Extending Shelf-Life, Marketing Window, and Quality of Sweet Cherries in New York

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Sweet cherries (*Prunus avium* L.) are an excellent summertime snack food, with other uses as well. With the new USDA food guide recommendations that direct people to fill half their plates with fruit and vegetables, health-conscious consumers will be looking to add more variety to their diets (USDA, 2011). Sweet cherries are high in vitamin C and fiber and also contain several key phytonutrients such as carotenoids, quercetin, and anthocyanins (Kim et al., 2005). We expect that consumption of sweet cherries and other fresh produce will continue to rise as the fight to reduce obesity (especially in children) and illnesses such as diabetes intensifies. The "buy local" movement, in which consumers want to reduce food miles and contribute more of their dollars to the local economy, should also help increase consumption. Supplying local and regional supermarket chains, farmer's markets, along with pick your own enterprises, should generate increased sales.

"Modified atmosphere packaging (MAP) can be a useful tool to extend the season and marketability of sweet cherries. Growers who have a surplus of fruit that respond well to MAP can use this technology to their advantage selling local sweet cherries in the marketplace at a time when there is still demand to buy local. However, 6 years of trials with over 20 different cultivars has shown clear varietal differences in response to the effectiveness of MAP. Each individual variety must be tested in small lots by individual growers to make sure the varieties can meet quality standards for sale."

Unfortunately, sweet cherries have a relatively high respiration rate and therefore are a very perishable commodity with a short shelf life of 7-14 days in conventional cold storage. In addition, the local sweet cherry season is typically about 3 weeks long. Thus in many cases, the fruit must be sold at low prices to expedite movement and prevent complete losses that can occur once the fruit quality declines below market standards (Padilla-Zakour et al., 2007). Pressures on large retail buyers to lock in low prices on bumper crops of fruit from the Pacific Northwest prior to the start of the local season further complicates marketing locally. Another caveat is untimely rain events just prior to harvest, which can crack and split significant amounts of fruit and further reduce the chances of large wholesale local buyers purchasing significant volumes of sweet cherries grown in the region.

In recent years, the use of Modified Atmosphere Packaging (MAP) has been used to extend shelf life in many types of produce. MAP designed specifically for sweet cherries has gained acceptance in many of the larger sweet cherry production areas in the world, such as in the US (Pacific Northwest), Europe, and Australia. The principle use in MAP for sweet cherries in some of these regions has been to allow the use of cheaper transportation (via ship instead of air freight, for example) to overseas markets. In contrast, smaller production areas such as the Eastern US can make use of MAP for season extension of such a short growing season. For example, a large crop of a certain variety that holds up well in MAP can be marketed over a period of 4-6 weeks, instead of 10-14 days. Extending the marketing window for high quality local cherries may further raise public awareness of the availability of healthy, quality fruit and increase consumption. In this article we present a continuation of the research that was presented in two past NYFQ issues (Kahlke et. al., 2009 and Padilla-Zakour et. al., 2007).

NY Trials 2005-2009

Past work has shown the use of MAP alone cannot guarantee good quality. The correct variety, along with specific cultural practices and rapid cooling, disinfecting at harvest, and packing relatively quickly following harvest, work in concert to extend shelf-life and quality. Research by Padilla-Zakour et al. (2007) has shown that shelf life is optimized best with MAP in sweet cherries by a combination of treatment in the field with gibberellic acid, harvest at optimum maturity, rapid cooling of cherries after harvest by hydrocooling with proper fungicide application, proper sorting of fruit defects and debris prior to MAP, and refrigerated storage at 38°F or lower. The above treatments have extended cherry storage life to as long as 30-45 days in certain varieties.

However, 6 years of trials with over 20 different cultivars has shown clear varietal differences in response to the effectiveness of MAP. Each individual variety must be tested in small lots by individual growers to make sure the varieties can meet quality standards for sale. The fruit must be free from major blemishes, have intact stems with green stem color, and have acceptable taste and texture. Another precaution to be taken with MAP is if fruit is not properly cooled before packaging, condensation can form and anaerobic conditions may result, leading to product spoilage (Rai et al., 2002). This was confirmed locally by growers who had problems with their coolers, or who did not properly cool their cherries to below 40°F before packing them in the MAP. There were also reported differences in results that were likely based on harvest maturity. Over-ripe or overly soft fruit going into the MAP bags do not fare as well as fruit harvested at the correct or slightly under-ripe maturity. Harder cherries tend to fare better

than softer and overly large cultivars. Light, or white/yellow-fleshed cherries will show bruising and blemishes clearer than dark varieties.

Chemical analysis was done for most varieties tested in most years. In many cases, comparisons were made between brix, acid, and titrateable acidity levels of cherries at harvest, and at 4 + weeks after storage in MAP bags and in un-bagged controls. Overall, the brix and pH were slightly lower in the MAPs compared to the un-bagged controls at 4+ weeks, although not always. This was probably due to the significant water loss in the controls, leading to higher brix. Higher brix and almost no water loss in the MAP indicates lower TA and higher pH. Color analysis was also done in 2008. Darker cherries tended to be darker in the MAPs as compared to the un-bagged controls, and the whiter-fleshed cherries ('Emperor Francis') tended to be lighter in the MAP. In all cases, gas analysis was performed in the MAP at 10-15 days. CO_2 concentrations ranged from 3.5-14.1%, while O_2 ranged from 6.6-15.0%, within the manufacturer's recommended range in nearly all cases.

2010 Studies

In 2010 we received a Northeast SARE partnership to continue trying the MAP liners with some of the cultivars that have worked in the past, and extending its use on different farms. In addition, some new varieties not previously tried were tested. A major difference between the on-farm trials in 2010 compared to 2008 & 2009, is that rapid cooling methods (hydro-cooling plus a disinfectant or fungicide) were compared with static cooling methods in 2010. This was done for three of the cultivars that were previously found to be promising, at three different farms. Six sweet cherry growers named as cooperators on this project ended up choosing 1-4 varieties that had shown promise with previous MAP testing or that had not been tested before. The growers each used their standard pre-harvest practices followed by their usual method of harvest (hand-harvest at acceptable maturity), followed by sorting/culling, in which the grower's crew graded and discarded fruit with defects such as cracking or splitting, and removed leaf and other debris. Following sorting (for most studies) fruit were cooled overnight statically in a grower's cooler at temperatures between 32-39°F. The following day, weighing and packing was done. The fruit were weighed and packed into MAP bags or put loose in cardboard boxes (controls) by the project leader. In most cases, 3 replicates of 20 pounds of sweet cherries went into MAP, and ten pounds of un-bagged controls went loose into 2 cardboard boxes. For some studies, 10 pounds of cherries were put into the smaller 10 pound MAP liners. In all studies, the MAP were either Lifespan L204 20-pound or L212 10-pound bags designed for sweet cherry storage (courtesy of Chris King, Amcor, Australia). The air was pushed out of the MAP after packing, and special twist ties were put on. All fruit were then put back in the grower's coolers. A technician from the NYSAES measured CO_2 and O_2 concentrations in the MAPs 12-15 days after the packing of cherries in liners. All atmospheres were within recommended levels. Evaluations began at 4 weeks after packing, +/- 3 days.

At 4 weeks post-packing, evaluations began visually, looking at the fruit through the clear MAP bags, and noting condition. Control fruit were also examined visually to start. Notes were made of stem color, approximate percentage of rots, splits, or pits, and if the cherries appeared to be dehydrated or drying out. One replicate MAP was then opened, and 20 fruit were taken randomly from all portions of the liner. The numbers of rots, pits, and splits were recorded. In addition, stem color, and percentage of stems missing were noted. Remaining fruit with stems were pulled with increasing force and rated on stem hold.

Following this analysis the grower and/or project leader tasted a handful of cherries, and rated the flavor and texture. In concert with taste, overall appearance, and stem color/hold, a marketing rating was given. An explanation of these 4 marketing categories follows: Unacceptable – the grower could not sell these cherries (too many rots, pits, brown stems, etc.); Fair – if the farmer had no other cherries, and culled out the rots, pitted cherries, etc., they may sell some; Acceptable – they are not going to be confused with fresh picks (a few rots, perhaps stem color not bright green), but the flavor/texture was acceptable; Fresh – these cherries are nearly indistinguishable from fresh-picked cherries (very few culls- green stems, very few missing stems, no off-flavors, very good flavor/texture).

If the 4 week (+/- 3d) MAPs were Acceptable or Fresh, the other 2 replicates remained sealed until the following week, and the evaluations were repeated. If the 4 week MAP was Fair or Unacceptable, the experiment was terminated. Un-bagged controls were kept for comparison purposes for the duration of the experiments. If the 5 week (+/- 3d) evaluations were Acceptable or Fresh, the last replicate remained sealed another week, and final evaluations were then done at 6 weeks (+/- 3d). If the 5 week MAP was Fair or Unacceptable, the experiment was terminated.

If a grower chose a variety for comparison of hydro-cooling versus static-cooling, the following methods were used: For the unhydrocooled treatment, growers harvested sweet cherries by hand at acceptable maturity. Immediately following harvest, fruit were sorted and culled as described previously. The fruit was then cooled overnight statically in a grower's cooler at temperatures between 32-39°F. The following day, the cherries were than weighed and packed into MAPs or put loose in cardboard boxes by the project leader as previously described. For the hydro-cooled treatment, the same variety was harvested from the same block one day after the statically-cooled fruit were harvested. After harvest, fruit was hydro-cooled for in a stainless steel tub with chlorinated (50-100 ppm, pH 7) cold water (~ 35°F) for 10-20 minutes. In addition, one grower used Scholar fungicide at a rate of 4 liquid ounces of Scholar (fludioxonil) per 100 gallons of water in the tub. The third grower (3rd variety) hydro-cooled with a cascading hydro-cooler with chlorinated (50-100 ppm, pH 7) cold water (~ 35°F) for 10-15 minutes. In addition, the grower used Scholar fungicide at a rate of 4 liquid ounces of Scholar per 100 gallons of water in the hydro-cooler. Sweet cherries were packed as described above, but with 3 MAP replicates per hydro-cooled treatment, plus 3 MAP replicates per statically-cooled treatment. There were 2 replicates each of un-bagged controls for the hydro-cooled and statically-cooled fruit. Evaluations were done as described earlier.

2010 Results

Budbreak, full bloom, and harvest dates were very early in 2010, and harvest ended up being 1-2 weeks ahead of normal. The growing season was characterized by timely rains, and development of near record growing-degree days due to the earliness of budbreak. However, there was no period of extreme heat, drought, rain, or severe weather. With a few exceptions, most tree fruit growers in

Table 1. Summary of Western New York, modified atmosphere packaging studies with sweet cherries in 2010.

Cultivar	Farm ID	Static- Cooled	Hydro-Cooled	Controls (un-bagged)	Rating at 4 weeks	Rating at 5 weeks	Rating at 6 weeks
Sam	F	X			Acceptable	Acceptable	Acceptable
Sam	F			X	Unacceptable	Unacceptable	Unacceptable
Sam	D	X			Acceptable	Fair/Unaccept	
Sam	D			X	Fair/Unaccept	Unacceptable	
Sam	B	X			Fair/Unaccept	Unacceptable	
Sam	B		X		Fair/Unaccept	Unacceptable	
Sam	B			X	N/A *	N/A *	
Hudson	F	X			Accept./Fresh	Acceptable	Acceptable
Hudson	F			X	Fair/Unaccept	Unacceptable	Unacceptable
Hudson	D	X			Acceptable	Fair if culled	
Hudson	D			X	Fair/Unaccept	Unacceptable	
Hudson	E	X			Fair-Acc if culled	Fair-Acc if culled	Fair if culled
Hudson	E		X		Acceptable	Acceptable	Acceptable
Hudson	E			X	Fair/Unaccept	Unacceptable	Unacceptable
Hudson stems	C	X			Acceptable	Acc, some stem loss	Acc. if cull Brown
Hudson	C			X	Fair-Acc if culled	Unacceptable	Unacceptable
Emp. Fran.	C	X			Accept./Fresh	Accept./Fresh	Acceptable
Emp. Fran.	C			X	Unacceptable	Fair/Unaccept	Unacc., Fair if culled
Emp. Fran.	E	X			Acceptable	Unacc. Fair if culled	
Emp. Fran.	E			X	Unacceptable	Unacceptable	
19's	A	X			Acceptable	Acceptable	
19's	A		X		Acceptable	Acceptable	
19's	A			X	Unacceptable	Unacceptable	
Summit 40 F	F	X			Fair-Acc if culled		
Summit 40 F	F			X	Fair if culled		
Summit 50 F	F	X			Fair if culled		
Summit 50 F	F			X	Unacceptable		
Hardy Giant	E	X			Acc., some culls	Fair, but many culls	Unacceptable
Hardy Giant	E			X	Unacceptable	Unacceptable	Unacceptable
Honey	E	X			Fair-Acc if culled	Fair if culled	
Honey	E			X	Fair	Unacceptable	

N/A * - cherries discarded by accident prior to evaluation at 4 weeks.

Western NY agreed that 2010 was one of the best growing seasons on record. Untimely rains just prior to anticipated harvest did cause some significant rain-cracking in a few cases. Fruit size and quality of sweet cherries at harvest were good to excellent. Fruit for this study were harvested at proper maturity, were free from brown rot, and properly cooled after harvest, with one exception, in which there was a cooler failure. Thus, it could be argued that the 2010 growing season represented a "best case scenario" for sweet cherry quality, when they were packed into MAPs. Table 1 has a summary of each variety/location tested.

Nearly all of the varieties tested had similar results in storage life, taste, texture, stem color, stem hold, and stem loss across the different farms. There were a few exceptions. As predicted, sweet cherry quality and marketability were better in hydro-cooled fruit as compared to statically-cooled fruit in most cases. The addition of a fungicide in 2 of the hydro-cooling treatments reduced the number of rots as compared to statically-cooled treatments with no fungicide. For the variety Sam, the MAP cherries were still saleable after 6 weeks for 1 grower, and after 5 weeks for another. The 3rd grower had unusual pitting in the MAP fruit at 4 weeks that could not be explained. Fruit was unacceptable at 4 weeks. It should be noted that the MAP manufacturer indicates that pitting is not caused by the liners, it is primarily caused by impact damage below the epidermis. Perhaps rough handling at harvest was a factor. Hudson was another promising variety that was tested at 4 farms in 2010. On 1 farm, the fruit were still saleable at 6 weeks, and the other 3 were saleable at 5 weeks. With Emperor Francis, one farm had saleable fruit at 6 weeks, and the other was good at 5 weeks. Three varieties (19, Summit, and Honey) that were not previously tested were included in the study. 19 showed excellent promise, and storage up to 5 weeks. It is interesting to note that the hydro-cooled 19's had noticeably firmer fruit than the static treatment. However, the hydro-cooled treatment had burned stem tips, probably indicating exposure to chlorine too long or at too high a concentration. Summit had some temperature issues at harvest (the cooler failure) and subsequently the fruit were not properly cooled before packing, causing an unacceptable number of rots. Honey bruised too easily and lost too many stems, even though the flavor was still good. The previously stated theory seemed to hold for 2010 as well- firmer cherries seem to do better in MAPs than larger, softer cherries. In addition, some cultivars like Regina have a sensitivity to the high levels of CO2 in the liners, and develop an off-flavor, and therefore are not recommended for MAP use.

Impact of Results/Outcomes/Economics

A summary of the results of the past 6 years of research for 22 cultivars is presented in Table 2. Even if 30% of fruit is culled after 4-6 weeks, this is fruit that is in demand after all fresh cherry supplies are exhausted. One grower sells her MAP sweet cherry fruit at Farmer's Markets, and can get a premium for the fruit. Another grower puts about 20,000 pounds of a certain variety in MAP each year, and sells them from 2-5 weeks after harvest. In addition, MAP liners are inexpensive. The current cost of the

Table 2. MAP Sweet Cherry Variety Summary 2005-2010.

Cultivar	# yrs Tested	# farms Tested	Range in MAP with acceptable quality (weeks PH)[1]	MAP Stem Color at max storage[2]	Stem Hold/ Loss[3]	Taste/ Texture	Notes
19	2	1	4.5-5	G-Y	NS	good	Hydro-cooled fruit were firmer than static cooled at analysis
Black Gold	1	1	4.5	G-Y	NS	good	Only 1 year/1 farm testing
Cavalier	1	1	4	G-Y		good	Only 1 year/1 farm testing
Columbian	1	1	3	G-Y	NS	good	Only 1 year/1 farm testing
Emperor Francis/ Queen Anne	3	3	5-6	G-Y	NS	good	Texture still very crunchy at 6 weeks, however, flavor has been described as bland
Hardy Giant	3	1	3-5	G, G-Y	NS	good	This variety will not store well in liners if fruit are over-mature or soft
Hartland	1	1	4	G	slightly loose	good	Only 1 year/1 farm testing
Hedelfigen	4	4	NR, see notes	G-Y	see notes	see notes	In 2009, one grower reported good quality after nearly 4 weeks in liners, while 2 growers reported off-flavors and severe breakdown. A previous multi-year NYSAES study reported good quality at 4 weeks, but with stem loss of 60-80% after 30 days, with flavor deteriorating rapidly after 30 days.
Honey	1	1	3-4?	mainly G	see notes	see notes	This variety bruised easily – future trials recommended with leaving air in liners. Stems loosening after 4 weeks, significant stem loss at 5 weeks.
Hudson	2	4	5-6	mainly G	NS	see notes	This variety has done the best in MAPs out of the 22 cultivars tested in NY. Texture is nearly the same as the day they are packed. Flavor is still quite good, but distinguishable from fresh-picked.
Lapin	3	1	4	G, G-Y	see notes	good	Stem loss and hold did not accelerate until after 30 days.
Oxheart	1	1	4	G-Y	NS	see notes	Only 1 year/1 farm testing, lots of rots, but non-culls tasted and looked acceptable.
Rainier	1	1	4-6?	G-Y	NS	good	MAP industry standard for the Pacific NW. Leave air in liners to avoid bruising.
Regina	4	4	NR, see notes	NS	see notes	see notes	All 3 growers in 2009 had total failure in MAPs with Regina – reporting sour tinny off-flavors, and flesh turning white after only 10-15 days. However, in multiple NYSAES trials, eating quality was very good 30 days, and still acceptable after 50 days, but stem loss and hold accelerated after 30 days.
Royalton	1	2	4?, see notes	G-Y	see notes	see notes	Conflicting results on 2 separate grower tests in 2008. One had poor stem color with acceptable eating quality, while the other had good stem color/hold/loss compare to un-bagged controls, but unacceptable eating quality. This obviously warrants further testing.
Sam	3	4	4-6, see notes	G, G-Y	see notes	good	Stem loss and hold is good for most growers at about 4 weeks, but progressively gets worse beyond that time. However, 1 grower still had good stem hold and color with minimal stem loss at over 6 weeks PH in 2010.
Schmidt	2	2	3.5-4?, see notes	G-Y	see notes	good	Schmidt has tasted among the best emerging from the MAPs, however, stem loss and hold seem to be a problem.
Summit	1	1	?, see notes	G-Y	NS	See notes	Cooler failure occurred shortly after this variety was packed, but some fruit looked/tasted acceptable at 4 weeks, but there were to many rots to warrant continuation.
Sweetheart	4	2	4-4.5? see notes	G, G-Y	NS	see notes	In multiple NYSAES studies, eating quality was acceptable 30 days. In a grower study in 2009, improper cooling may have caused cherries to be discarded after only 3 weeks?
Van	1	1	? see notes	G-Y	NS	good	Only 1 year/1 farm testing - flavor and quality were good, but liners were opened and cherries sold after only 19 days.
Vic	1	1	? see notes	G-Y	NS	good	Only 1 year/1 farm testing- grower noted that this cultivar may be too soft for MAP use; liners were opened and cherries were culled/ sold in under 4 weeks.
White Gold	1	1	4.5?, see notes	G-Y	NS	good	Only 1 year/1 farm testing- but grower said cherries looked great and tasted fresh after 32 days.

Range in MAP w/acceptable quality (weeks postharvest (PH)[1] NR= not recommended for use in MAP liners

MAPs are approximately 50 cents per 10 or 20 pound liner. In a survey of over a dozen sweet cherry growers in 2009, all indicated this was affordable. Many growers have indicated that they cannot sell all of their fresh supply of certain varieties in time before spoilage occurs. This would be a viable option for growers with the right varieties.

The use of MAP can be a useful tool to extend the season and marketability of sweet cherries. The proper use of MAP on the correct varieties in concert with proper care of cherries during the growing season (control of brown rot and the recommended use of giberellic acid), harvest at correct maturity, and proper grading and cooling, can extend shelf life up to 6 weeks postharvest. Growers who have a surplus of fruit that respond well to MAP can use this technology to their advantage selling local sweet cherries in the marketplace at a time when there is still demand to buy local.

Areas Needing Additional Study

New varieties and those cultivars that have not been previously tested need to be tried, at least on a small scale to start. In addition, even cultivars that have worked successfully on other farms need to be tried on a small scale first on individual farms. The ease of use and fact that cherries can be visually evaluated quickly (the liners are clear, so it is easy to see though the bags and look at them without opening and ruining the concentrations of CO_2 and O2) will enable farmers to try their varieties under their own conditions. Additional growers are in the process of trying MAPs for the first time on their sweet cherries in 2011.

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