The Cold Storage of Apples

by W. V. HUKILL and EDWIN SMITH

THE METHODS of storing apples have improved a great deal in recent years. The progress does not depend so much on new discoveries or revolutionary changes as on closer attention to practical ways of providing the best conditions for keeping the fruit good.

For best results in storage, apples must be harvested when mature but not fully ripe and stored under conditions that will arrest the rate of ripening and the growth of rot-producing fungi, avoid shrivelling, and not result in low-temperature disorders. With a few exceptions, these conditions embody a storage temperature of 30° F., or slightly above the freezing point of apples, and a relative humidity of 85 percent. A few varieties grown in certain regions are susceptible to low-temperature disorders and have to be stored at temperatures of 36° or 38° F. This has resulted in the development and use of controlled-atmosphere storage. McIntosh apples can be stored at 40° in a controlled atmosphere of 5 percent carbon dioxide and 2 percent oxygen for longer periods than they can be stored in air at 32°. Varieties, however, have specific atmospheric requirements as to this type of storage.

Complex chemical changes in the tissue of apples continue during ripening until the fruit becomes overripe and unpalatable, with subsequent collapse. The changes are retarded as the temperature is lowered; thus the storage life of the fruit is lengthened. Research has shown that at 30° F. about a fourth more time is needed for apples to ripen than at 32°. Apples standing in an orchard at 70° may ripen as much in 3 days as they would during a month's storage at 30°. When held in a cold storage room that has a temperature of 36° at one end and 30° at the other, apples, although alike when stored, will become overripe in the one place but remain in excellent condition in the other.

The degree to which the requirements can be filled depends upon the management of all the processes through which apples must go on their way from the tree to the table, equipment that is available for each process, and the operation of equipment or the execution of each process. Progress in cold storage of apples begins with management of the movement of the fruit through the various processes of growing, harvesting, packaging, storing, transporting, and distributing.

No apples should be assigned for late storage unless they are of good quality. Those to be stored should be moved to the storage promptly. The length of storage period should be limited by the variety and quality of the fruit. Apples should be moved from storage while they still have enough life to withstand normal handling and exposure during transportation to market and distribution. Good storage can be wasted on apples poorly chosen for storage or poorly handled before and after storage, just as good apples can be lost by poor storage. This principle is being applied more and more, and much of the current progress in apple storage is due to improvement in this kind of management.

The improvement of buildings and equipment can be traced from the early fruit cellar through the ventilated storage cooled by night air, to refrigerated storages that have come into common use in the past 20 years or so. Methods of applying refrigeration to apples have likewise been changing. In recent years the cooling is mostly accomplished by moving cooled air through the storage rooms rather than by having cooling coils spaced about the rooms. Perhaps the most common way to cool the circulating air in modern plants is to pass it through a spray of chilled brine.

The first objective in a refrigerated storage is to cool the fruit promptly and maintain a temperature at or near the optimum. If cooling is to be done quickly there will be a large demand upon the refrigerating machinery at harvesttime. A large volume of air must be circulated to distribute the refrigeration to all the stored fruit. Even after the apples are cooled, there is always some variation in temperature from time to time in a storage room, and the fruit in some parts of the room is necessarily warmer than that in other parts. Best storage conditions are those that will keep the variation in temperature to a minimum.

In order to effect prompt cooling and uniform low temperatures, three requirements must be met. The first is ample refrigerating capacity; in the Pacific Northwest this would be about 6 tons of refrigeration for each 1,000 field boxes of apples brought to the storage daily. The second is ample volume of air circulation; 1,000 cubic feet of air a minute for each ton of refrigeration is considered a minimum. The third requirement is provision for the air to move effectively among all the packages; this depends upon the arrangement of air ducts, freedom from obstruction to air movement through the room, and arrangement of the stacks of boxes to permit access of air.

The first and second requirements—ample refrigeration and air circulation—can be provided by machinery. A plant loaded beyond its capacity cannot cool the apples promptly.

The third requirement, good air distribution, is more than a matter of plant capacity; it calls for careful attention to detail in design and operation. A large number of methods of air distribution are in use. The simplest is to discharge the cold air through nozzles at one point in the storage room and pick up the return air nearby. This is likely to result in a relatively wide range of temperatures in different parts of the room. Perhaps the most elaborate method is to discharge cold air from a large number of openings in ducts spaced through the room, and to pick up the return in an equal number of return ducts. In that method, the air velocities through the room may be slow. The most effective placement of ducts for providing uniform air distribution is a single discharge duct along one wall of the room and a single return duct along the opposite side. For good operation, the air is delivered to and returned from the room at the ceiling or near it.

Whatever the arrangement of the ducts, it is necessary to have a clear space at the ceiling throughout the room. Girders that extend across the path of air flow or packages stacked too close to the ceiling prevent free movement of air. Failure to leave an open space between stacks of packages results in poor circulation.

Even with plenty of refrigerating capacity and air volume, and with the best possible air distribution, absolute uniformity of temperature cannot be had. The air leaving the room will be warmer than that entering. For that reason, the fruit nearest the delivery openings is exposed to the coldest air. In the most modern plants, the variation in temperature of the fruit at different points is held to a minimum by automatically reversing periodically the direction of air movement. By doing so, none of the fruit is continuously exposed to the coldest air, and none to the warmest. When warm apples are brought into a storage room, it is desirable that they be cooled as quickly as possible. Reversing the air direction periodically permits using air as cold as 22° to 25° F. to get rapid cooling without danger of freezing.

For economy, several inches of insulation are used on all outside walls, the roof and the floor. In the Pacific Northwest, as much as 24 inches of dry mill shavings are often used for insulating the roof of storage houses. Mineral materials are best for ground-floor insulation; they should be protected from ground water by a waterproof membrane. Wall and ceiling insulation is protected by a vapor-proof lining between it and the outside air. No amount of insulation will totally prevent heat from coming through a wall or floor. Packages of fruit sitting directly on a ground floor receive heat from the ground, and they are kept too warm.

Persistent attention to details of operation is essential even in the best apple storage. In a well-operated plant, packages are spaced so that air may move freely among the stacks and between the fruit and the walls. A clear space is left for air to circulate over the packages and under the ceiling at all points. Outside doors are not left open unnecessarily. Temperatures and conditions of fruit are observed regularly.

A number of apple storages are now equipped for effective reversed-air circulation. In constructing most of these plants, careful attention was given refrigerating capacity, blower capacity, and all details that affect the distribution of air. Fruit temperatures in this type of storage both during the cooling period and after storage temperatures are reached, have shown that it represents a distinct step toward meeting all the requirements for highest apple quality. The modern apple storage can furnish consumers with crisp, juicy apples throughout the season with a program of management that segregates apples most suitable for late storage from those that should be consumed early. It gives special attention to getting storage apples into storage promptly, prevents overloading the storage facilities, and handles the fruit in all stages in conformity with its requirements.

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FOR FURTHER READING

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