Postharvest Treatments to Decrease Soggy Breakdown and Soft Scald Disorders Of Honeycrisp Apples

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Several storage operators in New York have experienced high incidences of soft scald and soggy breakdown with Honeycrisp fruit. We know that these disorders are worse when fruit are stored at lower temperatures such as 33°F than at warmer temperatures such as 38°F, but even higher storage temperatures are not adequate for control of the disorders in very high-risk fruit. In our studies of the disorders we found that a 1-week delay in cold storage of harvested fruits eliminate soggy breakdown and soft scald development.

The post-harvest management of Honeycrisp apples is complicated by the development of high incidences of bitter pit, soft scald and soggy breakdown in the fruit. Bitter pit is a calcium-related disorder that can occur on the tree or develop during storage, but can be managed by cultural practices such as calcium spray applications in the field *(Rosenberger in this issue)*. Major disposing factors that have been implicated in the occurrence of soggy breakdown and soft scald in other varieties are over-maturity of fruit at harvest, and preharvest factors such as climate, light crops, large fruit, and vigorous soils. However, the greatest concern about soft scald and soggy breakdown is their random occurrence in the marketplace.

We have been investigating a number of postharvest treatments that might decrease the incidence of soggy breakdown and soft scald in stored Honeycrisp apples. We know that these disorders are worse when fruit are stored at lower temperatures such as 33°F than at warmer temperatures such as 38°F, but even higher storage temperatures are not adequate for control of the disorders in very high risk fruit. Preliminary studies showed that a delay in cold storage that we thought would aggravate soggy breakdown and soft scald development actually eliminated these disorders. We also investigated the effects of diphenylamine (DPA) because it has been shown to control these disorders in other varieties.

Materials and Methods

Honeycrisp apples were harvested from a Western New York orchard on September 17, 1999, and randomized into 24 lots of 40 fruit. In addition, three 10-fruit samples were taken for analysis of maturity. Fruit were then transported to the Cornell University Orchard laboratory in Ithaca. Internal ethylene concentrations (IEC) were measured on the maturity samples. The fruit lots were divided to provide three replicates for each of the following treatments:

1. Stored at 33°F;
2. Stored at 36°F;
3. DPA-treated, and stored at 33°F;
4. DPA-treated, and stored at 36°F;

5-8. Same as 1-4, except that fruit were kept at 50°F for 1 week, prior to cold storage.

DPA treated fruit were dipped in 1000 ppm Shield liquid DPA 15% for 1 minute, allowed to drain for two hours, and placed into cold storage at the same time as non-treated fruit. All fruit were kept in plastic perforated bags during cold storage.

After storage for 12 weeks, fruit were transferred to an evaluation room maintained at 68°F. After one day, IEC, soluble solids content (SSC) and firmness were measured on 10 fruit samples per replicate. On day 7, the firmness and SSC of 10-fruit replicates was again measured, and all remaining fruit assessed for presence of external and internal disorders.

In 2000, fruit were treated as described in 1999, except that a different orchard block in Western New York was used to obtain fruit on September 20, the storage temperatures were 33°F and 37°F, and four replicates were used for each treatment. IEC, firmness, SSC, and titratable acidity were measured at harvest, and after storage for 12 weeks plus 1 or 7 days at 68°F.

In 2001, fruit were treated as described in 1999, except that fruit were obtained from an orchard in the Champlain Valley.

Results

In the first year, incidence of soft scald and soggy breakdown combined was decreased by 9 percent when fruit

were stored at 36°F compared with 33°F, or treated with DPA before storage at 33°F (Table 1A). Without a delay treatment of one week at 50°F, the lowest disorder incidence occurred in fruit kept at 36°F after DPA treatment. However, soft scald and soggy breakdown incidences were markedly reduced by a week at 50°F, and averaged less than 1 percent, irrespective of prior DPA treatment or subsequent storage temperature.

Bitter pit incidence was not affected by storage temperature or DPA treatment, but averaged 25 percent in fruit kept for a week at 50°F compared with 14 percent in fruit without a pre-storage delay (Table 1A). Decay incidence (17 percent overall) was relatively high in fruit after storage, but was not affected by any treatment (data not shown).

Overall, in 2000, the incidence of soft scald and soggy breakdown combined was reduced by higher storage temperatures and by delays at 50°F before cold storage, and by delay at 33°F but not at 37°F (Table 1B). Soggy breakdown incidence was reduced by DPA, but only when no delay treatment was applied. Bitter pit incidence was higher at 37°F than at 33°F, and after delay treatment. The highest incidence occurred in fruit of the elay treatment stored at 37°F. However, DPA reduced bitter pit incidence at 37°F but not 33°F. Decay incidence averaged 5 percent and was not affected by any treatment (data not shown).

Quality of stored fruit was assessed in 1999 by measuring flesh firmness and soluble solids contents of the fruit (data not shown). These averaged 15.8 lb and 13.3 percent, respectively, and were not affected by treatment or shelf life of 1 or 7 day at 68°F after storage (data not shown). IEC were measured only after 1 day at 68°F after removal from storage. Fruit kept at 36°F had 68 ppm ethylene compared with 53 ppm in fruit kept at 33°F (P=0.031), and 69 ppm in DPA-treated fruit compared with 60 ppm in control fruit (P=0.009). No effect of delay treatment was detected. An interaction between temperature and delay was detected however (P=0.019); IECs in fruit kept at 50°F before storage were higher (75 ppm) and lower (45 ppm) than fruit without a delay treatment (average of 60 ppm) when stored at 36 or 33°F, respectively.

A detailed analysis of treatments on fruit quality was also performed in 2000 (Table 2). Firmness was not affected by any factor. Soluble solids contents were lower in fruit stored at 37°F than at 33°F. Informal tasting of fruit, however, could not detect any differences between treatments, and the importance of the small treatment effects on soluble solids and titratable acidity is uncertain.

TABLE 1

Incidence of soft scald, soggy breakdown and bitter pit in Honeycrisp apples either untreated or treated with 1000 ppm DPA, and stored immediately or after a week at 50°F, at 33°F or 36°F (1999), and 33°F or 37°F (2000) for 12 weeks plus 7 days at 68°F.

A. 1999

Treatment	Soft scald and soggy breakdown (%)	Bitter pit (%)
33°F	28	14
36°F	19	11
33°F + DPA	19	11
36°F + DPA	8	18
33°F + delay	2	20
36°F + delay	0	34
33°F + DPA + delay	0	17
36°F + DPA + delay	0	27

B. 2000

Treatment	Soft scald (%)	Soggy breakdown (%)	Bitter pit (%)
33°F	13	7	8
37°F	0	0	13
33°F + DPA	13	3	5
37°F + DPA	0	0	5
33°F + delay	0	0	13
37°F + delay	0	0	40
33°F + DPA + delay	3	0	22
37°F + DPA + delay	0	0	13

TABLE 2

Firmness, soluble solids content, and titratable acidity of Honeycrisp apples either non-treated or treated with 1000 ppm DPA, stored immediately, or after a week at 50°F, at 33°F or 37°F after storage for 12 weeks plus 7 days. (2001)

Effects		Firmness (lb)	Soluble solids (%)	Titratable acidity (% malic acid)
Temperature	33°F	12.2	11.9	0.233
	37°F	12.3	11.6	0.239
	Significance	NS	**	NS
DPA	-	12.2	11.8	0.237
	+	12.3	11.7	0.235
	Significance	NS	NS	NS
Delay	-	12.2	11.7	0.230
	+	12.3	11.7	0.242
	Significance	NS	NS	*
Shelf life	1 day	12.3	11.7	0.255
	7 days	12.2	11.7	0.217
	Significance	NS	NS	***

Discussion

Low storage temperature increases the incidence of soft scald and soggy breakdown in Honeycrisp apples, consistent with the view that these disorders are low temperature injuries. Injury risk for Honeycrisp, therefore, could be reduced by using warmer storage temperatures, e.g. 36-37°F. However, only relatively low volumes of fruit are available because production is still limited. Separate storage facilities to those maintained at 32°F to maintain quality of other varieties in air storage are not always a realistic option, and increasing storage temperatures would compromise quality of the other varieties. In addition, even higher storage temperatures do not control soft scald in fruit that are highly susceptible to development of the disorder.

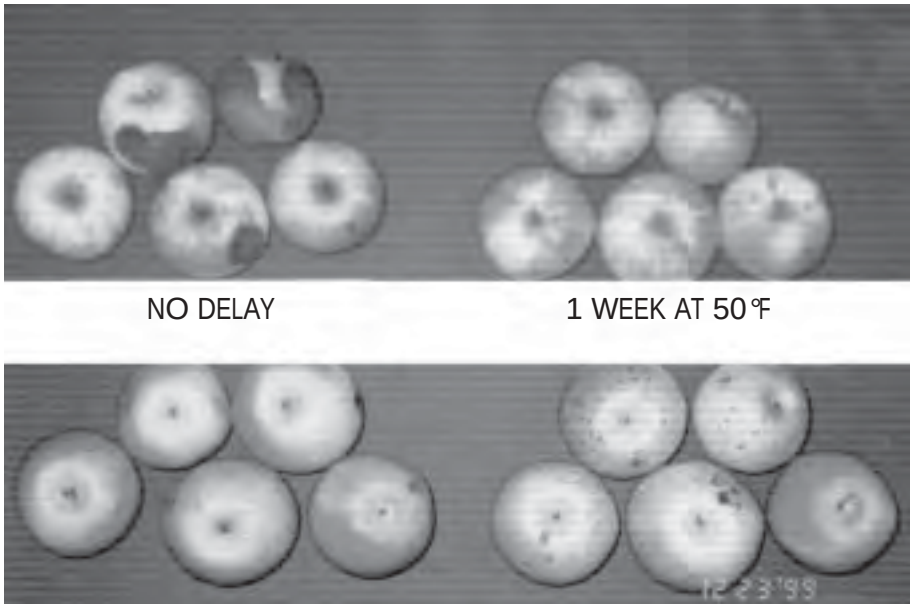

Figure 1. Effect of delay treatment on increasing the incidence of bitter pit in Honeycrisp apple fruit.

DPA has been shown to reduce soft scald development in other varieties, but was not effective enough to prevent the disorder in Honeycrisp when fruit were stored at 33°F. Higher DPA concentrations might allow better control of soft scald and soggy breakdown, but may still be less effective for a highly susceptible cultivar such as Honeycrisp.

We have found that the most effective treatment for control of soft scald is a short storage at 50°F for a week before cold storage, even if the subsequent storage temperature is 33°F. We did not investigate a wider range of delay periods at 50°F, but fruit susceptibility was reduced markedly by as little as one day at 68°F in trials in Massachusetts. The mechanism by which delays before cold storage inhibit development of soft scald is not known.

In general, delays at warmer temperatures before cold storage of apple fruit is discouraged because softening rates and therefore loss of marketable quality can increase. Honeycrisp is a remarkable apple however, with slow softening characteristics. Its firmness is maintained for long periods even under air storage. Our data indicate that firmness and other quality factors were not affected negatively by a 1-week delay at 50°F before cold storage. Informal taste panels using grower groups also indicated that no effects of treatment could be detected during these storage periods. However, the effect of delays before cold storage on quality characteristics for longer storage periods are not known. Therefore, this method should be considered only if fruit will be stored for less than several months in air.

Our greatest concern about use of delay treatments, as well as warmer storage temperatures, is increased bitter pit development as illustrated by Figure 1. Bitter pit incidence is generally increased by postharvest treatments that increase fruit metabolic rates. Therefore, unless the susceptibility of fruit can be decreased by preharvest factors such as calcium spray regimes *(Rosenberger, this issue)* losses of fruit due to bitter pit may be as high as those resulting from soft scald development. Nevertheless, several New York storage operators who sustained major fruit losses due to soft scald development in the past have utilized a delay procedure in their operation. Fruit have been kept in the corridor outside storage rooms for a week prior to cold storage with good results.

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Christopher Watkins is a research and extension professor who leads Cornell's postharvest research and extension in fruit crops. Jackie Nock is a research support specialist who works with Watkins.