

# Pear

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**Scientific Name and Introduction:** *Pyrus communis* L., the pear fruit is a member of the family Rosaceae. The fleshy part of pear fruit consists of the fused base of the calyx (sepals), corolla (petals) and stamens, which are interpreted by one school of anatomists as being the “receptacle.” Therefore, pears are also a member of pome fruits (Hulme and Rhodes, 1971). Commercial pear production on the Pacific Coast is largely confined to nine districts including the Wenatchee and Yakima Valley areas in central Washington; the Hood River Valley in north central Oregon, and the Rogue River Valley around Medford in southern Oregon; in California, the foothill district of Eldorado, Placer, and Nevada counties, the Sacramento River district, the coast district north of San Francisco Bay known as the Santa Clara Valley district, and the southern California acreage mostly in the Antelope Valley in Los Angeles County (Childers, 1949). Pears rank 3<sup>rd</sup> among the most important tree fruits grown in the world and 4<sup>th</sup> among all fruits for which statistics are available (Childers, 1949). In 1998-99, the total ‘Bartlett’ pear production in the Pacific Northwest averaged approximately 62,112 short tons (Northwest Fresh Bartlett Marketing Committee, 1998) and Winter pear production 400,000 short tons (Pacific Cost Winter Pear Marketing Order, 1998). All important pear varieties grown in the U.S. belong to the European species and commercial pear production is confined to six main varieties, namely Bartlett, Beurré d’Anjou, Beurré Bosc, Beurré Hardy, Doyenne’ du Comice and Seckel. Other minor varieties include Winter Nelis, El Dorado, Kieffer and Packham’s Triumph.

**Quality Characteristics and Criteria:** Pear fruit requires a period of cold storage at -1 °C to induce normal ripening and develop high dessert quality upon ripening. Ripening is defined as: “the composite of the processes that occur from the latter stages of growth and development through the early stages of senescence and that results in characteristic aesthetic and/or food quality, as evidenced by changes in composition, color, texture or other sensory attributes” (Watada et al., 1984). When pear fruit meet the chilling requirement after a period of cold storage, they should be ripened at 20 °C in air for 4 to 7 days depending upon the variety for the development of high dessert quality. Quality characteristics and criteria of a properly ripened pear fruit are buttery and juicy texture with the distinct pear aroma and taste of each pear cultivar.

**Horticultural Maturity Indices:** Pear fruit are capable of developing good dessert quality upon ripening only when they are harvested at proper maturity. Pear fruit harvested with improper maturity are more susceptible to physiological disorders and have a shorter storage-life. Immature pear fruit are more susceptible to superficial scald, shriveling and friction discoloration while over mature fruit tend to have higher incidence of core breakdown and CO<sub>2</sub> injury (Fidler et al., 1973; Hansen and Mellenthin, 1962; Mellenthin and Wang, 1974). One of the most satisfactory and easiest ways of determining proper harvest maturity is to measure fruit firmness. Pressure tests using a penetrometer on the pared surface gives an indication of flesh firmness. Firmness decreases with maturation. Different varieties have different firmness at maturity. Recommended ranges of firmness for harvesting different pear varieties in terms of Newtons of force (1 N = 0.225 lb-force) as measured by a 8-mm plunger tip are as follows: d’Anjou, 57.8 to 66.7; Bartlett, 66.7 to 84.3; Bosc, 62.7 to 71.6; Comice, 49.0 to 57.8; Hardy, 41.2 to 49.0; Kieffer, 52.9 to 66.7; Seckel, 57.8 to 66.7; Packham, 57.8 to 66.7; El Dorado, 57.8 to 66.7; and Winter Nelis, 57.8 to 66.7 (Hansen and Mellenthin, 1979; Williams et al., 1978).

Heat units accumulated during 9 weeks following full bloom provide an accurate prediction of maturity and harvest date. The equation can be expressed as: Daily Heat Unit = (Maximum Temp. + Minimum Temp.)/2 - 45 °F. Heat units accumulated during 9 weeks following full bloom have been

developed at the Mid-Columbia Agricultural Research and Extension Center to provide an accurate prediction of the commercial harvest date for d'Anjou and Bartlett pear cultivars. The 50-yr record (1944 to 1994) at this Center has shown that correlation coefficients between the number of days from full bloom (FFB) and the accumulated heat units (AHU) are -0.9213 for d'Anjou pears and -0.8300 for Bartlett pears, respectively. The linear equations between DFFB and AHU are:

$$\text{DFFB} = 177.5472 - 0.0481 \times \text{AHU} \text{ ('d'Anjou')} \text{ and } \text{DFFB} = 147.5377 - 0.0353 \times \text{AHU} \text{ ('Bartlett')}$$

In Oregon's Hood River Valley district, the entire pear producing area covers the gradients of different elevations between 500 ft (152 m) and 2,000 ft (610 m). The dates of full bloom or the dates of first commercial harvest between the lower elevation and the upper elevation could be as long as three weeks apart. The predictive models for the harvest maturity of d'Anjou and Bartlett pears grown in 14 orchards representing the entire Hood River Valley district have been developed (Varga and Chen, 1995). Other predictive methods such as days from full bloom, SSC, and starch-iodine test are quite variable from season to season and have not been adopted for routine practice by the pear industry.

**Grades, Sizes and Packaging:** Grades include Extra Fancy, U.S. No. 1, Fancy and Unclassified (or Third Grade) for all Winter pear cultivars and U.S. No. 1 and Fancy for 'Bartlett,' primarily based on external appearance. Number of pear fruits per standard 20-kg box is used to classify the fruit size. They are categorized as 50, 60, 70, 80, 90, 100, 110, 120, 135, 150, 165, and 180 fruit/box.

**Pre-cooling and Optimum Storage Conditions:** Pears are very sensitive to temperature. The storage-life of 'd'Anjou' and 'Bartlett' pears has been reported to be 35 to 40% longer at -1 °C than at 0 °C (Porritt, 1964). Most pears in the Pacific Northwest are stored at -1 °C with RH of 90 to 94% (Hansen and Mellenthin, 1979). Many operators of pear storage rooms use thermocouples in the air and in fruit to determine temperatures at selected areas in the storage. Precise temperature control is needed to prevent freezing when pears are stored at these low temperatures (Hartman, 1931). Rapid removal of field heat and prompt cooling of harvested pears are essential for long-term storage. During the pull-down period, room temperatures of -3.5 °C to -2.0 °C can be used but should be raised to -1 °C as the fruit temperatures approach this temperature (Hansen and Mellenthin, 1979). Delay in cooling shortens storage-life. It has been suggested that the core temperature should be reduced to near the holding temperature in 4 days (Porritt, 1965). When pears are packed in cartons before cooling, cartons should be stacked to provide exposure of the sides to airflow (Sainsbury and Schomer, 1957). Pears lose moisture rapidly; hence, it is advisable to hold the RH > 90%. Polyethylene liners are effective in controlling moisture loss. Intermediate temperatures of 2.5 to 10 °C are harmful to some pear cultivars. 'Bartlett' pears stored at this temperature have dry texture and inferior flavor (Porritt, 1964).

**Controlled Atmosphere (CA) Considerations:** CA storage has been used successfully to extend the storage-life of pears and to maintain greater capacity for ripening. The optimum and safe CA for commercial use is 2 to 2.5% O<sub>2</sub> + 0.8 to 1% CO<sub>2</sub> (Hansen and Mellenthin, 1979). Use of short-term high CO<sub>2</sub> treatment improves keeping quality of 'd'Anjou' pears (Wang and Mellenthin, 1975). Treatment with 12% CO<sub>2</sub> for 2 weeks immediately after harvest has a beneficial effect on retention of ripening capacity. Keeping 'd'Anjou' pears in a low O<sub>2</sub> atmosphere (1.0%) with ≤ 0.1% CO<sub>2</sub> can also maintain higher dessert quality and reduce incidence of superficial scald after long-term cold storage (Hansen, 1957; Mellenthin et al, 1980).

**Pear Ripening in Storage:** Most pear cultivars require a period of cold storage before they will ripen normally at room temperature (Blankenship and Richardson, 1985; Drouet and Hartmann, 1979; Knee, 1987; Leblond and Ularic, 1973; Morin et al., 1985). Most cultivars do not soften appreciably during cold storage. Hence, they require a period of ripening at warm temperature to develop good flavor and texture

for eating. The best ripening temperature after storage is about 15 to 21 °C (59 to 70 °F). Higher temperatures may result in poor quality or decay. Most cultivars fail to soften at 30 °C (86 °F). It is generally recognized that ethylene induces ripening.

A striking characteristic of climacteric fruit is their autocatalytic ethylene production, i.e., ethylene stimulates its own synthesis, (Pech et al., 1994). During storage at -1 °C, 1-aminocyclopropane-1-carboxylic acid (ACC; the immediate ethylene precursor) starts to accumulate and, as a consequence, pear fruit begin to produce ethylene and ripen normally upon exposure to room temperature. Exposure of pear fruit to a storage temperature of -1 to 0 °C (30.2 to 32 °F) stimulates synthesis of ACC and ethylene, because low temperature induces biosynthesis of ACC oxidase and ACC synthase (Lelièvre et al., 1997; Blankenship and Richardson, 1985; Wang et al., 1985; Agar et al., 2000). The duration of chilling required for proper ripening is cultivar-dependent (Wang et al., 1985) and varies with storage temperature (Gerasopoulos and Richardson, 1995; Sfakiotakis and Dilley, 1974). Storage duration at -1 °C, which is required to induce normal ripening of pear fruit, is 2 to 4 weeks for 'Bartlett' (Puig et al., 1996; Agar et al., 1999b), 2 to 3 weeks for 'Bosc' (Chen et al., 1982) and 7 to 8 weeks for 'd'Anjou' (Chen et al., 1982).

Exogenous ethylene, at 100 µL L<sup>-1</sup>, has been used commercially to pre-condition under-chilled 'Bartlett' and 'd'Anjou' pears at 20 °C for 2 to 3 days before shipment. Pre-conditioned pear fruit are capable of ripening normally and uniformly upon reaching the retail markets or for the canning process (Agar et al., 1999, 2000; Chen et al., 1996; Puig et al., 1996).

**Ethylene Production and Sensitivity:** Rates are low at harvest at < 0.1 µL kg<sup>-1</sup> h<sup>-1</sup>, but gradually increase during air storage at -1.1°C (30 °F). After 3 mo of air storage at -1.1 °C (30 °F) + 1 day at 20 °C (68 °F), ethylene production of 'd'Anjou' was: 0.5 µL kg<sup>-1</sup> h<sup>-1</sup>; 'Bosc,' 30 µL kg<sup>-1</sup> h<sup>-1</sup>; and 'Comice,' 30 µL kg<sup>-1</sup> h<sup>-1</sup>.

Most pear cultivars will exhibit climacteric-like ethylene production during the ripening period at 20 °C (68 °F) when optimally mature fruit have satisfied their chilling requirement at -1.1 °C (30 °F). The chilling requirement of optimally mature pears stored at -1.1 °C (30 °F) for induction of normal ripening capacity is as follows: about 60 days for 'd'Anjou,' 30 for 'Bosc,' 30 for 'Comice,' and 15 days for 'Bartlett.' The magnitude of ethylene production at the climacteric-like peak is as follows: 10 to 20 µL kg<sup>-1</sup> h<sup>-1</sup> for 'd'Anjou,' 40 to 80 µL kg<sup>-1</sup> h<sup>-1</sup> for 'Bosc,' 80 to 200 µL kg<sup>-1</sup> h<sup>-1</sup> for 'Bartlett,' and 60 to 80 µL kg<sup>-1</sup> h<sup>-1</sup> for 'Comice' fruit.

Unripe pear fruit are somewhat sensitive to ethylene depending upon different cultivars. 'Bartlett' pears are most sensitive to ethylene; 'Bosc' and 'Comice' fruit are moderately sensitive; and 'd'Anjou' fruit are least sensitive to ethylene for induction of ripening. Nevertheless, it is best to avoid storing pear fruit near ripe fruit or other fresh produce that produces appreciable levels of ethylene. Pre-conditioning treatment of pear fruit with 100 µL L<sup>-1</sup> ethylene at 20 °C (68 °F) for 72, 48 or 24 h will induce ripening within 3 to 6 days, depending on cultivar (Chen et al., 1982; Elgar et. al., 1997; Wang and Mellenthin, 1972).

### Respiration Rates:

Temp. (°C)	'd'Anjou'						'Bartlett'				
	Days in Storage						Days in Storage				
	1	25	50	100	150	200	1	10	20	90	120
	(mg CO <sub>2</sub> kg <sup>-1</sup> h <sup>-1</sup> )										
-2	5.0	2.0	2.0	2.3	2.4	2.7	-	1.5	2.2	3.2	3.8
-1	5.0	2.0	2.0	2.4	2.5	2.8	-	2.2	2.4	3.6	4.2
0	5.0	2.4	2.5	3.2	4.1	4.5	-	2.5	2.6	5.6	5.9
2	5.0	3.1	3.6	5.1	-	-	-	3.2	4.5	-	-
10	9.0	6.0	7.0	-	-	-	16.0	8.1	24.0	-	-
21	17.0	7.0	7.0	-	-	-	16.0	38.0	-	-	-

To get  $\text{mL kg}^{-1} \text{h}^{-1}$ , divide the  $\text{mg kg}^{-1} \text{h}^{-1}$  rate by 2.0 at  $0^\circ\text{C}$  ( $32^\circ\text{F}$ ), 1.9 at  $10^\circ\text{C}$  ( $50^\circ\text{F}$ ), and 1.8 at  $20^\circ\text{C}$  ( $68^\circ\text{F}$ ). To calculate heat production, multiply  $\text{mg kg}^{-1} \text{h}^{-1}$  by 220 to get BTU per ton per day or by 61 to get kcal per metric ton per day.

**Physiological Disorders:** Superficial scald, also called storage scald, is a cosmetic symptom of surface browning affecting only a few layers of cells beneath the skin. Eating quality of fruit is not affected. Frequently, fruit appear normal after several months in cold storage but then develop scald symptoms after a few days at room temperature. The unpleasant brown appearance makes fruit difficult to market.

Superficial scald affects 'd'Anjou' pears and other pear and apple cultivars. The cause of superficial scald is that conjugated trienes, the oxidative products of a naturally occurring terpene,  $\alpha$ -farnesene, are toxic to the epidermal and endodermic cells of the fruit peel (Chen et al., 1990b). Factors that usually increase the severity of the disorder include immaturity, high fruit nitrogen, low fruit calcium, warm pre-harvest weather, delayed cold storage, high storage temperatures, and high RH during cold storage.

**Scald Control Methods:** *Conventional control method.* The primary control of superficial scald on 'd'Anjou' pears at the present time is a postharvest treatment of ethoxyquin, an antioxidant (Hansen, 1964; Hansen and Mellenthin, 1967, 1979). Ethoxyquin is recommended at a concentration of 2,700 ppm, which can be applied to the fruit either as a drench, as a line spray, or by impregnating it into paper wraps (Hansen and Mellenthin, 1979). Drenching fruit is done as soon as possible after harvest, usually no later than 2 days. Unfortunately, this treatment often causes considerable phytotoxicity when the ethoxyquin solution becomes more concentrated at contact points between fruit or between fruit and wooden bins. Fruit at these contact points develop pinkish (or blackened) ring markings during storage (Porritt et al., 1982), and the injured fruit become unmarketable. Ethoxyquin treatment as a line spray or a paper wrap is carried out during commercial packing. Because it usually takes about 3 mo to pack all fruit stored in air, fruit may receive ethoxyquin protection as early as 1 week after harvest or as late as 3 mo after storage using either of these two ethoxyquin treatments. Although both treatments do not cause any phytotoxicity to fruit, delay in ethoxyquin application has resulted in significant incidence of scald disorder at terminal markets. Current recommended ethoxyquin treatments are inadequate.

*Split application of ethoxyquin control method.* Drenching 'd'Anjou' fruit with 1,000 ppm ethoxyquin within 2 days after harvest controlled scald development for 4 mo in air storage without causing phytotoxicity to fruit. Drenching fruit with 1,000 ppm ethoxyquin within 2 days after harvest plus an additional line spray of 1,700 ppm ethoxyquin within 3 mo of harvest controlled scald development for 5 mo in air storage (Chen, et al., 1990a).

*Non-chemical control method.* A short-term (3 to 4 mo) CA storage of 'd'Anjou' pears at  $-1^\circ\text{C}$  in  $0.8\% \text{O}_2 + < 0.1\% \text{CO}_2$  (denoted as low  $\text{O}_2$ ) effectively controls development of superficial scald without inducing Black Speck and Pithy Brown Core (Chen and Varga, 1997a, 1997b). Fruit stored in a short-term low  $\text{O}_2$  regime remain free from scald after 8 weeks in air at  $-1^\circ\text{C}$ . These fruit can be safely packed without antioxidant treatment and marketed after 2 mo of air storage.

*Combined ethoxyquin/CA control method (Chen and Varga, 1997b).* For 'd'Anjou' fruit destined for mid-term (5 to 6 mo) or long-term (7 to 8 mo) CA storage, a pre-storage drench of fruit with 1,000 ppm ethoxyquin within 2 days after harvest was necessary in order to control superficial scald disorder. The concentrations of  $\text{O}_2$  and  $\text{CO}_2$  in CA storage must be kept at 1.5% and  $< 0.5\%$ , respectively, throughout the entire storage period to minimize the development of Black Speck and Pithy Brown Core. An alternative method would be to store field-run d'Anjou pears in low  $\text{O}_2$  ( $0.8\% \text{O}_2 + < 0.03\% \text{CO}_2$ ) at  $-1^\circ\text{C}$  for 90 days until qualified. Low  $\text{O}_2$  stored fruit can either be pre-sized or packed with in-line spray of 2,700 ppm ethoxyquin within 2 weeks after returning to air storage. Treated fruit can be further stored in regular CA storage ( $2\% \text{O}_2 + 1\% \text{CO}_2$ ) for another 3 to 4 mo at  $-1^\circ\text{C}$  for late season marketing.

Pithy Brown Core (PBC) affects 'd'Anjou' pears stored in either sealed polyethylene box liners or CA storage with elevated  $\text{CO}_2$ . It is characterized by pithy, brown areas in the core region of the fruit. It may be restricted to brown flecks between the carpels or it may encompass the entire core and extend into the

surrounding flesh. In some instances, the tissues collapse producing cavities. The affected tissues are dry and pithy, in contrast to the soft, watery texture resulting from core breakdown. The disorder is associated with high CO<sub>2</sub> in atmospheres of sealed box liners or CA storage and is considered to be a form of CO<sub>2</sub> injury. It is aggravated by the combination of low O<sub>2</sub> and high CO<sub>2</sub> levels in CA storage. Susceptibility to PBC increases with factors that induce fruit senescence, such as late harvesting, delayed storage, slow cooling, high storage temperatures, and extended CA storage (Hansen and Mellenthin, 1962). Fruit from trees with low vigor and fruit grown in cool seasons are more susceptible to PBC (Hansen and Mellenthin, 1962).

*PBC Control Methods:* For fruit stored loose in bins, i.e., field-run fruit, CO<sub>2</sub> should be maintained at < 0.03% when O<sub>2</sub> in CA storage is 0.8 to 1.0% (Chen and Varga, 1997a). The maximum storage length of 'd'Anjou' fruit stored under low O<sub>2</sub> should be no longer than 120 days. For fruit stored loose in bins, CO<sub>2</sub> should be maintained at < 0.5% when O<sub>2</sub> in CA storage is 1.5 to 1.8%. The maximum storage time of fruit stored in the CA regime described above should be no longer than 8 mo. For fruit stored loose in bins, CO<sub>2</sub> should be maintained at < 1.0% when O<sub>2</sub> in CA storage 2.0 to 2.5%. The maximum storage time of fruit stored in the CA regime described above should also be no longer than 8 mo (Chen and Varga, 1997a).

For fruit stored in packed boxes, only the CA regime with 2.0 to 2.5% O<sub>2</sub> + < 1.0% CO<sub>2</sub> gives minimal risk for 'd'Anjou' pears to develop PBC after prolonged CA storage, i.e., 6 to 8 mo (Chen and Varga, 1997a).

Black Speck (BS) or "skin speckling" of 'd'Anjou' pears becomes an economic problem to the pear industry after prolonged CA storage. It has been observed frequently in commercial CA storage. It is a physiological disease and is suspected to be closely associated with PBC. Kupferman (1988) reported that BS could develop on 'd'Anjou' pears with or without PBC. Similar to PBC, 'd'Anjou' fruit develop BS only in CA storage. The unbalanced O<sub>2</sub>/CO<sub>2</sub> ratio in CA storage must be an initial factor to cause skin injury of fruit. It was confirmed that BS was induced by O<sub>2</sub> ≤ 1.0% in CA storage for longer than 4 mo and was not affected by CO<sub>2</sub> < 1% (Chen and Varga, 1989). Each BS spot consists of several hundred epidermal cells discolored to dark brown. The distinct specks scatter randomly on the peel tissue and are not restricted to around the lenticels. It affects only five to six layers of hypodermal cells of the skin (Chen and Varga, 1989; Kupferman, 1988; Lee, et al., 1990).

*BS Control Methods:* Since BS is associated with low O<sub>2</sub> (≤ 1%), a CA regime with O<sub>2</sub> at 1.5% or higher will alleviate the disorder after prolonged CA storage. For 'd'Anjou' under low O<sub>2</sub> storage (0.8 to 1.0% O<sub>2</sub>), storage should not exceed 120 days (Chen and Varga, 1997a).

Black End of 'd'Anjou' pears begins with symptoms appearing when fruit are one-third to one-half full size. It is a protrusion of the calyx due to the retarded development of tissues around the calyx. As the disorder progresses, the calyx lobes turn black, the tissues surrounding the calyx opening become hard, and a brownish discoloration forms. This discoloration may appear first in separate spots, which later coalesce; or there may be a large area completely and uniformly discolored from the beginning. The final color of affected tissues is black, and cracks up to 3 cm in length may appear in the blackened area. The affected area is usually confined to approximately 1 to 2 cm around the calyx, but it may cover the entire lower half of fruit in severe cases. Discoloration usually does not extend deep into the flesh, sometimes only affecting the skin.

*Black End Control Methods:* Black end is believed to be caused by water imbalance that is due to a restricted root system. Excessive subsoil moisture in the Spring damages feeder roots, inducing development of the disorder. Fruit grown on trees with Asian rootstocks (*Pyrus serotina* Rehder) are highly susceptible to black end. Fruit grown on trees with French rootstocks (*Pyrus communis* L.) are generally free from the disorder (Davis and Tufts, 1932; Heppner, 1928).

Core Breakdown has been referred to in different investigations as internal breakdown, core rot, brown heart, and mealy core. As the names imply, this disorder of pears is characterized by the softening and

browning of tissues in the region of the core. The breakdown may be closely confined to the core or may extend into the surrounding flesh. In the early stages, the affected tissues are soft and watery; they later become dark brown. The disorder is often associated with an external skin discoloration resembling senescent scald.

*Core Breakdown Control Methods:* Over-mature fruit are more susceptible to core breakdown in storage and the market. Late-harvested pears are unable to slow their metabolic activities sufficiently for successful storage at -1 °C (30.2 °F). Serious breakdown can occur in storage or after pears are removed to ripen at 20 °C (68 °F). Late-harvested pears show an increase in CO<sub>2</sub> in the tissues around the core area until the onset of core breakdown. Such fruit produce an abnormally high amount of acetaldehyde until core breakdown is advanced. ‘Bartlett,’ ‘Bosc’ and ‘Comice’ pears are highly susceptible to core breakdown, whereas ‘d’Anjou’ pears are somewhat resistant. Harvesting fruit at optimum maturity and rapidly pre-cooling before storage are essential to reduce core breakdown (Harley, 1929; Hartman, 1925).

Senescent Scald occurs differently in various pears. Pears can be classified broadly into two groups based on their storage behavior. One group, including ‘d’Anjou,’ ‘Winter Nelis,’ ‘Packham’s Triumph’ and ‘Hardy,’ senesce very slowly in cold storage and generally do not lose their capacity for normal ripening at room temperature as a result of extended storage. These pears are subject to storage scald, called Anjou scald or superficial scald. The other group of pears, which includes ‘Bartlett,’ ‘Bosc,’ ‘Howell,’ ‘Comice,’ ‘Sierra’ and ‘Flemish Beauty,’ show a higher rate of senescence during cold storage; fruit lose their ability for normal ripening at room temperature after prolonged storage. As storage length is extended, fruit become yellow and ultimately develop a dark brown discoloration of the skin called senescent scald. This may occur in cold storage or after fruit are removed from cold storage and subjected to higher temperatures. Fruit are inedible and remain firm, but the skin sloughs off easily (Porritt et al., 1982).

*Control Methods for Senescent Scald:* Methods are similar to core breakdown disorder, with over-mature fruit are more susceptible to senescent scald in storage and in the market. Pears that are harvested late do not exhibit a decrease in metabolic activity necessary for storage at -1 °C (30.2 °F). There are no control measures other than harvesting pears at optimum maturity, reducing the storage period and improving postharvest handling, like fast cooling of pears immediately after harvest and maintaining constant temperature at -1 °C (30.2 °F) throughout storage (Porritt et al., 1982).

**Postharvest Pathology:** A detailed description of pear diseases and control measures can be found in “Compendium of Apple and Pear Diseases” (1990). Postharvest decays in pear fruit are often difficult to identify through symptoms alone. Many decay pathogens do not sporulate on fruit in cold or CA storage. The only reliable method for identifying decays is to isolate and identify the causal agent. Isolations are easily accomplished by removing the fruit skin over the margin of a decayed area and plating some of the decayed flesh on potato-dextrose agar.

Fungi causing postharvest decays in pome fruits can be subdivided into two broad groups: 1) those causing primarily postharvest decays, and 2) those that also cause fruit decays in the field. Postharvest decays attributable to fungi in the latter group usually result from infections that occurred in the field but were quiescent or otherwise escaped notice at harvest. Control measures for these diseases are based on the protection of fruit from pre-harvest infections. Control measures broadly applicable to many postharvest diseases include both sanitation and harvesting, as well as handling methods that maintain the integrity of harvested fruit. Sanitation measures are especially important for reducing exposure of fruit to spores of wound pathogens, such as *Penicillium* and *Botrytis*. Harvesting and handling methods are important, because wounded, bruised, or overmature fruit are more susceptible to many postharvest decay fungi. Rapid cooling after harvest helps reduce the incidence of decays in storage, because low temperatures reduce both the rate of fungal growth and the fruit senescence. Low temperatures prevent development of incipient infections by some fungi in storage, such as those causing white rot and brown rot.

Postharvest decay pathogens infecting pears in the field and causing symptoms in stored pears as a result of incipient or quiescent infections are: *Botryosphaeria dothidea* (White rot), *B. obtusa* (Black rot),

*Glomerella cingulata* (Bitter rot), *Monilinia fructicola* (Brown rot), *M. fructigena* (Brown rot), *M. laxa* (Brown rot), and *Phytophthora cactorum* (Phytophthora fruit rot).

Postharvest diseases commonly found in pears after storage are: Blue mold (*Penicillium*), Gray mold (*Botrytis cuberea* Per.), Bull's-eye rot (*Pezizula malicorticis* [H. Jacks.] Nannf.), Alternaria rot (*Alternaria alternata* [Fr.] Keissler), Mucor rot (*Mucor piriformis* E. Fischer), Side rot (*Phialophora malorum* [Kidd & Beaumont] McColloch), Cladosporium rot (*Cladosporium herbarum* [Pers.] Link), Coprinus rot (*Coprinus psychromorbidus* Redhead & Traquair), Fisheye rot (*Butlerella eustacei* Weresub & Illman), Pink rot (*Trichothecium roseum* (Pers.) Link), and Rhizopus rot (*Rhizopus stolonifer* [Ehrenb.] Vuill.).

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