Commercial Handling and rage Practices for Winter Pears

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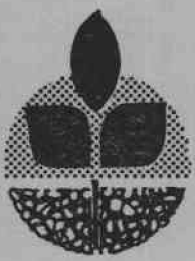

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COMMERCIAL HANDLING AND STORAGE PRACTICES FOR WINTER PEARS

Elmer Hansen and W. M. Mellenthin

INTRODUCTION

Winter pears, including the varieties Anjou, Bosc, Comice, and Winter Nelis, provide a succession of fruit to the market during the winter and early spring months from November to June. Commercial production of these varieties is confined primarily to the Wenatchee and Yakima districts in Washington, the Mid-Columbia and Medford districts in Oregon, and the Placerville and Santa Clara areas in California where climatic, soil, and topographic features, as well as relative freedom from fire blight, are particularly favorable for pear production. During the more than 60-year period in which winter pears have been grown in these areas, production has increased to six million packed boxes per year.

The ultimate objective of commercial handling and storage practices for winter pears, in common with all fresh produce, is to maintain the fruit in a condition acceptable to consumers throughout the marketing season. To achieve this, correct procedures must be used during harvesting, packaging, storage, transportation, as well as in ripening and handling the fruit in terminal markets.

There are two types of problems in the commercial pear industry. One problem is caused by unfavorable handling or storage practices—picking at the wrong stage of maturity, slow rate of cooling, and unfavorable storage temperatures. A second problem is associated with variable quality conditions inherent within the fruit, which are determined primarily by specific varietal characteristics and also by environmental conditions during the growing season. Varietal characteristics vary according to length of storage life, reaction to storage and ripening temperatures, color changes during ripening, chemical composition and flavor, among others. Unfavorable weather conditions also can affect fruit quality and increase susceptibility to various physiological disorders, including Anjou scald, cork spot, and friction discoloration during handling operations.

Harvesting, handling, and storage practices for winter pears initially were based on early research by a number of workers, including Lewis, Magness, and Cate (*12*); Hartman, Reimer, and Norris (*11*); Diehl (*3*); and Heukel and Smith (*13*). Since then, experimentation on plastic film packaging materials (*5*) led to the commercial use of film box liners. Still later, controlled atmosphere storage came into use for some varieties (*8*). New and improved chemical controls for decay and disorders, together with improved refrigeration systems, made a longer storage season possible. Also, recent data on environmental factors affecting fruit maturation and quality have provided additional information for predicting storage life and quality (*16*). Thus, a gradual evolution of technical information over the years has led to the current practices of handling and storing winter pears.

Most of the later information, while available in various technical journals and other sources, has not been brought together in a form useful to the winter pear industry. The purpose of this bulletin is to recommend winter pear handling and storage practices that are consistent with both the older and the newly acquired information.

DETERMINING HARVEST MATURITY

Optimum quality and storage life are initially dependent upon harvesting at the right stage of maturity. Pears picked when immature lack flavor, tend to shrivel in storage, and, in the case of Anjous, are more susceptible to scald and friction discoloration during postharvest handling (*15, 23*). Immature pears also have not attained the physiological development required for ripening (*24*). Conversely, fruit harvested at an advanced stage of maturity tends to be coarser in texture and must be handled and cooled rapidly to avoid ripening in storage. Premature loss in color and softening in storage of winter pears, as well as Bartletts, usually can be traced to overmaturity at harvest. Delaying harvest to gain size seldom is justified economically, since the tonnage gain can be nullified by reduced storage life, unfavorable inspection reports, and subsequent loss in market price. When necessary to delay harvest because of unfavorable weather, segregate the late-picked fruit. Watch the fruit carefully while in storage and market before color changes and softening develop.

Over the years, the pressure test as a measure of flesh firmness has been the most reliable and seasonally consistent method for determining harvest periods for all pear varieties. The original Oregon Pressure tester was based on the work of Murneek (*18*), who found that during maturation of pears there is a period of rapid cell enlargement and decrease in cell wall thickness which can be correlated with a decrease in flesh firmness as measured by pressure tester (*19*).

Although the Oregon tester was the first instrument developed, the Magness-Taylor instrument (*14*), because of its size and convenience, now is being used by growers and fieldmen in all districts. Variations in readings among individuals making the tests generally are caused by differences in selecting fruit samples in the orchard and in applying pressure on the plunger. Select approximately 15 fruits in the 100 to 120 size range from trees of good vigor. Do not include fruit from interplanted young trees since they usually are less mature. Sample the orchard at approximately the same time each day. In testing, remove three small circular slices of skin about the size of a dime around the widest part of the fruit. Hold the tester vertically over the pared surface and apply steady, uniform pressure until the plunger breaks through the flesh.

An improved modification of the Magness-Taylor tester, commonly referred to as the U-C tester, has been developed by the University of California at Davis (*2*). The special spring and scale features tend to eliminate the personal variations encountered in applying pressure with the Magness-Taylor instrument, making accurate readings possible even with inexperienced personnel. Because of its higher cost, the U-C tester is most useful for Extension agents, regional experiment stations, and receiving packing plants, where the fruit of individual growers can be tested.

In addition to flesh firmness, other physical fruit characteristics are useful indicators of maturity. Change in ground color and development of a smooth, waxy skin are indicative of maturity, especially in Anjou. Also, if a cross-section is cut through the center with a sharp knife blade, the moist rather than dry cut surface is an indication of maturity. Soluble solids are not a reliable maturity indicator for pears but should be at least 10 percent for best quality and prevention of freezing in storage. Seedless pears have a tendency to drop before fully mature.

Harvest Pressure Tests for Winter Pear Varieties

Variety	Pressure Test Range
Anjou	15-13
Bosc	16-14
Comice	13-11
El Dorado	13-15
Packham	13-15
Seckel	13-15
Winter Nelis	15-13

The optimum pressures may vary according to district and season. Thus, some areas may find optimum maturity toward the lower range for specific varieties. Experience indicates that winter pears harvested within the pressure ranges listed will provide fruit of good storage and market quality. Fruit harvested at pressures below the optimum range should be segregated for storage.

Each variety requires a certain period of time to attain full maturity after pollination and start of growth. The number of days required varies according to season and district, but falls within a specific range for variety, i.e., 135 to 147 days for Anjou. This information provides an approximate time for the harvest period each season and is most useful when used in conjunction with the pressure test.

The number of days required from full bloom to maturity is to be influenced by the temperature conditions prevailing in the 4 to 9 weeks following full bloom. Maturity for Anjou and Bartlett can be determined by using a graph based on the number of daily accumulated heat units above a 45°F base for the 9-week postbloom period. Tests conducted over a 20-year period in the Hood River Valley show that results of this method agree closely with those of pressure tests. With this information, seasonal harvest dates can be predicted several months before harvest, making it possible for growers and receivers to plan in advance for labor, materials, and supplies. The method has limitations, however. Time of full bloom must be determined accurately and daily temperature records must be kept for specific areas. The information required has not been determined for all varieties so is not applicable in all districts.

HARVESTING

Proper handling practices to preserve fruit quality begin during harvest. These include careful transfer of fruit from tree to bin to prevent bruises and stem punctures, immediate movement to storage, rapid removal of field heat, and completion of harvest within the pressure range for the variety.

The harvest season for winter pear varieties in all districts, as a general rule, starts with Anjou, followed by Bosc, Comice, and Winter Nelis. Temperature conditions preceding and during harvest can affect the length of the harvest season. Also, some varieties may mature more rapidly than others during cool seasons. Experiments conducted in the Medford district from 1926 to 1928 by Hartman and others (*11*) showed that the length of the harvest season for best quality varied from 19 to 24 days for Anjou, 9 to 15 days for Bosc, 5 to 15 days for Comice, and 16 to 30 days for Winter Nelis. However, quality ratings in these tests were made only after several months of storage. For long-term storage under current practice, it is recommended that harvesting be completed within 15 to 17 days for Anjou and Winter Nelis and with 7 to 10 days for Bosc and Comice.

For rapid removal of field heat, move the fruit into storage within 24 hours after picking. Longer delay will reduce storage life. When cool night temperatures prevail during harvest, pears picked in mid-to-late afternoon can be left in the orchard until the following morning. Reducing fruit temperature ranging from 70° to 80°F to as low as 50°F during the night lowers the amount of field heat to be removed in storage.

PRE-STORAGE TREATMENT

Optimum storage life and market quality depend on proper pre-storage treatment, including controls for decays and physiological disorders, as well as proper grading and packing operations.

Fruit to be stored loose should be given fungicidal and scald treatments within 7 days after harvest. Apply as a drench, using approved chemicals at the rate recommended by the manufacturer. Since current fungicide treatments are in the form of suspensions, use adequate agitation to prevent settling out.

Ethoxyquin offers effective scald control on Anjou pears (*10*) and can be used in four ways: as a drench or a line spray, combined with the wax application, or in com-

mercially prepared paper wraps. In drench or line sprays, a concentration of 2,700 ppm is recommended and can be applied in combinations with the fungicide treatment. Ethoxyquin and the fungicide can be combined with the material used for waxing. Apply only a light application of wax, since a heavy coating will retard or inhibit ripening after the fruit is removed from storage (*22*).

A serious problem encountered with Anjou pears some seasons is friction discoloration during grading and packaging operations (*23*). Experimental work (*15*) indicates the disorder is more prevalent after cool growing seasons. Early picked fruit and smaller sized fruit tend to be more susceptible. Susceptibility also increases during storage. No effective control for friction discoloration has been developed. However, during seasons when susceptibility tends to be high, grade and pack fruit stored in bins as soon as possible, preferably within 5 to 6 weeks after storage. Use of smooth grader belts and slower belt and brush movements also tend to reduce the amount of discoloration.

Type of container used for packaging affects the cooling rate in storage. The change from wooden boxes to cartons has been accompanied by cooling problems that have not been completely solved. Tests by Sainsbury and Schomer (*21*) showed that Anjou pears in wooden boxes cooled three times faster than similar fruit in unventilated, tightly stacked, fiberboard cartons. The delay in cooling in cartons stored under these conditions resulted in advanced color and ripeness. When cartons were well exposed to air movement for heat removal, the difference in fruit condition in boxes and cartons was just barely perceptible. This indicates that cooling of Anjous in unventilated cartons requires careful stacking and may not be adequate for seasonal fruit with less than normal keeping quality. Bosc pears also have more critical cooling requirements and would not be cooled properly in unventilated cartons.

Heat loss in unventilated cartons is restricted to conduction though fruit tissue and container walls and can be increased by venting. According to Mitchell and others (*17*), venting 5 percent of the side area of corrugated containers may be expected to reduce cooling time by 25 percent (data for Bartlett pears). For detailed information on the size and location of vents, refer to their manual.

Increased use of bulk bins for winter pears also has created problems, especially in preventing excessive moisture loss and shrivel. Pears in bins also tend to become compacted during hauling from orchard to packing plant,

with subsequent decrease in air space and slower cooling rate. Experimental results indicate that lining the sides and, after cooling, covering the tops of bins with 1.25 mil polyethylene film to be the best method for preventing shrivel without adversely delaying cooling (*26*).

STORAGE CONDITIONS

Winter varieties of pears, while less critical than Bartletts with regard to storage requirements, are more sensitive to rate of cooling and storage temperatures than most varieties of apples. This particularly applies to Bosc, Packham, and Seckel. With a generally higher respiratory activity, more heat of respiration must be removed during the cooling period. The importance of proper storage design, cooling capacity, and operation is readily apparent when considering that the entire production of 50 to 200 or more acres of harvested fruit can be accumulated within a single modern storage room. Also, the length of time the fruit is stored often exceeds the growing period. Thus, the growing period for Anjou pears is approximately 145 days as compared to a potential storage period of 180 to 270 days.

The most important storage conditions required for pears include a proper stacking arrangement to allow for ample and uniform air movement, rapid removal of field heat, adequate volume and velocity of air to maintain a uniform temperature throughout the storage room, and sufficient coil surface to provide a relatively low differential between coil surface and room temperature for maintaining relative humidity in the range of 90 to 94 percent.

While winter pears are less critical than the Bartlett variety in regard to rate of cooling, fruit temperature should be reduced to 30°F within at least 6 to 8 days when cartons are used. Fruit in bins can be cooled to 30°F within 2 to 3 days. During the pull-down period, room temperatures of 26° to 28°F can be used but should be raised to 30°F as soon as the fruit temperatures approach 30°F.

Pears are more subject to shrivel than apples during storage. Stem end shrivel begins to appear at a moisture loss of 2 to 3 percent, and severe shriveling develops at a 4 to 5 percent loss in moisture. Relative humidity should be maintained at 90 to 94 percent. Although increasing storage humidity to 95 to 98 percent by introducing water vapor is very effective in reducing moisture loss, the practice is not recommended for winter pears stored at 30°F because of ice formation on fruit and floors.

Controlled atmosphere storage. The main advantage of CA storage for winter pears is providing a way to maintain fruit quality over a long period, thus extending the market season. Also, Anjou pears stored in a low O_2 atmosphere (2 to 2.5 percent) tend to be protected from scald. The benefits of using modified atmosphere for winter pears was first shown by the development and commercial use of sealed polyethylene films as a packaging material. They created a lower oxygen and higher carbon dioxide concentration around the fruit (5). The seasonal occurrence of brown-core in pears packed in sealed poly bags proved to be a serious problem and led to the use of perforated films. This practice prevented occurrence of the disorder, but the benefit of the modified atmosphere realized in sealed bags was no longer attained. Subsequent experimentation has shown that pears are highly susceptible to excessive CO_2. This is especially apparent following cool growing seasons and in fully mature fruit (9). The safe concentration of CO_2 for winter pears is below 1 percent. At this concentration, CO_2 has little beneficial effect and low levels of O_2 must be relied upon to provide the benefits of CA storage. Optimum and safe CA atmosphere for commercial use is 2 to 2.5 percent O_2 and 0.8 to 1 percent CO_2.

To obtain the maximum benefits from CA storage for pears, three essential procedures should be observed. First, the storage room should be filled with fruit picked from the beginning to the middle of the harvest period, since this portion of the crop has the optimum potential for long storage life. Second, the room should be sealed when filled, and third, after the correct atmosphere has been established, it should be maintained throughout the storage period. Delaying CA storage after harvest or terminating it prematurely greatly reduces the period during which fruit quality can be preserved. If poly bags are used as a packaging material for pears in CA storage, the film should be perforated with 12 1/8-inch holes. Inadequate ventilation can result in brown-core injury.

In establishing the modified atmosphere following harvest, reduce the O_2 concentration to the recommended level within 14 to 15 days, maintaining a storage room temperature of 30°F. Under no circumstances should the temperature be raised to gain a faster reduction of O_2 concentration. Levels of CO_2 higher than 1 percent (4 to 5 percent) are not injurious during the early pull-down period but should be maintained at 0.8 to 1 percent when the O_2 level has been reduced to 5 percent. At lower O_2

concentrations, pears become more sensitive to CO_2 injury (*1, 8*).

At the end of the storage period, Anjou pears can be marketed for 3 to 4 weeks if the room temperature continues to be maintained at 30°F. At the present time, similar information is not available for other winter pear varieties.

Short-term high CO_2 treatment. Recent experiments have shown that using high CO_2 concentrations for a short period immediately after harvest has a beneficial effect on retaining fruit quality of Anjou pears during the subsequent storage season (*25*). Initial tests showed that treatment with 11 to 12 percent CO_2 for 2 weeks helped retain fruit quality during an 8-month storage period. Information on other winter pear varieties is not currently available. In commercial use, CO_2 can be supplied from dry ice or cylinders. Dry ice should be placed at a sufficient distance from the fruit to avoid freezing. CO_2 from cylinders can be released directly into the airstream from the blowers. Fruit should be dry before exposing it to CO_2 to avoid skin injury.

RIPENING

One of the most important principles in handling any fresh produce is delivery to the consumer in a good, edible condition, with as much as possible of the original quality preserved by good handling and storage practices. In the case of pears, this requires removal from storage and marketing while still in a physiological condition for ripening with good quality.

The term "storage life," as applied to pears, is misleading unless the residual life which the fruit must have to ripen properly after removal from storage is considered. Perhaps a more inclusive term such as "postharvest life" would be more meaningful in referring to all phases of commercial handling of the fruit including storage, transport, marketing, ripening, and final retailing to the consumer.

Actual length of the storage period varies according to variety, seasonal growing conditions, and handling and storage practices. Under optimum conditions in 30°F storage, the approximate storage period for winter pears is:

Variety	Storage period
	Days
Bosc	110-120
Comice	120-130
Anjou	180-220
Winter Nelis	200-240

If CA storage is used, the storage period for Anjou pears can be extended up to 30 days. Because winter pear varieties will not ripen at harvest, they require exposure to storage temperature. Ripening develops when they are returned to a warm temperature (*6*). This period varies from 4 to 6 weeks for Bosc and Comice to approximately 8 weeks for Anjou. During these storage periods, the fruit develops the capacity for producing ethylene at a sufficient rate to activate the ripening processes (*24*). Consequently, Anjou pears that are marketed prior to Thanksgiving require ethylene treatment, a method commonly used for ripening of bananas and tomatoes.

Ripening of pears involves a number of independent biochemical reactions that may respond differently to temperature. Thus, Anjou pears have been shown to soften within a temperature range of 40° to 80° F, while softening of Bosc was inhibited at 50°F and lower (*7*). In contrast, loss in green color occurs slowly in Anjou even at higher temperatures but occurs rapidly in Bosc. This difference in rate of softening and color development in Anjou pears results in the fruit becoming fully soft for eating while still retaining one-half or more of the original green color. This variety also will develop better texture and eating quality if ripened within a temperature range of 60° to 65°F. A mealy rather than a juicy texture tends to develop at higher temperatures, especially late in the season. When fully ripe fruit is kept at 30°F for 10 to 14 days, the yellow color will continue to develop. Proper ripening procedures can produce good to excellent quality Anjou pears as well as other varieties.

Climatic variations within a growing season as well as the differences between seasons are one of the major factors which affect the storage duration and quality of winter pears. Recent studies (*16*) have shown that Anjou quality and the capacity to ripen after long storage periods were influenced by the daily-hourly average (DHA) temperatures prevailing during the 6 weeks before harvest. Fruit grown under high or low DHA conditions did not

ripen uniformly and were more susceptible to certain physiological disorders. This suggests the possibility of seasonal climatic differences in the various districts resulting in seasonal differences in fruit quality and ripening capacity.

Pre-conditioning should be included among the commercial handling practices for winter pears. As indicated, ripening of pears is a critical process in regard to temperature and other factors and should be controlled by some segment of the industry until the fruit reaches the retail market. In pre-conditioning winter pears for the retail market, the fruit should be kept at 62° to 65°F until softened to a pressure test of 9 to 10 pounds. The fruit can then be returned to 30°F for short periods, if required for later marketing. Fruit can be delivered to retailers without injury at a 5- to 6-pound pressure reading.

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