sake of color that
it suffers in firmness. For cold storage, fruit should not be so ripe or highly colored as is best for ordinary storage. *Greenings* are said to hold best in cold storage when the bloom will rub off leaving the skin smooth and shiny; and the same rule applies less markedly to Baldwins.

Methods of harvesting, packing and handling in transportation have the greatest influence on keeping quality. Handlers of apples sometimes roll barrels of fruit, allowing them to strike against other barrels. This rough handling may bruise the fruit almost to the middle of the barrel. But some varieties are more easily injured by rough handling than are others. Northern Spy is one of the easiest to bruise and barrels are often found to go down in storage early on this account. Tolman *Sweet* and Yellow Bellflower are very sensitive to rough handling.

Most storage men believe that apples should go into storage as soon as picked. Others believe that with some varieties it may be well to allow the fruit to lie on straw on the ground for two or three weeks to secure higher color. If any disease be present, the sooner fruit be put into refrigeration the better.

With varieties that ripen very unevenly, like McIntosh, Oldenburg and Fall Pippin it is probably best to make two or three pickings, so that fruit of fairly uniform ripeness may be stored.

It is impossible to give in any brief way the differences which mark varieties, so that topic is not discussed here; but in the complete bulletin, notes on each of the 165 varieties stored are given which include, in separate paragraphs under each variety, the results of the tests of keeping quality in ordinary storage at the Station, notes upon the Station apples included in the U. S. Department of Agriculture cold-storage test at Buffalo, and a summary of the experience of cold-storage men. In the notes on Station tests are given the seasons in which each variety was tested, the number of fruits stored, their average life for the seasons tested and the mean date of deterioration of the last fruit of the variety.

The notes on three varieties are quoted below, as an illustration of the method of treatment:
Alexander (*Wolf River* incorrectly). This is an early fall apple and is not often put into storage.

In Station test 60 apples were stored Sept. 9, 1897. The average life extended to Nov. 4, the last fruit being thrown out Jan. 12.

In the experience of storage men its season in cellar storage is until October and in chemical cold storage until November. It goes down quickly and does not stand heat well before going into storage. It should be shipped the day it is picked and under ice.

**Baldwin.** A leading variety for cold storage purposes, ranking in season between Rhode Island *Greening* and Ben Davis.

In the Station tests fruit of 1895, '96, '97 and '98 was stored. The mean dates were Oct. 13 for storing; May 10 for average life; June 29 when last fruits went out. Results variable but indicate that under the conditions of the tests the season may extend through April. With two crops a considerable portion of the fruit remained sound till early June.

In the Department cold storage tests hard, light-colored, small fruit from this Station, stored Oct. 15, was still hard and sound May 1.

According to storage men its season in cellar storage is until March or April, varying from Feb. 15 in unfavorable seasons (Fenton) to June 1 in favorable seasons (Payne). Season in chemical cold storage until May or June. Graham states that the fruit will hold until June if well colored on the tree, but only until April if colored on the ground. It goes down gradually with some liability to scald late in the season, Phillips Bros. specifying March and later in common storage and Graham May 1 and later in chemical cold storage "unless stored immediately after picking." Wilson says Baldwin is less liable to scald if picked as soon as the plump seeds are black than if left on the tree until it gets its full color. Moreover in the latter case much of the crop would be lost besides putting off picking until very late in the fall. Beckwith remarks that a gray Baldwin grown on the heavy soil of the Lake Ontario shore keeps longer than any other Baldwin. The higher-colored Baldwins grown on sandy or gravelly land are said to scald earlier. Large specimens are liable to become mealy (Howes) and scald and burst (Wilson, Morgan) but those of medium size only rarely.

**Barbel (Sugar Barbel).** In the Station tests fruits from the crops of 1895 and '96 were tested, the average number under observation each season being 77. The mean date of storing was Oct. 1, of average life Feb. 7 and of decay of last fruits June 12. Decay began in November and proceeded gradually through the season.