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Storage Life and Ripening Behavior of 'Cascade' Pears as Influenced by Harvest Maturity and Storage Temperature

SHU SHANG MA,[1] PAUL M. CHEN,[2] AND EUGENE A. MIELKE[2]

Abstract

'Cascade' pears (*Pyrus communis* L.) harvested at three stages of maturity with flesh firmness (FF) of 77.7 N, 63.0 N and 55.1 N respectively were stored in air at either –1°C or 2°C to evaluate storage life, ripening behavior, and dessert quality upon ripening at 20°C. Fruit stored at –1°C softened at a much slower rate than fruit stored at 2°C during 5 months of air storage, regardless of harvest maturity. Fruit stored at –1°C developed little internal browning (IB) or senescent scald (SS) until after 5 months of air storage, while fruit stored at 2°C developed IB and SS after 3 months of air storage regardless of harvest maturity. It was concluded that the proper temperature for long-term storage of 'Cascade' pears is –1°C. Regardless of harvest maturity, fruit were incapable of ripening normally without exposure to any chilling temperature. After one month of air storage at –1°C or 2°C, all fruit were capable of ripening normally. Early harvested fruit ripened with melting juicy texture but lacked flavor. Fruit harvested later were capable of developing high dessert qualities including melting juicy texture, distinct mixed 'Bartlett' and 'Comice' pear aroma and tart sweet taste upon ripening. Fruit with FF between 63.0 N and 55.1 N was considered to be at optimum maturity for commercial harvest.

Introduction

'D'Anjou,' 'Bartlett,' 'Bosc' and 'Comice' pears are the most important cultivars grown in the Pacific Northwest. Unlike the recent high rate of cultivar turnover in apple, the importance of rapid cultivar turnover has not been recognized by the pear industry. This is in part because of the lack of harvest maturity and storage information on new cultivars, which may possess storage characteristics and eating qualities superior to the traditional cultivars. The fact that pear growers are dependent on a few traditional cultivars may eventually reduce market options and endanger the viability of pear industry in this region. There is a critical need to identify new pear cultivars, which are optimally suited to regional climate and marketing demands. The storage and ripening behaviors of these new pear cultivars must be known prior to recommendation for commercial production.

The 'Cascade' pear was originally developed by F.C. Reimer at the Southern Oregon Experiment Station, Medford, Oregon about 1940. The parentage is 'Comice' x 'Max Red Bartlett.' The cultivar was patented 9 August 1988 as "Reimer Cultivar Pear Tree" (21). The patent of "Reimer Cultivar Pear Tree" provides the detailed description of vegetative and fruit characteristics, including the shape and the size of trees and fruit, the estimated harvest period of fruit, and the storage life of fruit (21). Sugar and Lombard (18) renamed "Reimer Cultivar Pear Tree" as 'Cascade' red winter pear, and Carlton Plants Nursery, Dayton, Oregon in 1986, had applied for the patent name of 'Cascade' red winter pear.

[1]Research Scientist, Shaanxi Fruit Crop Research Center, Dong Yi Road, Xi'an, Shaanxi, 710065, China.

[2]Professors of Horticulture, Mid-Columbia Agricultural Research and Extension Center, Oregon State University, 3005 Experiment Station Drive, Hood River, OR 97031-9512, USA.

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Corresponding author. Eugene A. Mielke, Tel.: 541-386-2030; Fax: 541-386-1905; e-mail: eugene.mielke@orst.edu.

Initially the fruit was described as having a melting, juicy texture and a tart sweet flavor, with an expected storage life of between 6 and 8 months in air at –1.1°C (12, 18). Further literature regarding optimum harvest maturity, proper storage temperature, storability, and ripening behavior of 'Cascade' pears is not available. Commercially harvested fruit has been plagued with reports of poor flavor and quality after only a few months of storage. The objective of this study was to study the storage life and the ripening behavior of 'Cascade' pears as influenced by harvest maturity and storage temperature. Our goal was to provide the pear industry with useful scientific information on the optimum harvest maturity and the proper storage temperature for long-term storage of 'Cascade' pears.

Materials and Methods

'Cascade' pear grown at the Mid-Columbia Agricultural Research and Extension Center, Hood River, OR was harvested on 27 August, 5 September and 15 September, 1998 with flesh firmness (FF) of 77.7 N (denoted as: H1), 63.0 N (H2) and 55.1 N (H3) respectively (1N [Newton] equals 0.225 lbs force). The fruits of each harvest were transferred into 20-kg wooden boxes with perforated polyethylene liners, and stored at either –1°C or 2°C in air. In addition, 3 boxes of fruit were held at 20°C for 7 days to study ripening behavior of un-stored fruit. At monthly intervals, 3 boxes of fruit from each harvest-storage temperature combination were taken out of storage and ripened in an identical manner.

After 1, 3, 5 and 7 days of ripening at 20°C, 10 fruits (designated as an experimental unit) from each of 3 replicate boxes were used to determine flesh firmness, extractable juice, soluble solid content, and titratable acids. Flesh firmness (FF) was determined with a UC pressure tester with an 8-mm plunger (2 punches per fruit). For the determination of extractable juice (EJ), soluble solid content (SSC) and titratable acids (TA), fruits used for the determination of FF were peeled and sliced, and 100 g of flesh tissue was juiced in a juice extractor (Acme Model 6001) for one minute. EJ was measured in a 100-ml cylinder and expressed as milliliter (ml) EJ per 100 g flesh weight (FW). SSC was read by an Atago hand refractometer (NSG Precision Cells, Inc., Hicksville, New York). TA was determined by titrating 10 ml of juice to pH 7.2 using 0.1 N NaOH and calculated as milliequivalent (meq) acids per 100 ml juice (3).

After 7 days of ripening, the dessert quality of ripened fruit, including flesh texture and flavor (acid/ sugar balance and aroma), were rated on a nine-point hedonic scales, with 9 = buttery and juicy texture combined with flavorful taste, and 1 = mealy, coarse and dry texture combined with off flavor (14). In addition, incidences of the storage disorders including senescent scald and internal browning were assessed.

At the beginning of each sampling interval when the boxes of fruit were transferred from the cold storage to the ripening room at 20° (denoted as "on day 0 of ripening"), 5 fruits per replicate were weighed and transferred into a respiration chamber at 20°C supplied with a constant rate of airflow at 200 ml/min. The rate of ethylene production from each replicated fruit sample was determined daily for 15 days beginning 24 hours after being transferred to the respiration chamber (denoted as "on day 1 of ripening") by gas chromatography according to the previously described method (3).

A three-way split-plot analysis of variance (ANOVA) was used for statistical analysis to determine the effect of storage temperature on fruit firmness during monthly storage intervals. In this case, storage temperatures were the main plots, different harvest maturities (i.e., dates) were the sub-plots, and monthly storage intervals were the sub-sub-plots. Data including FF, EJ, TA, SSC during ripening and the rates of ethylene production during ripening were also subjected to a three-way split-plot ANOVA in which different harvest maturities were the main plots, monthly storage intervals were the sub-plots, and days of ripening were the sub-sub-plots. In this case, data from the two different storage temperatures were treated as separate experiment for the purpose of illustrating the ripening behaviors of the fruit after different storage intervals in air at either –1°C or 2°C. A two-way split ANOVA was used to analyze the quality ratings for texture or flavor in which different harvest maturities were the main plots and monthly storage intervals were the sub-plots. In the case of incidences of storage disorders, only means ± standard deviation (SD) are presented since data did not follow a normal distribution.

Results and Discussion

Effect of storage temperature on fruit softening and storage disorders

'Cascade' pears stored at –1°C softened gradually while those stored at 2°C softened rather rapidly regardless of different harvest maturities (Figure 1). The softening pattern of each harvest group was parallel to the other groups during 5 months of storage regardless of the storage temperature (Figure 1). The results indicate that 'Cascade' fruit harvested at earlier maturity would be firmer than fruit harvested at later maturity at each corresponding storage interval. In order for pear fruit to be safely packed and shipped to retail markets with minimal risk of blemishing and bruising, FF of pear fruit should not be softer than 35.3 N (8 lb-force) at any storage interval (16). At the storage temperature of –1°C, the longest storage intervals for 'Cascade' fruit to retain FF at 35.3 N or firmer were 5 months for H1 fruit, and 4 months for H2 and H3 fruit (Figure 1). At the storage temperature of 2°C, H1 and H2 fruit could only be stored for two months, while H3 fruit could only be stored for one month in order to retain the minimal FF requirement of 35.3 N (Figure 1). It was evident that the proper temperature for long-term storage of 'Cascade' pear fruit in air would be at –1°C. Previously published reports indicated that at Medford, Oregon 'Cascade' pears had a long storage life (6 to 8 months in air at –1.1°C) (12, 18, 21). However, our data clearly showed that the longest storage life of 'Cascade' pears was no longer than 5 months in air at –1°C based on the minimal FF requirement of 35.3 N. The reason for this discrepancy is not known, but might be due to the climatic differences between the Medford and Hood River growing districts. It is also possible that the differences in initial firmness at harvest between the two locations that could account for differences in maximum length of storage.

The incidences of storage disorders of 'Cascade' pear are shown in Table 1. At the storage temperature of –1°C, 'Cascade' fruit was free from any storage disorders within 4 months of air storage. After 5 months of storage at –1°C, the incidences of internal browning (IB) of 23%, 35% and 30% and senescent scald (SS) of 0%, 22%, and 20% appeared in or on H1, H2, and H3 fruit, respectively. 'Cascade' fruit stored in air at 2°C for 2 months were also free from any storage disorders. However, after 3 months of air storage at 2°C or longer, incidences of IB and SS were rather severe, regardless of harvest maturity. In general, incidence of IB was higher than SS at each corresponding storage interval, and H1 fruit had lower incidences of both kinds of storage disorders than H2 and H3 fruit. Therefore, the development of storage disorders of 'Cascade' pears was associated with the higher storage temperature, extended storage duration and late harvest maturity as described for other pear cultivars (4, 6, 15, 19). Based on the necessity for freedom from storage disorders, the longest storage life for 'Cascade' fruit in air at –1°C was 4 months and at 2°C was 2 months regardless of harvest maturity. Therefore, only data obtained within these storage lengths were subjected to the statistical analyses of ripening behaviors of 'Cascade' fruit as influenced by the harvest maturity.

Effect of storage length on ripening behaviors —Fruit stored in air at –1°C

Regardless of harvest maturity, 'Cascade' fruit could not produce any measurable amount of ethylene to induce normal

Table 1. Incidences of internal browning (IB) and senescent scald (SS) of 'Cascade' pears with 3 harvest maturities after different months of air storage at either –1°C or 2°C.

Storage Month	Harvest Maturity[z]	–1°C IB (%)	–1°C SS (%)	2°C IB (%)	2°C SS (%)
1	H1	0	0	0	0
	H2	0	0	0	0
	H3	0	0	0	0
2	H1	0	0	0	0
	H2	0	0	0	0
	H3	0	0	0	0
3	H1	0	0	50.0 ± 4.3[y]	0
	H2	0	0	60.0 ± 4.8	50.8 ± 4.2
	H3	0	0	80.0 ± 5.5	55.8 ± 3.5
4	H1	0	0	77.3 ± 5.6	33.3 ± 3.5
	H2	0	0	75.2 ± 4.6	55.2 ± 4.8
	H3	0	0	100	57.9 ± 5.0
5	H1	23.3 ± 3.4	0	100	50.0 ± 4.5
	H2	34.7 ± 3.6	21.7 ± 3.0	100	56.7 ± 5.1
	H3	29.9 ± 3.2	20.0 ± 3.1	100	66.7 ± 5.5

[z]H1, H2, H3 = Fruit were harvested on 27 August, 5 September, and 15 September 1998 with FF of 77.7, 63.0, and 55.1 N, respectively.
[y]Mean ± Standard Deviation.

ripening without exposing to chilling (data not presented). Exposing winter pears to a certain period of chilling temperature is required for the induction of normal ripening process (1, 5, 10, 11, 17). The amount of chilling required is influenced by storage temperature (7, 20). H1 and H2 fruit stored for 1 month produced low rates of ethylene without reaching a climacteric-like peak when they were held at 20°C for 15 days (Figure 2). H3 fruit stored for 1 month produced higher rates of ethylene as compared to those produced by H1 and H2 fruit and peaked on day 9 of ripening at 20°C (Figure 2). As chilling duration increased at –1°C, the magnitude of ethylene production increased regardless of the harvest maturity (Figure 2). The number of days required to reach the climacteric-like peak of ethylene production was also shortened with the increase in storage length. H2 and H3 fruit stored for 4 months exhibited the highest rates of ethylene production (35 and 25 $\mu l\ kg^{-1}\ h^{-1}$ respectively) on day 1 of ripening at 20°C and progressively decreased thereafter without showing the ethylene climacteric-like peak during 15 days of ripening (Figure 2). Similar ethylene production patterns have been reported for 'd'Anjou' (8) and 'Bosc' pears (2).

Regardless of the harvest maturity, 'Cascade' pears were incapable of softening normally at 20°C if the fruit had not been exposed to the storage temperature of –1°C indicating that a period of chilling was required for the induction of normal ripening capacity (Data not presented). Except for H1 fruit stored for 1 month, which only softened partially to 27 N, all fruit were capable of softening to a proper ripeness with FF between 9 N and 17 N on day 7 at 20°C, regardless of storage length or harvest maturity (Figure 3).

After 1 to 4 months of air storage at –1°C, EJ of unripe 'Cascade' fruit were about 70 ml per 100 g FW (Table 2) but reduced significantly to 60 ml per 100 g FW after 7 days of ripening at 20°C regardless of harvest maturity (Table 2). As the storage duration increased, EJ of all ripened fruit decreased to a smaller extent. The reduction of EJ in ripened fruit was directly associated with an increase in melting juicy texture quality, which had mean scores greater than 8.0 for fruit stored for 1 month, and gradually decreased to

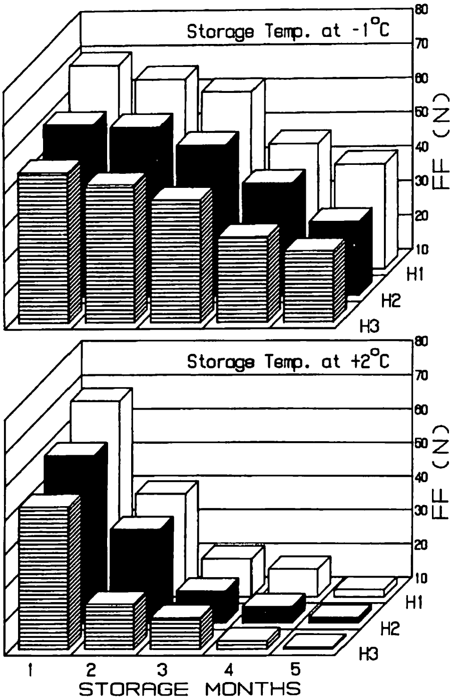

Figure 1. Changes in flesh firmness (FF) of 'Cascade' pears during 5 months of air storage as influenced by two storage temperatures (-1°C and +2°C) and three harvest maturities. LSD$_{.05}$ = 5.6N.

around 7.7 or lower for fruit stored for 4 months (Table 2). Reduction of EJ of ripened pear tissue results from an increase in water-soluble polyuronides in the pulp tissue, which increase the hygroscopic binding capacity of juice (2). Although H1 fruit could ripen with highly melting juicy texture quality regardless of the storage length, the flavor quality was always scored lower than 4.0 by the taste panelists (Table 2). This was due to the lack of distinct aroma for ripened H1 fruit (18). Flavor of ripened H2 and H3 fruit was scored above 7.0 when the fruit had been stored for only 1 month and improved to above 8.0 when the fruit had been stored for 2 months or longer (Table 2). It was evident that the development of flavor of 'Cascade' fruit was associated with later harvest maturities.

In general, TA in H1 fruit was always higher than those in H2 and H3 fruit, regardless of the state of ripeness (Table 2). TA decreased during 4 months of storage, but there were no significant differences in TA between unripe and ripe fruit (Table 2).

SSC in H1 fruit were slightly lower than those in H2 and H3 fruit at each corresponding storage interval (Table 2). There was a highly significant increase in SSC in ripe fruit, when compared to unripe fruit,

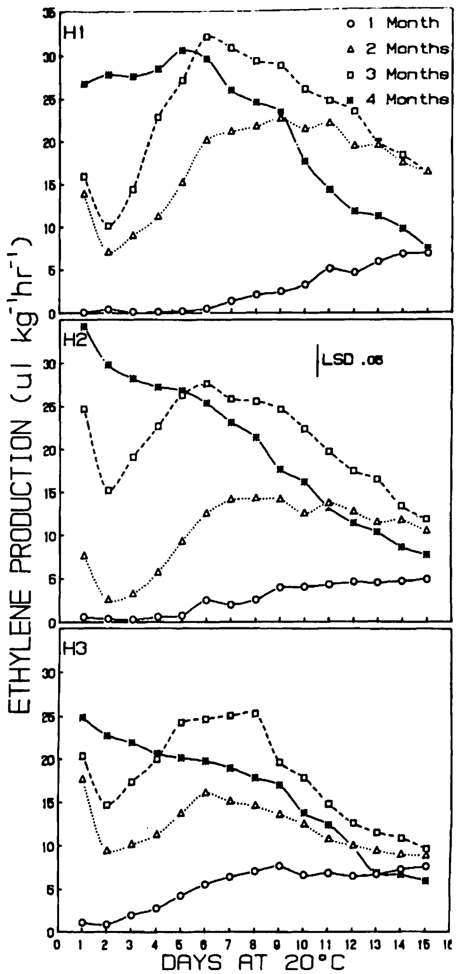

Figure 2. Ethylene production of 'Cascade' pears with 3 harvest maturities during 15 days at 20°C after monthly storage intervals at –1°C. LSD$_{.05}$ = 4.26 µl kg^{-1} h^{-1}.

Table 2. Changes in extractable juice (EJ, ml 100 g^{-1} FW), titratable acids (TA, meq 100 ml^{-1} juice), soluble solids concentration (SSC, %) and dessert quality ratings (score 1-9) of 'Cascade' pears with 3 harvest maturities after 4 monthly storage intervals in air at −1°C. Unripe and ripe fruit referred to the fruit that had been transferred to a ripening room at 20°C for one day or seven days respectively. Dessert qualities were assessed on day 7 at 20°C.

Storage Month	Harvest Maturity[z]	EJ		TA		SSC		Quality ratings	
		Unripe	Ripe	Unripe	Ripe	Unripe	Ripe	Texture	Flavor
1	H1	69.8	47.3	5.34	5.17	13.8	14.6	8.1	3.2
	H2	71.8	48.7	3.92	4.13	14.1	14.5	8.3	7.1
	H3	70.8	57.0	3.26	3.61	14.1	14.7	8.2	7.7
2	H1	68.7	52.4	4.63	4.98	13.7	14.4	8.1	3.6
	H2	71.2	57.0	3.23	3.64	14.1	14.5	8.3	8.4
	H3	72.3	57.7	3.39	3.51	14.2	14.6	7.8	8.8
3	H1	71.8	57.4	4.37	4.01	13.5	13.6	8.3	3.8
	H2	71.7	59.3	3.92	4.03	14.0	14.4	7.7	8.5
	H3	73.3	58.2	3.35	3.90	14.0	14.5	7.9	8.8
4	H1	69.5	61.0	3.69	3.96	12.9	13.2	7.7	3.7
	H2	73.2	61.7	3.32	3.68	13.8	13.7	7.5	8.1
	H3	73.0	56.5	3.46	3.36	13.9	14.1	7.3	8.2
LSD.05		5.1		0.82		0.2		NS	1.1

Source[y]	D.F.	Significance				
M	2	0.0217[x]	0.0000	0.0218	0.6000	0.0000
S	3	0.0000	0.0000	0.0163	0.1169	0.0098
R	1	0.0000	0.1386	0.0032		
MxS	6	0.0212	0.0055	0.3052	0.8945	0.8684
MxR	2	0.5896	0.6506	0.4173		
SxR	3	0.0001	0.9442	0.4565		
MxSxR	6	0.0033	0.7390	0.8787		

[NS]Not significant; [x]The actual significance probabilities.
[z]H1, H2, H3 = Fruit were harvested on 27 August, 5 September, and 15 September 1998 with FF of 77.7, 63.0, and 55.1 N, respectively.
[y]M = Maturity (Harvest 1, 2, and 3); S = Storage (Months); R = Ripeness (Unripe or Ripe).

regardless of harvest maturity (Table 2). The SSC of unripe and, particularly, ripe H1 fruit, and of ripe H2 and H3 fruit decreased significantly after 4 months in storage, whereas SSC of unripe H2 fruit stayed fairly stable with no significant decrease (Table 2). The results imply that changes in both TA and SSC in 'Cascade' pears associated with harvest maturity, storage length and state of ripeness might only affect the acid/sugar ratio of pulp tissue, which is closely related to the taste quality of ripe fruit. Therefore, ripened H2 and H3 fruit should taste sweeter (or less tart) than ripened H1 fruit.

Effect of storage length on ripening behaviors —Fruit stored in air at 2°C

As described above, 'Cascade' pears stored at 2°C for 3 months or longer developed intolerable incidences of internal browning and senescent scald disorders. Therefore, data related to the ripening behaviors after 3 months of storage at 2°C were not presented and discussed.

H1 fruit stored for 1 month produced low rates of ethylene without reaching a climacteric-like peak when they were held at 20°C for 15 days (Figure 4). H2 and H3 fruit stored for 1 month produced higher rates of ethylene as compared to those pro-

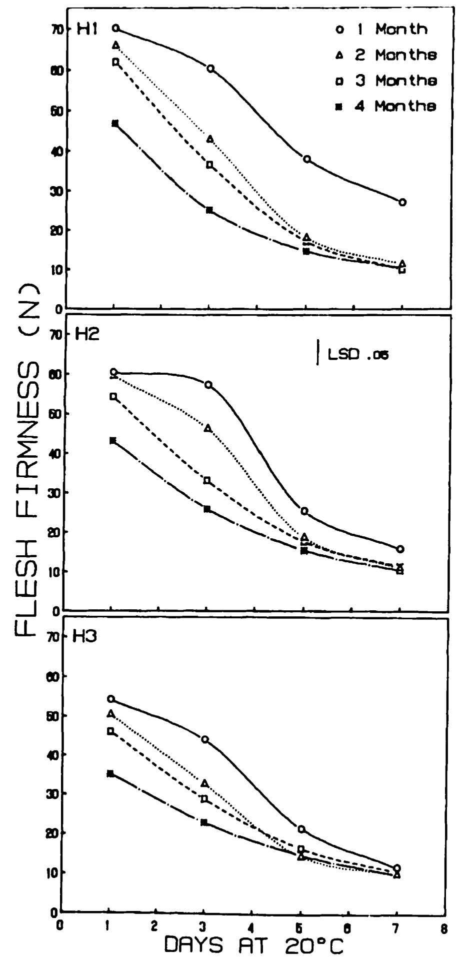

Figure 3. Change of flesh firmness of 'Cascade' pears during a 7-day period of ripening at 20°C after monthly storage intervals at –1°C. $LSD_{.05}$ = 6.23N.

duced by H1 fruit and peaked on day 9 of ripening at 20°C (Figure 4). After 2 months of storage, all fruit produced a high rate of ethylene (approximately 25 μl kg^{-1} h^{-1}) on day 1 of ripening at 20°C, and the rate progressively decreased thereafter without showing the ethylene climacteric-like peak during 15 days of ripening (Figure 4). The results reconfirmed the data of fruit softening and disorders in storage as described above, indicating that the longest storage life of 'Cascade' fruit was only 2 months at 2°C (Figure 1 and Table 1). From the profiles of ethylene production, the physiological state of 'Cascade' pears stored at 2°C for 2 months (Figure 4) was equivalent to that of fruit stored at –1°C for 4 months (Figure 2). It was apparent that the senescence rate of 'Cascade' pears stored at 2°C was much faster than that of the fruit stored at –1°C. Since ripening is part of the senescence process, 'Cascade' pears stored at 2°C are similar in ripening

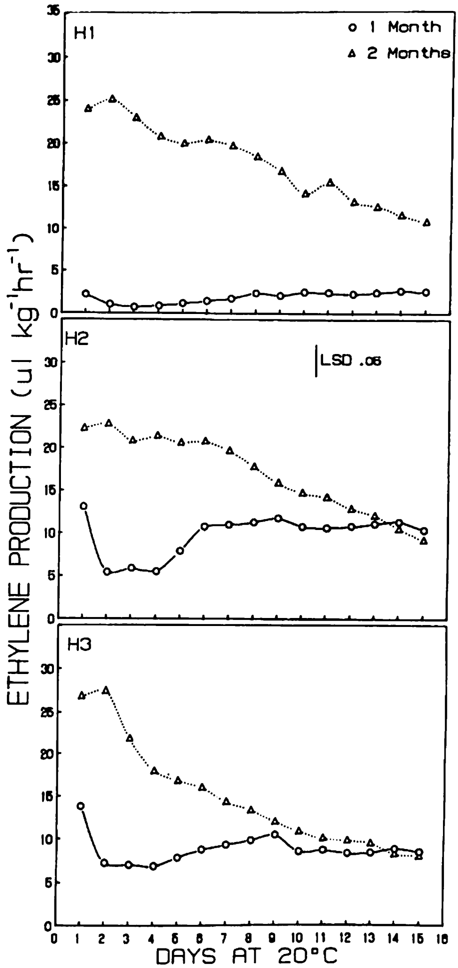

Figure 4. Ethylene production of 'Cascade' pears with 3 harvest maturities during 15 days at 20°C after monthly storage intervals at 2°C. $LSD_{.05}$ = 3.50 μl kg^{-1} h^{-1}.

Table 3. Changes in extractable juice (EJ, ml 100 g^{-1} FW), titratable acids (TA, meq 100 ml^{-1} juice), soluble solids concentration (SSC, %) and dessert quality ratings (score 1-9) of 'Cascade' pears with 3 harvest maturities after 2 monthly storage intervals in air at 2°C. Unripe and ripe fruit referred to the fruit that had been transferred to a ripening room at 20°C for one day or seven days respectively. Dessert qualities were assessed on day 7 at 20°C.

Storage Month	Harvest Maturity[z]	EJ		TA		SSC		Quality ratings	
		Unripe	Ripe	Unripe	Ripe	Unripe	Ripe	Texture	Flavor
1	H1	68.1	49.7	5.63	4.29	14.1	13.7	8.8	3.5
	H2	71.1	54.8	4.87	4.09	14.7	13.5	8.2	8.1
	H3	72.0	58.2	3.42	3.73	13.4	14.2	7.6	8.6
2	H1	68.0	57.9	4.54	4.44	13.5	13.4	7.2	3.9
	H2	70.5	57.3	3.49	4.00	13.6	13.7	7.4	8.2
	H3	67.8	59.5	3.22	3.54	13.0	13.3	6.2	8.6
LSD.05		4.1		0.77		0.7		0.6	1.3
Sources[y]	D.F.	Significance							
M	2	0.0010		0.0000		0.0193		0.0154	0.0000
S	1	0.0446		0.0054		0.0014		0.0006	0.5833
R	1	0.0000		0.2465		0.9366			
MxS	2	0.1239		0.3627		0.7471		0.4885	0.8496
MxR	2	0.0285		0.0354		0.0416			
SxR	1	0.0004		0.0104		0.2110			
MxSxR	2	0.3060		0.1706		0.0370			

[x]The actual significance probabilities.
[z]H1, H2, H3 = Fruit were harvested on 27 August, 5 September, and 15 September 1998 with FF of 77.7, 63.0, and 55.1 N, respectively.
[y]M = Maturity (Harvest 1, 2, and 3); S = Storage (Months); R = Ripeness (Unripe or Ripe).

activities to that described for 'Bartlett' pears stored at 4.4°C (13).

All fruit were capable of softening to a proper ripeness with an approximate FF of 10 N on day 7 at 20°C after either 1 month or 2 months of storage (Figure 5). Although H3 fruit softened to 23 N after 2 months of storage at 2°C, they continued to soften and develop high dessert qualities between day 5 and 7 of ripening at 20°C (Figure 5 and Table 3).

Regardless of storage length, EJ of all fruit stored at 2°C with different harvest maturities decreased significantly to less than 60 ml per 100 g FW on day 7 of ripening at 20°C with a concomitant development of melting juicy texture quality (> 6.0 scores) (Table 3). Similar to those fruit stored at –1°C, H1 fruit were incapable of developing high flavor quality upon ripening (< 4.0 scores), implying that H1 fruit were picked at an immature stage (Table 3).

The decrease in TA in 'Cascade' fruit was weakly associated with the harvest maturity and the storage length, while the changes in SSC were less conclusive (Table 3).

Conclusions

Storage temperature and harvest maturity had significant effects on the storage life of 'Cascade' pears. At –1°C, 'Cascade' pears, regardless of harvest maturity, could remain free from storage disorders during 4 months of air storage. H2 and H3 fruit could be kept in marketable conditions until 4 months of storage at –1°C in air, while H1 fruit had a storage life of 5 months at the same storage temperature. Unfortunately, H1 fruit were incapable of developing commercially acceptable flavor quality upon ripening. At storage temperature of 2°C, 'Cascade' pears at 3 different harvest maturities developed substantial incidences of storage disorders

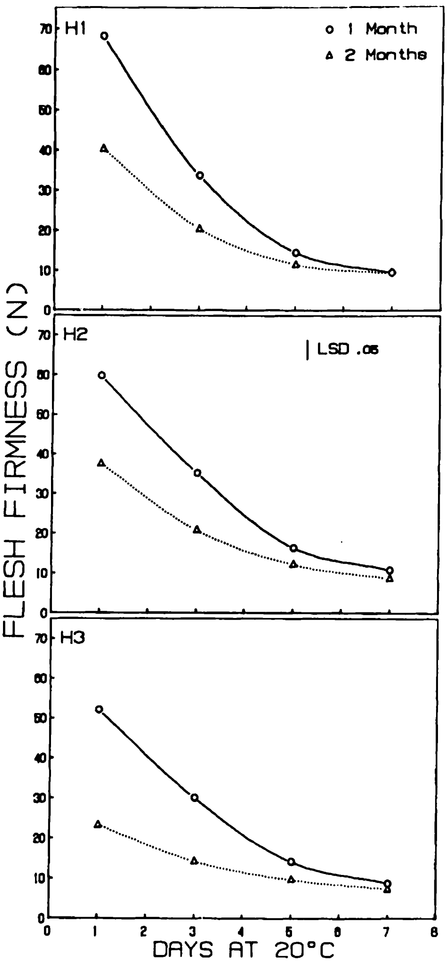

Figure 5. Change of flesh firmness of 'Cascade' pears during a 7-day period of ripening at 20°C after monthly storage intervals at 2°C. $LSD_{.05}$ = 3.39N.

if the storage length was longer than 2 months. Therefore, the longest storage life of 'Cascade' fruit at 2°C was only 2 months. It was concluded that the proper temperature for long-term storage of 'Cascade' pears would be at –1°C, which is typical of many other pear cultivars (9).

In 1998, H2 fruit were picked on 5 September, which was approximately 10 days after the last commercial picking date of 'Bartlett' fruit and exactly 5 days prior to the first commercial picking date of 'Comice' pears grown in Hood River district. The results were not in agreement to the statement that 'Cascade' pears should be harvested during late 'Bartlett' harvest or immediately following 'Bartlett' but before 'Comice' (18). In this study, FF of 'Cascade' fruit at the optimum maturity was between 63.0 N (H2) and 55.1 N (H3), which was far lower than the recommended FF range (between 90 N and 80 N) (18). The reason for this discrepancy is not known, but it is speculated that climatic differences between the fruit growing districts (i.e., Hood River and Medford) are responsible. Further study over a period of years is required to verify the changes in flesh firmness (FF) of 'Cascade' pears during fruit maturation, as influenced by the climatic differences between pear growing districts.

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Apple Flavonoids and UV-B

There was no common effects of UV-B and temp (10°C and 20°C) across 5 apple cultivars. UV-B increased quercetin glycoside in the shaded side of 'Gala,' 'Royal Gala,' and 'Braeburn' fruit only at 20°C. UV-B irradiation of the exposed sides of 5 cvs, of either side at 10°C, and of 'Pacific Rose' and 'Aurora' at either 10°C or 20°C had no effect on quercetin glycoside levels. Levels of chlorogenic acid increased markedly with UV-B irradiation. Both exposed and shaded sides of fruit of all cvs increased in chlorogenic acid levels of 10°C and 20°C after UV-B Irradiation. UV-B irradiation increased anthocyanin levels in exposed and shaded sides of fruit of all cvs at 20°C and on 'Braeburn' and 'Aurora' at both 20°C and 10°C. UV-B at either temp had no effect on either the relative proportions of the glycosides of quercetin or relative proportions of the pyrocyanidins. From Lancaster et al. 2000. J. Hort. Sci. & Biotech 75(2):142-148.

Citrus Leaves and Fruitlet Abscission

In satsuma mandarin trees defoliation shortly after anthesis of old (previous season) or young (current season) leaves increased fruitlet abscission up to 60% during the following 12 weeks. In foliated plants, maximum rate of abscission occurred 41 days after anthesis. In plants without old or young leaves, maximum abscission rates occurred 32 and 54 days after anthesis respectively. Defoliation had little effect on endogenous GA. Carbohydrates were low with the highest conc. 21 days after anthesis when sucrose and hexoses were slightly lower and higher respectively in defoliated plants. Removal of either old or young leaves advanced and increased abscission and reduced the sucrose/hexose ratio of fruitlets during the initial period of fruit set. From Mehouachi et al. 2000. J. Hort. Sci. & Biotech 75(1):79-85.