Increasing Storage & Market Life of Jonathan Apples
Michigan State University
Cooperative Extension Service
Marketing Series
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Revised June 1974
4 pages

Extension Bulletin E-627 (Revised)
Marketing Series • June 1974

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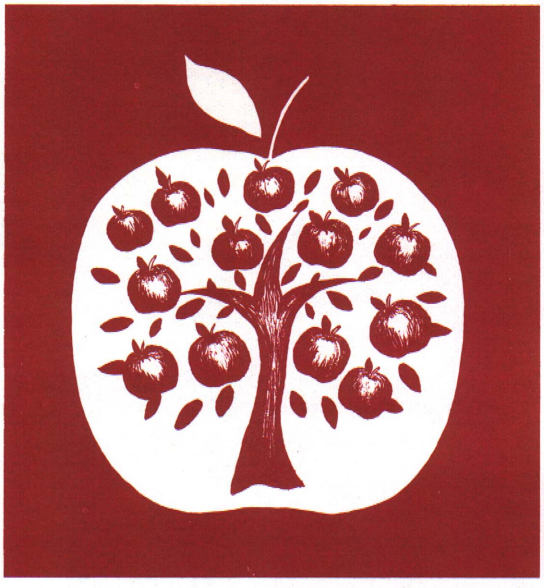

Art: Dona Porter Jacobs

By D. H. Dewey and D. R. Dilley, Dept. of Horticulture

Prior to the mid-1950's, Jonathan apples were considered to be of relatively short storage life and were marketed within a few months after harvest. The discovery of controlled atmosphere (CA) storage greatly lengthened the life of the fruit and enabled marketing throughout the spring months.

The benefits from CA are primarily control of Jonathan spot and soft scald (ribbon scald), two serious disorders of apples that have plagued this variety for many years. Control of soft scald provides another benefit of CA — once this disorder is eliminated, the apples can be stored at 32°F instead of 36°F, which previously was the only way of preventing soft scald. By using this lower storage temperature, most degradation processes within the fruit are retarded and fruit life is therefore lengthened, both in storage and during the subsequent marketing period.

Unfortunately, the use of modern storage methods doesn't solve all difficulties. Internal breakdown has continued to be a serious storage and market disorder, although its development is markedly slowed by modern storage methods. Changing market demands which require larger, redder apples have increased the hazards of internal breakdown in recent years. A method for control of internal breakdown is now available.

For maximum storage and market life of Jonathan apples:

1. Harvest at the proper stage of maturity;
2. Handle carefully and promptly;
3. Treat with calcium chloride, using a 4 percent solution, together with fungicide, applied thoroughly;
4. Store immediately at 36°F;
5. For CA storage, use 36°F for the first month, then 32°F for the remainder of the storage period, maintain carbon dioxide at 2 to 5 percent and oxygen at 3 percent;
6. Market or utilize the fruit promptly at the conclusion of the CA storage period.

Internal Breakdown

Internal breakdown (Jonathan breakdown or senescence breakdown) is known as an old-age disorder since it develops as the fruit become overripe and approach senescence. It is caused by overmaturity at the time of harvest, delays in handling the fruit from the orchard to the storage, relatively high storage temperatures, and storage for too long a period of time. Fruit harvested from young trees with a light crop are more susceptible to breakdown than apples from mature trees or trees bearing a normal crop load. Large apples are more susceptible to internal breakdown than small apples.

Internal breakdown first appears as a light brown discoloration of the flesh in areas of indefinite outline and usually near the skin or the vascular bundles, see Figure 1. Further browning occurs with aging so that practically all the flesh may become affected, with the skin becoming dull and dark in color. Softening of the flesh is marked and the apples are easily damaged by bruising.

Control of Internal Breakdown

Control of internal breakdown of Jonathan is achieved by a prestorage dip or drench treatment of the apples with a solution of 4 percent calcium

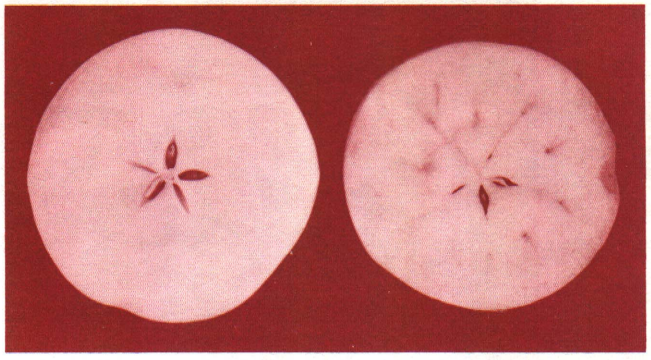

Fig. 1. Jonathan apples stored to March showing trace (left) to severe (right) internal breakdown in the flesh when cut laterally.

chloride in water. Use a commercial grade of dry calcium chloride which contains approximately 78 percent calcium chloride and 18 percent water. This grade dissolves readily in water without excessive heating and is not likely to have excessive quantities of impurities.

To prepare a 4 percent solution, use 40 grams of actual calcium chloride per liter of water, or 33.38 pounds of actual calcium chloride per 100 gallons of water. If the grade of calcium chloride used is 78 percent, then 42.8 pounds (33.38 lb. ÷ .78 = 42.8 lb.) of 78 percent calcium chloride for each 100 gallons of water makes a 4 percent solution. Add to this a recommended fungicide for control of storage rots caused by *Penicillium* sp. and *Botrytis* organisms. The fungicide also tends to serve as a safening agent to reduce the hazard of damage to the fruit by the calcium chloride and to facilitate good coverage of the fruit surface with the calcium chloride.

The solution may be used until it becomes unacceptable due to the accumulation of soil or debris. Use the same concentrations of calcium chloride and fungicide to replace the solution used up in application to the apples.

Drench applicators used to apply scald inhibitors to other varieties of apples are also recommended for treating Jonathan apples with calcium chloride. A suitable drench applicator is shown in Figure 2. Applicators designed to simultaneously treat two bulk bins of fruit with one stacked upon the other are satisfactory; however, whenever a single bin of fruit is treated, the liquid must not fall directly onto the apples. Use an empty bin or a solution deflector to prevent damage to the fruit by solution falling from heights in excess of 8 to 12 inches.

The bins of fruit may be moved through the applicator at a convenient rate as long as all apples become completely wetted. Solution supplied at the rate of 4 gallons per bushel of fruit gives adequate coverage. Drain the excess solution from the apples

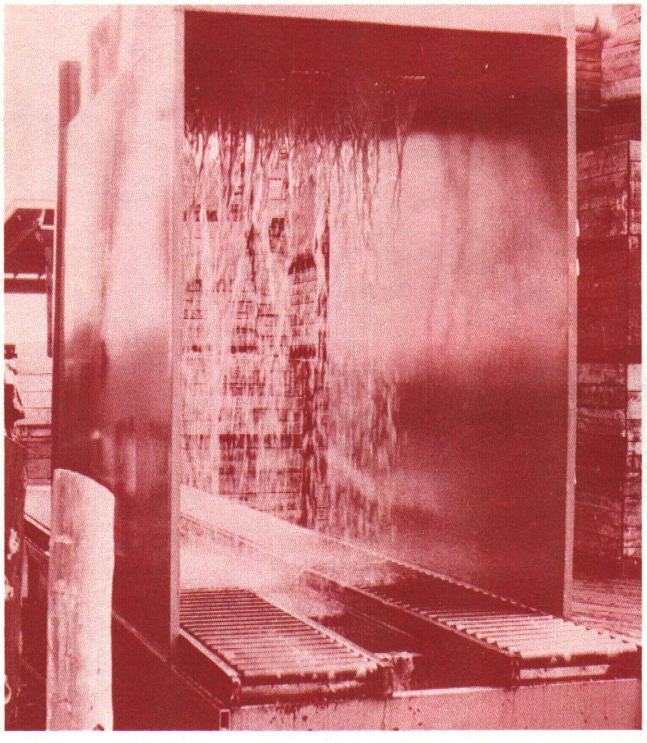

Fig. 2. Drench applicator suitable for applying calcium chloride to pallet bins of apples. A stack of two bins is placed onto the roller conveyor and pushed into the enclosed portion by a lift truck. The next stack of bins pushes the first stack to the back where it is removed after draining for a minute or so.

back to the reservoir of the applicator. The fruit should normally be placed in storage shortly after removal from the applicator. Rain will wash away the calcium chloride, which to be effective, must remain on the fruit throughout the storage period.

Calcium chloride is hygroscopic (absorbs moisture), which is believed to be one of the reasons for its effectiveness in preventing internal breakdown. Water absorbed from the storage room atmosphere helps to provide a continuous solution of calcium chloride on the surface of the fruit throughout the storage period. A relative humidity of 85 percent or higher in the storage room is needed to provide this water.

The treated apples must be washed after storage when they are prepared for fresh market or processing purposes. Empty the fruit from the storage bins in a water submergence dumper and wet brush, as is normally practiced in apple packinghouses. The washing operation utilized prior to fruit waxing removes the calcium chloride residues satisfactorily. Unwashed apples will retain enough calcium chloride to impart a salty flavor to the skin of the fruit or to the processed product.

Since calcium chloride is corrosive to most metals, equipment used for its application must be cleaned after use. The calcium chloride solution will likely

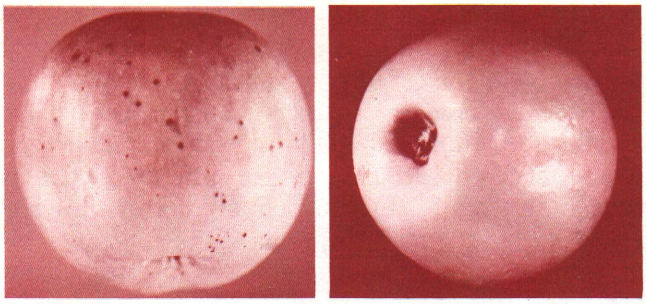

Fig. 3. Jonathan apples damaged by 4% calcium chloride solution. The spots on the side of the fruit (left) developed where the calcium chloride penetrated the lenticels. Calyx injury (right) resulted in the dark discoloration at the center of the calyx cavity where the sepals and fruit skin had been damaged previously by mites.

encourage corrosion of nails or other fruit bin fasteners, so corrosion-resistant fasteners are recommended.

Fruit injury may occur as a result of treatment by calcium chloride (Figure 3). Lenticel injury may result when there is penetration of the calcium chloride into the lenticels. Further movement of the calcium chloride into the adjacent living tissues of the apple skin or flesh causes the damage. Similar penetration through the cuticle or breaks in the skin may also cause injury. Tests have demonstrated that fruit with poor finish and large, poorly corked lenticels are readily damaged with a 4 percent calcium chloride solution and should not be treated. A weaker solution (2 percent) will cause less injury, but may not be adequate for control of internal breakdown.

Injury to the skin within the calyx cavity may occur on apples damaged by mites. The presence of mite eggs within the cavity indicates injury from the calcium chloride is likely to occur and treatment may be hazardous. The damaged tissues are usually black in color. The sepals may or may not show the black discoloration symptoms of injury. As true for lenticel injury, a reduced concentration of calcium chloride will reduce the total amount of calyx injury.

Brown Heart

Jonathan apples stored in controlled atmospheres (CA) occasionally develop an internal disorder called brown heart. Although the exact cause is unknown, it occurs only in CA storage and only during the storage period.

Brown heart develops in both the core and flesh of the fruit. It first appears as a chocolate-brown discoloration, quite well defined in area, yet without a sharp line of separation between the affected and healthy tissues. It is sometimes barely visible, but as it progresses, it may affect one-third or more of the fruit. The brown-colored tissues are firm and wet at an early stage of development (Figure 4). Later, (usually under continued storage) the affected tissues lose water, become dry and finally shrivel, leaving open pockets in the core or flesh (Figure 5). The dead tissue becomes light brown in color with the discoloration seldom extending beyond the pockets by more than one-eighth of an inch.

There are no external symptoms of brown heart except where large areas of flesh collapse to leave the outer flesh and skin sunken. The disorder is readily discovered by cutting the calyx half of the fruit at three or four points perpendicular to the axis of the fruit.

Preventing Brown Heart

Since no control for brown heart is known, it must be regulated by preventive measures. It is minimized by avoiding exposure of the fruit to temperatures near 32°F during the initial part of the CA storage period. Holding the fruit at 36°F during loading of the storage room and during the first month of CA storage will usually prevent its occurrence. After one month in CA, lower fruit temperature to 32°F for the remainder of the storage period. Using 36°F instead of 32°F during the loading period also avoids the danger of soft scald (ribbon scald) developing prior to the establishment of the CA. The scald disorder is then controlled by CA.

Fruit lots containing a large proportion of apples of large size, overmature, or afflicted with water core probably should not be stored in CA since they are more susceptible to brown heart than smaller, less mature, sound apples. These apples normally would not be considered suitable for storage for more than a month.

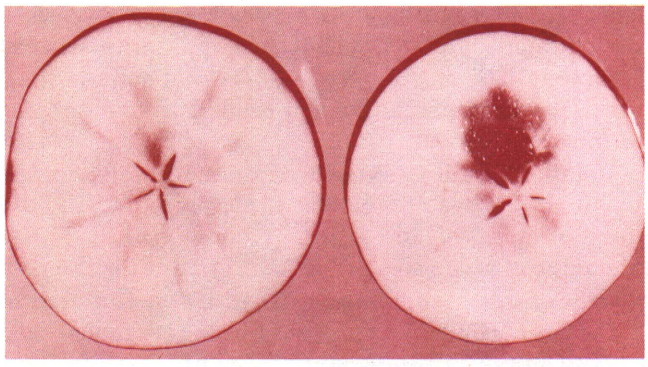

Fig. 4. Brown heart in the early stages of development. The apple at left has slight amounts of water core in the flesh and core and a single small area of brown heart between two of the seed cavities. The other apple shows extensive brown heart. At this stage affected tissues are moist and chocolate-brown in color — later dry out and appear as in Fig. 5.

Fruit Harvest and Handling

Harvest Jonathan apples for long-term storage when they are just past the mature stage of development and as they begin to ripen. At this stage, the apples are well developed in shape, show some yellowing of the ground color or undercolor, are of fair flavor, and firm-to-hard in flesh texture. Unfortunately, there is no good measure of proper maturity; it is a matter of personal judgement based on experience in the harvest and handling of fruit. Red coloration, although a highly desirable characteristic for fresh market apples, is not a good indicator of ideal harvest maturity. Since apples must frequently be left on the tree to develop enough red coloration to be marketable, storage and market life are often sacrificed. Fruit picked earlier or later than ideal for long-term storage should be identified, stored separately and marketed or used within a few months after harvest. The presence of water core, either near the core or in the flesh around the vascular bundles, is an indication that the fruit is somewhat ripe and unsuitable for long-term storage and late marketing.

Move Jonathan apples into storage promptly after harvest and cool to 36°F within a few days. Delays in handling of the picked fruit may result in undue ripening and considerable shortening of its storage and market life. This is because apples ripen and deteriorate approximately five times more rapidly at 70°F than at cold storage temperatures.

Controlled Atmosphere Storage

The proper conditions for the controlled atmosphere storage of Jonathan apples are 3 percent oxygen and 2 to 5 percent carbon dioxide, with a fruit temperature of 36°F during the first month and 32°F for the remainder of the storage period. Low levels of carbon dioxide (such as 2 to 3 percent) are satisfactory and used when Jonathans are stored with another variety which requires a low level of carbon dioxide, such as Delicious. The use of very low levels of carbon dioxide (less than 1 percent) may permit the development of Jonathan spot.

Jonathan apples should be immediately cooled when placed in storage, but only to 36°F, to avoid the development of soft scald (ribbon scald). Those placed under CA should be kept at 36°F for the first month of CA, then cooled to 32°F. Upon completion of the CA period, the apples should be retained at 32°F in cold storage until packed, marketed, or processed.

State regulations require that Jonathan apples can be sold under the CA label only after they have been at 5 percent oxygen or lower for a minimum of 60 days. CA apples stored for longer periods than 60 days should be maintained at the recommended storage temperature and atmospheric conditions until it is time to start unloading the room and preparing the apples for market. Interruptions of the controlled atmosphere condition of a storage room for partial loading, unloading or repair of equipment is permitted by law, and is not harmful to the life and value of the fruit, provided the interruptions are infrequent and of short duration.

Apples stored under CA conditions until early spring or later should be packed and moved into market channels within a month after the controlled atmosphere condition is terminated. Holding apples for a longer post-CA period may result in their becoming unmarketable due to softening and the development of disorders, particularly Jonathan spot. Apples taken from CA storage can be stored at 32°F since they are no longer susceptible to soft scald or brown heart development.

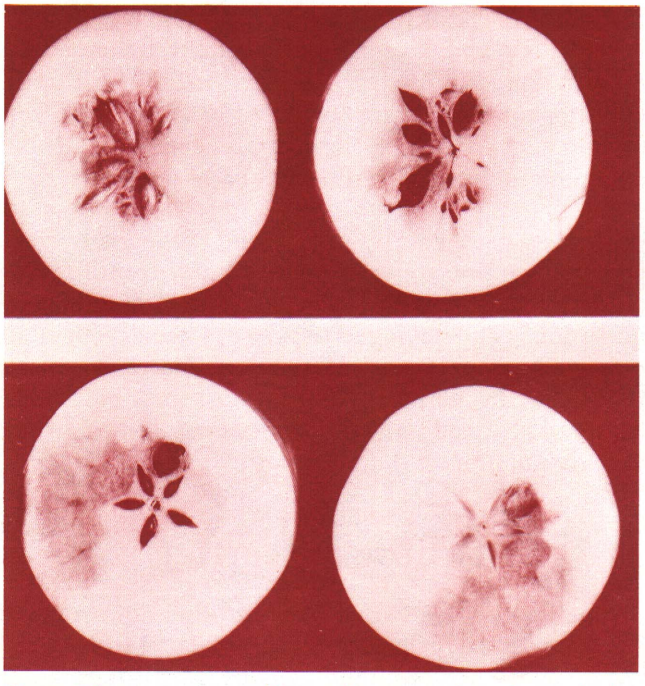

Fig. 5. These symptoms of brown heart are often observed when affected fruits are cut after long-term controlled atmosphere storage. These apples developed brown heart early in the storage period. The affected tissues were killed and then dried leaving the typical pockets or voids in the core and flesh.

Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8, and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Gordon E. Guyer, Director, Cooperative Extension Service, Michigan State University, E. Lansing, Mich. 48824. IP-IR-6:74-15M-JP