Harvest Date Effects on Maturity, Quality and Storage Disorders of Honeycrisp Apples from the Champlain Valley

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Initial enthusiasm for Honeycrisp has been tempered by concern about high incidences of bitter pit, soft scald, soggy breakdown and off-flavors associated with fermentation. This project determined that late harvest and low storage temperatures (33°F) increased the incidence of storage disorders. We recommend that fruit should be harvested as soon as appropriate color and flavor have been obtained. Ideal harvest would be about the second or third week of September in the Champlain region.

The Honeycrisp apple has been planted extensively in New York State, especially in Western New York and the Champlain Valley. The cultivar has outstanding flavor characteristics, and has been reported to remain crisp during air storage for nine months. The unusual crispness can be attributed to maintenance of high turgor potential and cell wall integrity. The industry's initial enthusiasm for Honeycrisp, however, has been tempered by concern about 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 management practices such as calcium spray application. In contrast, the occurrence of soft scald and soggy breakdown (and off-flavors associated with fermentation) in the fruit has been erratic in the marketplace, resulting in loss of confidence in the cultivar.

The symptoms of soft scald (synonym=deep scald) are the development of sharply defined brown lesions on the skin of the apple (Fig. 1), and can extend into the flesh. Susceptible cultivars include Fuji, Jonathan, McIntosh, Delicious and Golden Delicious. Soggy breakdown is an internal disorder, which in the worst cases results in a complete ring of soft, brown, spongy tissue that is often associated with soft scald symptoms (Fig. 2). Soggy breakdown may be present without soft scald, however, resulting in a nasty surprise for the unsuspecting consumer who bites into an affected Honeycrisp (fig. 3).

Major disposing factors that have been implicated in the occurrence of soft scald in several apple cultivars are over-maturity of fruit at harvest, and pre-harvest factors such as climate (dull, cool, wet summers), light crops, large fruit, and vigorous soils. A recent study of fruit from five growing locations in the United States indicated that susceptibility of Honeycrisp fruit to soft scald was affected by growing location, was usually greater in the second of two harvest dates, but was not associated with internal ethylene concentrations (IEC) in the fruit. However, no detailed information exists on harvest indices and the relationship of these to storage performance for Honeycrisp.

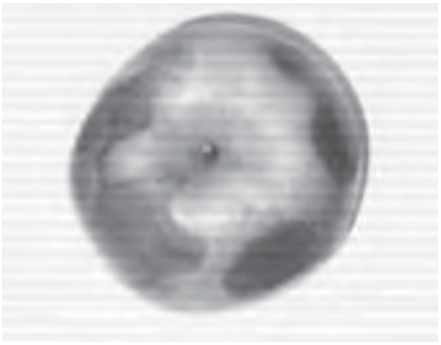

Figure 1. Soft scald on Honeycrisp.

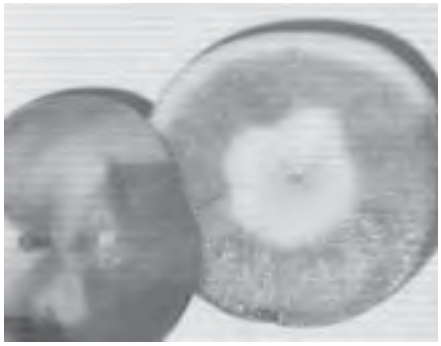

Figure 2. Soft scald and soggy breakdown of Honeycrisp.

Figure 3. Soggy breakdown of Honeycrisp—internal symptoms only with no external symptoms.

The objective of the present study was to investigate harvest date effects on quality, and storage temperature relationships with fruit susceptibility to soft scald and soggy breakdown.

Materials and Methods

In the 2000 harvest season, three orchard blocks were chosen in the Champlain region. These trees ranged from 3- to 5-years-old and were grafted on M.26 (blocks 1 and 2) or Bud.9 (block 3). Fruit were harvested from a minimum of 10 trees in each block on September 14, 21, and 28. The most commercially mature fruit were harvested on each occasion as judged by blush area, which usually was greater than 80 percent. In the 2001 harvest season, two orchard blocks were used for the experiments. Harvest dates were September 10, 17, 24, and October 1.

At each harvest, two replicate samples of 10 fruit were used for assessment of fruit maturity and quality. IEC, starch index, firmness, percent blush and soluble solids concentration (SSC) were measured in 2000 and 2001. Titratable acidity was measured only in 2000.

A further sample of 50-80 fruit was harvested, placed into perforated plastic bags, and stored on the day of harvest at 33 °F or 37 °F (2000), and 33 °F, 38 °F and 42 °F (2001), for 12 weeks (2000) and 16 weeks (2001). Fruit quality after storage was assessed on a 10-fruit sub-sample after further 1 or 7 day storage at 68 °F.

Results

Fruit were harvested on three occasions from three orchard blocks in the Champlain region in 2000, and stored at 33 °F or 37 °F. On the first harvest date (Sept. 14), IEC were high in two of the three orchards, being highest in orchard block 1 (Table 1). However, by Sept. 21, IEC did not increase significantly in orchard block 1, and increased only slightly in the other orchard blocks. On the last sampling date, the IEC of fruit from all blocks decreased rather than showing an autocatalytic rise that is typical of most other varieties. The starch index increased over time, but significant differences among orchard blocks were not detected for the second and third harvest dates. Firmness decreased over time, although there were differences in firmness among fruit from the three orchard blocks. SSC was not affected by harvest date, but varied by orchard block. Titratable acidity decreased over time, but the higher acidity of fruit from orchard block 1 compared with the other fruit was not consistently significant.

The incidences of soft scald and soggy breakdown were affected by harvest date and storage temperature (Table 2). Because within orchard block replication was not used, it is not possible to determine the significance of among-block differences. Nevertheless, the incidence of both disorders increased markedly with advancing harvest date; overall incidence at 33 °F was 5 to 7 percent on Sept. 14 compared with 82 percent on Sept. 28. However, incidence of the disorders in fruit harvested on Sept. 21 increased only at 33 °F. Even at the Sept. 28 harvest, the increased incidence, while averaging 39 percent, was lower at 37 °F than at 33 °F. Bitter pit and decay incidences were not affected by harvest date or temperature (although fruit could not be assessed on Sept. 28 because of the high soft scald and soggy breakdown incidences). The percentage of greasy fruit was higher at the Sept. 21 harvest

TABLE 1

Internal ethylene concentrations (IEC), starch index, firmness, soluble solids content (SSC) and titratable acidity in Honeycrisp apples harvested in the Champlain Valley, New York, on September 14, 21 and 28, 2000.

Harvest date (2000)	Orchard block	IEC (ppm)	Starch Index (1-8)	Firmness (lb)	SSC (%)	Titratable acidity (% malic acid)
Sept. 14	1	24.4	5.7	14.9	13.1	0.57
	2	0.4	4.6	13.7	11.0	0.41
	3	3.0	4.8	15.5	11.7	0.44
	Average	9.3	5.0	14.7	11.9	0.47
Sept. 21	1	29.2	6.0	14.6	12.6	0.42
	2	13.8	5.5	13.3	11.5	0.33
	3	12.4	5.9	14.5	11.8	0.40
	Average	18.5	5.8	14.1	11.9	0.38
Sept. 28	1	1.9	6.8	13.6	12.9	0.38
	2	7.1	7.2	12.3	11.3	0.27
	3	3.6	6.7	13.7	12.6	0.33
	Average	4.2	6.9	13.2	12.3	0.33
Significance						
Harvest date (H)		***	***	***	NS	***
Orchard block (O)		***	*	***	***	***
H x O		***	**	NS	NS	*

TABLE 2

Incidences of soft scald, soggy breakdown, bitter pit, decay and greasiness of Honeycrisp apples harvested in the Champlain Valley, New York, on September 14, 21 and 28, 2000 and stored in air at 33°F or 37°F for 12 weeks. Fruit (n = 50-80) were evaluated after a further 7 d at 68°F.

Harvest date (2000)	Orchard block	Soft scald (%)		Soggy breakdown (%)		Bitter pit (%)		Decay (%)		Greasiness (%)	
		33°F	37°F	33°F	37°F	33°F	37°F	33°F	37°F	33°F	37°F
Sept. 14	1	12	3	18	3	15	13	0	10	0	55
	2	3	0	3	0	0	0	0	0	5	44
	3	0	0	0	0	6	0	0	0	10	57
	Average	5	1	7	1	7	4	0	3	5	52
Sept. 21	1	52	0	52	0	33	54	7	5	56	82
	2	26	0	33	0	9	13	0	0	20	56
	3	58	3	64	3	8	8	0	0	25	53
	Average	45	1	49	1	17	25	2	3	34	64
Sept. 28	1	97	42	97	42	nd[z]	nd	nd	nd	nd	nd
	2	78	48	78	48	nd	nd	nd	nd	nd	nd
	3	70	28	70	28	nd	nd	nd	nd	nd	nd
	Average	82	39	82	39						
Significance											
Harvest date (H)		***		***		NS		NS		*	
Temperature (T)		***		***		NS		NS		***	
H x T		**		**		NS		NS		NS	

[z]nd Non detectable because of high soft scald incidence. ANOVA for harvest date and temperature performed only on Sept. 14 and Sept. 21 harvest dates.

TABLE 3

Firmness, soluble solids content (SSC), and titratable acidity of Honeycrisp apples harvested in the Champlain Valley, New York, on September 14, 21 and 28, 2000, and stored at 33°F or 37°F for 12 weeks plus 7 d at 68°F.

Main effects		Firmness (lb)	Soluble solids (%)	Titratable acidity (% malic acid)
Harvest date	Sept. 14	14.3	12.3	0.30
	Sept. 21	13.6	12.4	0.28
	Sept. 28	12.9	12.1	0.24
Significance		***	*NS*	**
Temperature	33°F	13.7	12.4	0.28
	37°F	13.6	12.1	0.26
Significance		NS	NS	NS
Shelf life	1 d	13.5	12.4	0.29
	7 d	13.7	12.8	0.25
Significance		NS	NS	**

TABLE 4

Incidences of soft scald, soggy breakdown, bitter pit, and decay of Honeycrisp apples harvested in the Champlain Valley, New York, on September 10, 17, 24 and October 1, 2001 and stored in air at 33°F, 38°F or 42°F for 16 weeks. Fruit (n = 50-80) were evaluated after a further 7 days at 68°F.

Harvest date (2001)	Temperature (°F)	Soft scald (%)	Soggy breakdown (%)	Bitter pit (%)	Decay (%)
Sept. 10	33	18	20	0	0
	38	0	0	8	0
	42	0	0	5	5
Sept. 17	33	47	57	0	3
	38	19	19	0	14
	42	1	1	1	39
Sept. 24	33	56	75	0	1
	38	11	12	0	1
	42	1	0	5	5
Oct. 1	33	71	86	0	0
	38	41	54	0	2
	42	0	0	0	34
Significance					
Harvest date (H)		**	***	**	NS
Temperature (T)		***	***	*	*
H x T		NS	NS	*	NS

TABLE 5

Effects of harvest date and storage temperature on quality attributes of Honeycrisp apples harvested in the Champlain Valley, NY, on September 10, 17, 24 and October 1, 2001 and stored in air at 33°F, 38°F or 42°F for 16 weeks. Factors were rated on a scale of 0=low, to 100=high.

Harvest date (2002)	Appearance	Texture	Flavor	Overall acceptability
Sept 10	50	61	52	44
Sept 17	56	56	45	42
Sept 24	69	62	52	46
Oct 1	70	52	42	42
Significance	***	NS	NS	NS
Storage temperature (°F)	**Appearance**	**Texture**	**Flavor**	**Overall acceptability**
33	59	59	33	25
38	63	62	53	55
42	62	53	38	41
Significance	NS	NS	***	***

than the Sept. 14 harvest, and at 37°F compared with 33°F.

Firmness and SSC were not affected by temperature or any other factor, and titratable acidity decreased with advancing harvest date and shelf life period (Table 3).

In 2001, fruit were harvested from two Champlain, NY, orchards and stored at 33°F, 38°F and 42°F for 16 weeks. At harvest, the overall IEC was barely different between orchards, averaging 9.6 and 7.5 ppm for orchard 1 and 2 respectively. The IEC differed among harvest dates averaging 7.3, 5.4, 12.4, and 9.1 ppm for harvests on Sept. 10, 17, 24, and Oct. 1, respectively. However, no interaction between orchard block and harvest date was detectable. The starch index was not affected by orchard block, but increased over harvest date averaging 5.8, 6.8, 7.5, and 7.7 units for harvests on Sept. 10, 17, 24, and Oct. 1, respectively. Differences in starch index between fruit from different orchards occurred only at harvest 1. Fruit softened with advancing harvest date, being 14.6, 13.6, 13.4, and 12.1 lb for harvests on Sept. 10, 17, 24, and Oct. 1, respectively. SSC was affected by orchard block but not by any other factor (data not shown).

After storage, soft scald and soggy breakdown occurred in fruit from the Sept. 10 harvest only at 33°F, but were present in fruit at both 33°F and 38°F from the other harvests (Table 4). While incidence of both disorders was lower at 38°F than at 33°F, disorder incidences were high even at 38°F. Fruit kept at 42°F had essentially no incidence of either disorder but did have higher, though variable, rot incidence. Bitter pit incidence was affected by harvest date and storage temperature, but not in a consistent fashion.

Only fruit firmness was assessed in 2001. No effect of storage temperature was detected (data not shown), although firmness declined with advancing harvest date. Fruit evaluations using an untrained panel found that the only factor that was affected significantly by harvest date was appearance (Table 5). Averaged over all harvest dates, flavor and overall acceptability were highest for fruit stored at 38°F. Comments indicated that this was due mainly to alcoholic off-flavors in fruit at 33°F and lack of flavor at 42°F.

Conclusions

Soft scald and soggy breakdown development is increased by exposure of

fruit to storage temperatures of 33 °F, especially those from later harvest dates. In late September/early October, even a higher storage temperature of 37 °F or 38 °F did not control the disorder. Storage at 42 °F controlled these disorders but resulted in higher decay and less acceptable flavor. Although advanced fruit maturity, e.g. block 1 in mid September, 2000, was sometimes associated with soft scald development, no consistent association was found that would link IEC to harvest date and storage incidence. This study did not identify any single factor that is related to fruit susceptibility to soft scald.

The major recommendations from this work are that fruit should be harvested as soon as appropriate color and flavor have been obtained. Based on the results from 2000 and 2001 season, ideal harvest would be about the second or third week of September in the Champlain region. Of the maturity indicators available, starch may be useful as a guide to over-maturity, and we tentatively suggest an index of 6 as a cut-off for harvest of fruit for long term storage in the Champlain region. A storage temperature of 38 °F is recommended. Storage operators need to find a way to ensure a dedicated room is available, especially as crop volume increases.

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 Chris Watkins at Cornell University. Kevin Iungerman is a Cornell University regional extension specialist in Northern NY.