Ethylene Treatment Promotes Early Ripening Capacity in Mature 'Comice' Pears

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Summary. **'Comice' pears (*Pyrus communis*) harvested early in the maturity range needed 25–31 days of storage at 0 °C to develop the capacity to ripen to an average firmness of 5 lbf within 5 days after being moved to 20 °C. After 24 h exposure to 100 ppm ethylene at 20 °C applied immediately after harvest, 17–27 days additional chilling were needed to develop ripening capacity, while ethylene exposure for 48 hours required an additional 7–17 days chilling. After 72 h ethylene exposure, ripeness was achieved within 5 days following 3 days cold storage, the minimum duration tested. Similar results were obtained when the sequence of ethylene treatment followed by cold storage was reversed. This technique may be applied to reduce the amount of time that 'Comice' pears must be stored after harvest before marketing fruit with the capacity to ripen.**

Pear fruit typically are harvested in a mature-green condition, but may not have the capacity to ripen to a buttery-juicy texture without postharvest exposure to low temperatures for a sufficient duration. Temperatures below 7 °C are considered to contribute to the postharvest chilling effect, while optimum ripening usually takes place at 15 to 18 °C (Hansen and Mellenthin, 1979). Cultivars of pear vary in the duration of postharvest chilling required in order to develop the capacity to ripen (Blankenship and Richardson, 1985; Sfakiotakis and Dilley, 1974). With more advanced fruit maturity at harvest, the duration of chill needed to induce ripening capacity generally decreases (Agar et al., 1999; Elgar et al., 1997; Looney, 1972).

Postharvest chilling stimulates the endogenous production of ethylene in pear fruit (Hansen, 1937). The postharvest chill requirement for the development of ripening capacity in pears may be replaced entirely or in part by exposure to ethylene. In 'Bartlett' pears, treatment with 100 ppm ethylene for 24 h at 20 °C obviates the need for postharvest chilling and promotes uniformity of ripening among individual fruit (Agar et al., 1999, 2000a, 2000b; Puig et al., 1996). In contrast, 'd'Anjou' pears harvested at optimum maturity need 3 d in 100 ppm ethylene if exposed to cold temperatures for 0–2 weeks, or 2 d if exposed to cold temperatures for 4–8 weeks (Chen et al., 1996, 1997).

Early marketing of pears, like many other fresh fruit and vegetables, is generally desirable for producers seeking to take advantage of relatively high prices. 'Comice', an important winter pear cultivar in Oregon, is typically stored at –1 °C for about 30 d after harvest prior to first shipment in order to assure that the pears have the capacity to ripen. The objective of this research was to evaluate the potential of ethylene treatments to reduce or replace the postharvest chill requirement and thereby facilitate earlier marketing of 'Comice' pear.

Materials and methods

All fruit were grown on 'Quince A' (*Cydonia oblonga*) rootstock in a commercial orchard near Medford, Ore. Early in the harvestable maturity range, as determined by a flesh firmness of 13–12 lbf, 2500 fruit were harvested and randomly divided into 100 lots of 25 fruit each and placed in an air-tight room. Ethylene was introduced into the room from a cylinder to a concentration of about 100 ppm as determined using a gas chromatograph (model AGC Series 400; Hach Carle, Loveland, Colo.) operated at 70 °C with an alumina column and flame ionization detector. Following ethylene exposure durations of 0, 24, 48, and 72 h at 20 °C, 25 replicate lots were removed from the room and placed in a regular storage room at 0 °C. After 3, 10, 17, 24, and 31 d at 0 °C, five replicate lots representing each ethylene exposure duration were removed. To evaluate the effect of ethylene exposure on the maintenance of fruit firmness during cold storage, five fruit from each replicate lot were measured for flesh firmness using a fruit texture analyzer (Güss Manufacturing, Strand, South Africa) fitted with an 8-mm-diameter tip immediately upon removal from storage. Firmness was measured in ~1.5-cm-diameter areas in the equatorial region on two opposite sides of each fruit, where the peel was removed with a kitchen peeler. The remaining 20 fruit from each replicate lot were placed on a laboratory bench at 20 °C to allow ripening. After 5 d at 20 °C, flesh firmness was measured as described above. Pears were considered ripe when a firmness value of 5 lbf or lower was achieved (Hansen and Mellenthin, 1979). Following firmness testing, ripe pears were sliced in half and examined for incidence of browning or deterioration in the core and flesh. A small portion of each of three to five randomly selected pear halves from each replicate was sampled by the authors for informal evaluation of eating quality.

The experiment was initially conducted in 2001, and repeated in 2002. In 2003, the same general procedure was followed except that the order of treatment was reversed and more chill durations were included; fruit were stored at 0 °C for 3, 7, 11, 15, 19, 23, or 27 d prior to exposure to 100 ppm ethylene at 20 °C for 0, 24, 48, or 72 h.

Results and discussion

The average initial flesh firmness at harvest of the 'Comice' pear fruit was 11.9 lbf in 2001 and 12.6 lbf in 2002. Fruit exposed to 100 ppm ethylene for 24 h maintained firmness during 31 d

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
2.5400	inch(es)	cm	0.3937
25.4000	inch(es)	mm	0.0394
4.4482	lbf	N	0.2248
1	ppm	$\mu L \cdot L^{-1}$	1
(°F – 32) ÷ 1.8	°F	°C	(1.8 × °C) + 32

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of storage at 0 °C in a pattern similar to that of fruit that were not exposed to ethylene. Fruit exposed to ethylene for 0 or 24 h had average firmness values of 10.3–10.8 lbf and 12.1 lbf in 2001 and 2002, respectively (Fig. 1). Following 48 h ethylene exposure, flesh firmness declined to average values of 9.4 and 10.1 lbf by the end of 31 d storage in 2001 and 2002, respectively. After 72 h in ethylene, firmness loss was apparent even after the 3-d minimum storage duration evaluated (10.1 and 10.6 lbf), softening by 31 d to 7.4 and 7.2 lbf in 2001 and 2002, respectively.

In the absence of exogenously applied ethylene, 'Comice' pears needed about 25–31 d at 0 °C to develop the capacity to soften to an average firmness of 5 lbf within 5 d at 20°C (Fig. 2). After 24 h exposure to 100 ppm ethylene at 20 °C, about 17 d additional chilling were needed to develop ripening capacity in 2001, and 27 d additional chilling were needed in 2002. Ethylene exposure for 48 h required an additional 7 or 17 d chilling in 2001 and 2002, respectively. After 72 h ethylene exposure, ripeness was achieved in 5 d after the 3 d minimum storage duration in both years. Similar results were obtained when the sequence of ethylene treatment followed by cold storage was reversed in 2003 (Fig. 3).

The percentage of fruit that ripened to 5 lbf or less within 5 d at 20 °C reached 100% with 48 h in ethylene + 17 d in 0 °C storage in 2001, and with 48 h in ethylene + 24 d in 0 °C storage in 2002 (Table 1). However, with 48 h in ethylene + 17 d in 0 °C storage in 2002 the majority of fruit were ripe and the remainder were sufficiently soft to suggest that ripening would be complete within an additional 1–2 d. While the average firmness of fruit exposed to ethylene for 72 h indicated that ripeness was achieved with 3 d of cold storage (Fig. 2), about one-half of the fruit receiving that treatment were not yet ripe after 5 d at 20 °C (Table 1). A higher percentage of fruit from the 72 h ethylene treatment were

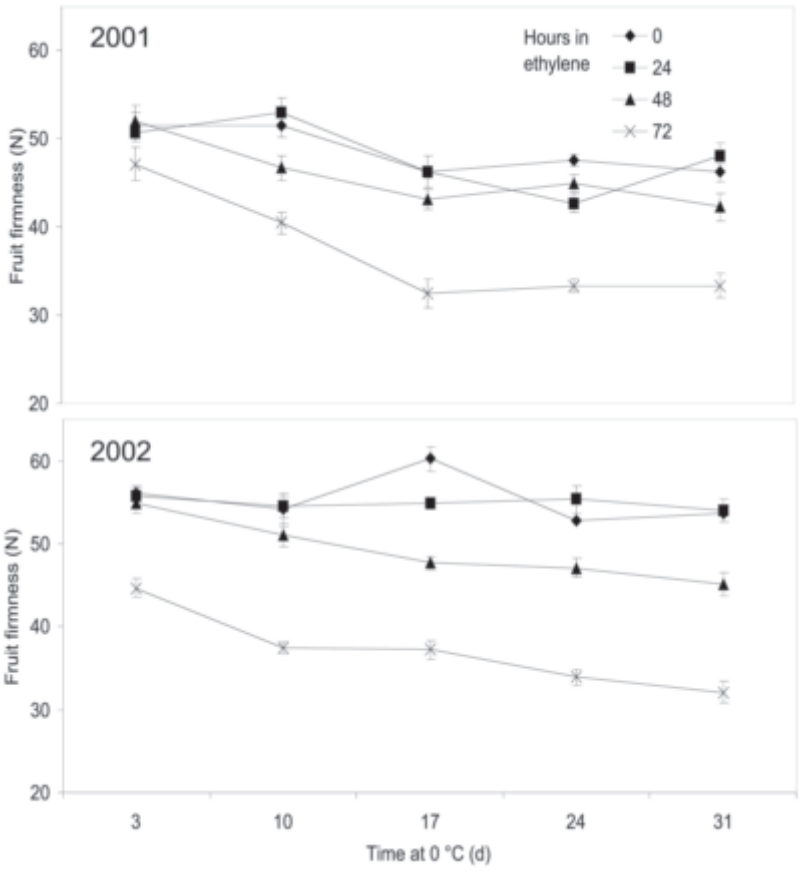

Fig. 1. Average firmness of 'Comice' pear fruit upon removal from storage at 0 °C following exposure to 100 ppm (μL·L^{-1}) ethylene for 0–72 h at 20 °C in 2001 and 2002. Vertical bars indicate SD; (1.8 × °C) + 32 = °F, 1 N = 0.2248 lbf.

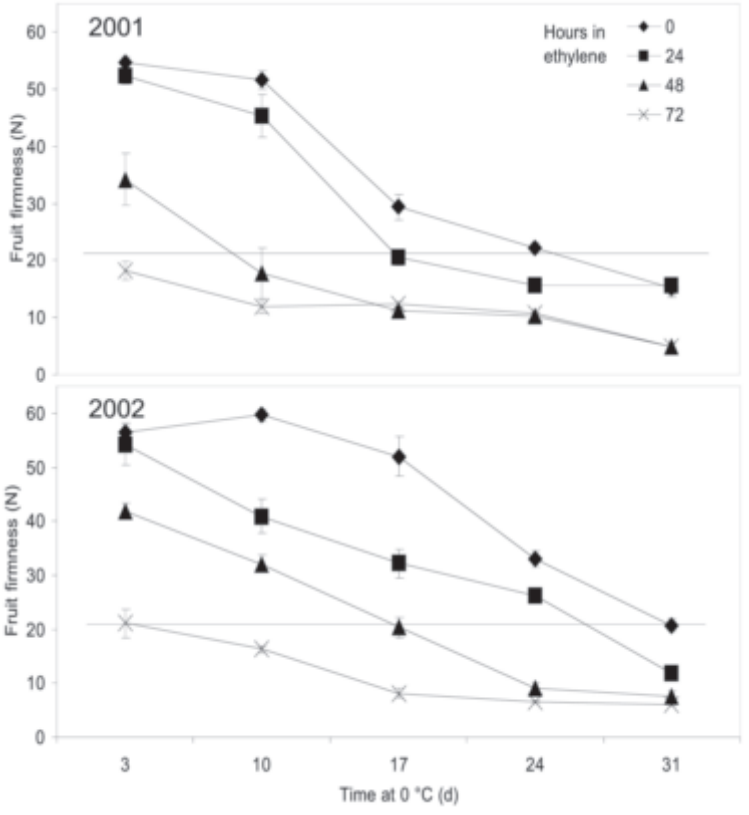

Fig. 2 (*right*). Average firmness of 'Comice' pear fruit after 5 d ripening time at 20 °C, following exposure to 100 ppm (μL·L^{-1}) ethylene for 0–72 h at 20 °C, then various durations of storage at 0 °C in 2001 and 2002. Horizontal bars indicate approximate firmness appropriate for consumption. Vertical bars indicate SD; (1.8 × °C) + 32 = °F, 1 N = 0.2248 lbf.

ripe when ≥10 d of cold storage also were applied.

The eating quality of pears that ripened during the study ranged narrowly from fair to good, without a clear association between treatment and eating quality (data not shown). The pears were generally juicy, with a moderately smooth melting texture. Flavor was equivalent to that of early season 'Comice' pears, which normally do not reach optimum flavor intensity until after ≥2 months of cold storage (Elgar et al., 1997).

Based on these results, a 24 h ethylene exposure at 20 °C would only slightly reduce the amount of time between harvest of 'Comice' pears and their marketability with the capacity to ripen. With 48 h ethylene exposure + about 17 d cold storage, pears with the capacity to ripen could be marketed while retaining sufficient firmness to withstand long-distance shipment. After 72 h ethylene exposure, 'Comice' pears could be marketed following brief chilling, but due to their softness would probably not be suitable for long-distance shipment. In 2003, two commercial producers of 'Comice' pears in southern Oregon reported successful marketing following 48 h ethylene treatment + about 2 weeks of cold storage (D. Sugar, unpublished).

The 48 h ethylene treatment plus 2 weeks chilling for inducing early ripening capacity in 'Comice' pears appears to be intermediate between that of 'Bartlett' pears (24 h ethylene, without further chilling) (Agar et al., 1999, 2000a, 2000b; Puig et al., 1996), and that of 'd'Anjou' pears (3 d ethylene plus 0–2 weeks chilling, or 2 d ethylene plus 4–8 weeks chilling) (Chen et al., 1996, 1997). The results from 2003 in this study indicate that for induction of early ripening capacity, the sequence in which 'Comice' pears are exposed to ethylene and to cold temperatures is not critical. Thus ethylene treatments could be applied at the point of sale as an alternative to treatment prior to shipping.

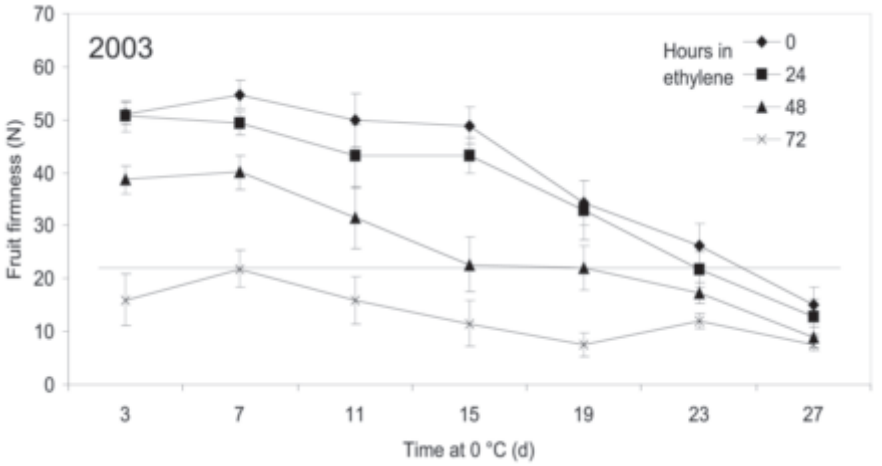

Fig. 3. Average firmness of 'Comice' pear fruit after 5 d ripening time at 20 °C, following various durations of storage at 0 °C, then exposure to 100 ppm (μL·L^{-1}) ethylene for 0–72 h at 20 °C in 2003. Horizontal bar indicates approximate firmness appropriate for consumption. Vertical bars indicate SD; (1.8 × °C) + 32 = °F, 1 N = 0.2248 lbf.

Table 1. Capacity of 'Comice' pear fruit to ripen following exposure to ethylene and low temperature.

Time in ethylene (h)[y]	Proportion of fruit ripe after 5 d at 20 °C (%)[z] Days at 0 °C[z] 3	10	17	24	31
			2001		
0	0	0	4	44	68
24	0	8	48	84	100
48	25	72	100	100	100
72	60	88	100	100	100
			2002		
0	0	0	0	8	72
24	0	16	28	32	100
48	0	12	72	100	100
72	40	92	100	100	100

[z](1.8 × °C) + 32 = °F.
[y]Pear fruit were exposed to 100 ppm (μL·L^{-1}) ethylene at 20 °C for 0–72 h, then placed in air at 0 °C for 3–31 d. Ripeness was determined by ability to soften to 5 lbf (22.2 N) within 5 d at 20 °C following each ethylene-low temperature combination treatment.

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