Shelf-life and Marketing Window Extension in Sweet Cherries by the Use of Modified Atmosphere Packaging

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"Sweet cherries have a relatively short shelf life of 7-14 days in conventional cold storage, which makes it difficult to market certain varieties that growers have in abundance. These varieties either cannot be harvested at ideal maturity or marketed in an acceptable period of time. They also tend to be consumer favorites. By using Modified Atmosphere Packaging (MAP) bags, growers in NY have begun to extend the marketing window to 30-50 days. Varieties differ in their response to MAP storage. This research assessed the response of several important NY sweet cherry varieties to MAP."

Sweet cherries (*Prunus avium* L.) are one of a handful of fruits that have generated excitement in recent years due at least in part to their reported health benefits. Cherries contain several key phytochemicals such as the powerful antioxidant anthocyanins and vitamin C (Kim et al., 2005). These and other phytonutrients contained in sweet cherries have anti-inflammatory properties that have been shown to relieve arthritis and gout (Wang, 1999). The beneficial chemicals in sweet cherries may help reduce the occurrence of some types of cancer, along with Alzheimer's (Olsson et al., 2004). These are just a few of the reasons cherries seem to be increasing in popularity on the public's radar. In commercial-growing regions in NY, consumption of sweet cherries and other fresh produce will hopefully continue to rise as the "buy local" movement strengthens. Supplying local and regional supermarket chains, farmer's markets, along with pick-your-own enterprises, will generate what farmers hope will be increased sales.

Unfortunately, sweet cherries have a relatively high respiration rate and are therefore a very perishable commodity with a short shelf life of 7-14 days in conventional cold storage. In addition, the local sweet cherry season may only be three weeks long. Thus in many cases, they 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).

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 Pacific Northwest of the USA and Canada, and in Europe, and Australia. In these regions, MAP of sweet cherries has been used to reduce the transportation cost (using ships instead of air freight, for example) to overseas markets. In contrast, smaller production areas such as the Eastern US may benefit from MAP by extending the otherwise very short growing and harvesting season. Extending the marketing window for high quality local cherries may further raise public awareness of the availability of healthy, quality fruit and thus increase consumption.

Past 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 sanitizer/fungicide application, proper sorting of defected fruit 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 30-40 days in certain varieties, but three years of trials with the cultivars Lapin, Sweetheart, Hedelfingen and Regina have shown clear varietal differences in response to the effectiveness of MAP. Past research has shown MAP Regina & Lapins had acceptable eating quality even after 50 days, however, stem loss was accelerated when compared to the non-MAP controls, and stem hold was also weaker.

For Regina, 30-day refrigerated MAP samples had significantly better eating quality than control samples, while Lapins showed no difference between MAP and controls. The 30-day results also showed that the eating quality of both Lapins and Regina cherries to be in the acceptable range. Changes in stem quality such as hold, color and loss, were minimal after 30 days of conventional or MAP storage for Lapins. For Regina, the three-stem quality factors showed no changes from fresh harvested fruit to 30-day conventional or MAP refrigerated storage.

The flavor of Hedelfingen MAP samples started to deteriorate after 30 days, while MAP Sweethearts had slightly better flavor and texture than the control samples. Stem quality for both Hedelfingen and Sweethearts at 30 days were the same for both MAP and control samples.

Samples stored for 50 days in MAP bags showed decreased flavor acceptability for Heldelfingen and decreased flavor and texture ratings for Sweethearts, to the point that both were considered to be of unacceptable eating quality.

Another precaution to be taken when packing fruit in MAP bags is that fruit should be properly cooled before (Figure 1)

Figure 1. Sweet cherries in cooler prior to storage in MAP bags.

bagging, as condensation can form in the closed package and anaerobic conditions may result from increased respiration rate, leading to product spoilage (Rai et al., 2002).

2008 Goals & Methods

The aim of the research for the 2008 season was to use whatever harvest, handling, cooling and packing methods growers were already using, and to add MAP. In addition, advice was given to growers in the use of hydrocooling and proper disinfecting (fungicide or sodium hypochlorite) practices. Some improvements were made by growers in this regard.

Five growers agreed to participate in the study, and seven tests were done on six varieties, with one variety tested twice (Royalton), from two different growers. Varieties tested included Cavalier, Sam, Schmidt, Hartland, Royalton and Emperor Francis. Cultural practices (whether using GA and/or a brown rot fungicide), harvest practices, cooling protocols, cooling methods/timing, sorting/grading, and packaging choice were all recorded. Following cooling (one day after harvest), the appropriate amounts of cherries were either put into MAP LifeSpan L212 10-pound bags or MAP LifeSpan L204 20-pound bags (courtesy of Chris King, Amcor, Australia). All testing was done at the grower's cold storage facilities. For each sampling time, 2-3 replicates of the cherries packaged in MAP bags plus two replicates of controls in their original packaging were evaluated. As controls, four growers used loose bulk cherries in waxed cardboard boxes, and one grower used unsealed vented (perforated) polybags, holding approximately 2.25 lb of cherries/bag. Thus in the case of the grower with the polybags, for the MAP replicates, four polybags of cherries were inserted directly into one 10-pound MAP Lifespan L212 bag. There were two MAP treatments – one evaluated 20 days after packing, one 30 days after packing.

One day after harvest, a fresh control sample was taken to the laboratory for analysis. Additional laboratory analysis was done at 20 days post-packing for the 20 day MAP treatment, and at 30 days post-packing for the 30-day treatment. Analysis of CO_2 & O_2 levels inside the MAP were done at approximately 10 days on each sample, which based on previous research is the time when atmospheres in the bag are at equilibrium. Fruit quality analysis consisted of pH, titratable acidity, brix, and fruit skin color, as measured with a Hunter colorimeter. Additional analysis included visual evaluation of stem color, along with stem hold and loss.

A taste test was also conducted by a panel of 10-16 individuals, (comprised of students, professors, office staff and research technicians), who said they liked sweet cherries. When possible the same subjects were used throughout the duration of the study.

Ratings were given on flavor, texture, and overall eating quality using a seven-point acceptability scale. Growers were also encouraged to taste the fruit at the appropriate timings of the treatments for additional feedback.

Results

The 2008 sweet cherry season proved to be a memorable one for most growers. A late frost significantly reduced production in the Pacific Northwest and NY growers expected an opportunity to capture additional markets. However, a late frost in the Eastern US along with several devastating hailstorms severely reduced yield for a number of growers. As a result, those who had good quality fruit were pressured to market the fruit as soon as possible. Therefore, in many cases, fruit were marketed before they were fully cooled, and in some instances growers skipped quality steps they usually took, such as hydrocooling. Growers in this study were not immune from taking the above shortcuts.

Published optimum storage atmospheres for sweet cherries are 3-10% O_2 and 10-15% CO_2 at 32°F (Mitcham et al., 2002). In addition, a humidity of 90-95% is recommended. The manufacturer of the Lifespan MAP stated that target levels are around 8% O_2 and 8% CO_2, along with temperatures under 40°F. Measured levels in this study ranged from 7.9-12.3 % O_2 and 5.7-8.3 % CO_2, nearing recommended values. Although relative humidity was not measured in this study, the manufacturer states that the MAP also prevents water loss and fruit shriveling by maintaining a high humidity environment of 90-95%. Previous studies by Padilla-Zakour et al. (2007) indicated that water losses in the MAP samples were less than in the controls.

Effects of 20 Day MAP storage vs. 30-Day MAP storage vs. controls. As a whole, there were no significant differences between most indicators of fruit quality between the 20 and 30 day MAP treatments. Both treatments reached equilibrium of O_2 and CO_2 levels by these dates, and past research has shown the effects of the MAP compared to un-bagged controls of the same age. Thus, the bags really start to pay for themselves at around the 30-day postharvest period and beyond.

Effects of MAP on color, acid, pH, and brix. Overall, the dark cherries (Cavalier, Sam, Schmidt, Hartland, and Royalton) got darker over 30 days with or without the MAP. The blush cherry (Emperor Francis) got lighter, (at least more yellow), over 30 days with or without the MAP bags. The MAP bags helped maintain the color of four of the cherry varieties (Schmidt, Emperor Francis and Royalton) for 30 days. Three varieties (Cavalier, Sam and Hartland) were unaffected. All of the cherry varieties lost acid over the 30 days with or without the MAP bags. The pH and Brix remained relatively stable over the 30 days with or without the MAP bags.

Effects of MAP on stem quality. Stem quality was evaluated by three criteria: color, hold and loss. Stem color was rated from 1 to 5, with 1 being brown and 5 being green. Stem hold or how hard it is to pull the stem off the cherry was rated from 1 to 3, 1 being that the stem was weak and easy to pull off the cherry, 3 being that the stem was strong, or hard to pull off. Stem loss or how many of the stems were loose in the container and had fallen off on their own was rated from 1 to 5, with 1 representing 100% loss, and 5 representing 0% loss. Stem quality of Royalton degraded over the 30 days with or without the MAP. This was probably the result of hail damage, ripeness, post harvest handling, or all three. Three varieties (Cavalier, Emperor Francis and Hartland) behaved similarly with MAP bags helping maintain stem color over 30 days (Figure 2). Hold and loss were unaffected. Two varieties (Schmidt and Royalton) behaved similarly although all three quality aspects were maintained over 30 days using the MAP bags. For one variety (Sam) the MAP bags maintained stem color over the 30 days period but stem hold was unaffected. However, it appears that the MAP bags accelerated stem loss. This suggests that care must be taken when selecting varietals candidates for MAP.

Effects of MAP on taste, texture, and overall eating quality. The taste panel rated the fruit acceptability on a scale of 1 to 7 for texture, quality, and overall acceptance, with 1 being the tester disliked the cherry very much, 4 representing neither liked nor disliked, and 7 liked the fruit very much. Generally, fruit quality diminished over the 30-day period in flavor, texture and overall acceptance. However, there were large variations in panelists' preferences. Some people really liked the light-colored Emperor Francis and everybody liked the fresh Royalton. Individually, three varieties (Sam, Hartland and one of the two Royalton plots) were unaffected by the MAP bags (Figure 3). In two varieties (Schmidt and one Royalton plot) the flavor and texture were very well maintained using the MAP bags over the 30-day period. In the two remaining varieties (Emperor Francis and Cavalier) it appears that the MAP bags negatively affected the flavor and texture, although the results were very close.

Conclusions

The earlier work of Padilla-Zakour et al. (2007) showed that a much-extended shelf life of fresh sweet cherries can be accomplished by proper field management and postharvest treatments. However, results clearly vary by cultivar. Our work from 2008 reinforced this conclusion, that each individual variety should be tested, at the very minimum, on a small scale prior to larger scale use and adoption. Past research showed that for specific cultivars, harvest at optimum maturity for storage, followed by rapid cooling of cherries after harvest by hydrocooling with proper fungicide application, along with proper sorting, grading, and drying before MAP, with refrigerated storage at 38°F or lower, would extend shelf life significantly. Under these conditions, the fresh shelf life of these select cultivars can be extended up to 30-40 days with minimal changes in quality.

Unfortunately, the reality is that it is very difficult for growers to optimize proper field management and postharvest treatments. The season is so compressed and the optimal maturity window so small for maximized storage that growers must have near-perfect conditions to merely accomplish getting most of the quality fruit harvested at the correct time. Many of the local cultivars that are grown in Western NY are susceptible to cracking, so a small amount of rain prior to harvest can significantly reduce quality in a short period. Brown rot in wet years is also a major quality issue, and the resistance management of fungicides for brown rot control also compound the problem. In years like 2008, late frosts and hail also take their toll on fruit quality and market conditions. Of the five growers in the study last season, only three regularly hydrocooled their cherries. With the shortage of cherries locally and in the Pacific Northwest, one of those growers chose not to hydrocool his fruit in 2008. None of the aforementioned growers uses a fungicide in their hydrocooling water. The high cost of a postharvest fungicide such as Scholar® is prohibitive, although past research has shown excellent decay control with this product. Sodium hypochlorite can be adequate, but only if pH is monitored/adjusted (between 6-7 values) and chlorine levels regularly checked and restored to levels above 50 ppm (preferably 70 ppm)

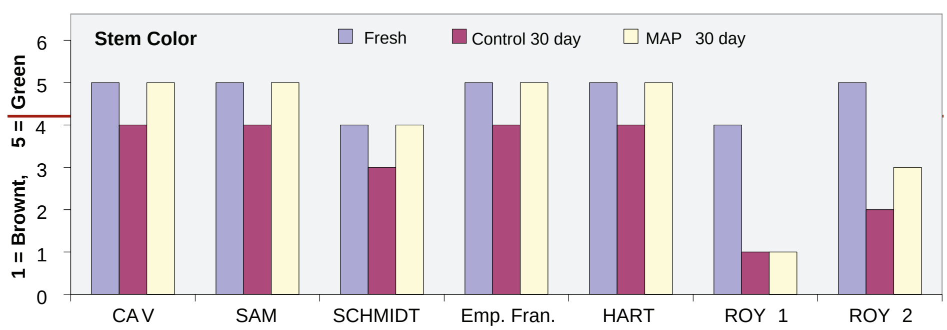

Figure 2. Stem color ratings for the seven lots of refrigerated sweet cherries tested. Ratings are on a scale of 1 to 5, with 1 being completely brown, and 5 being completely green, or the same color as the fresh samples.

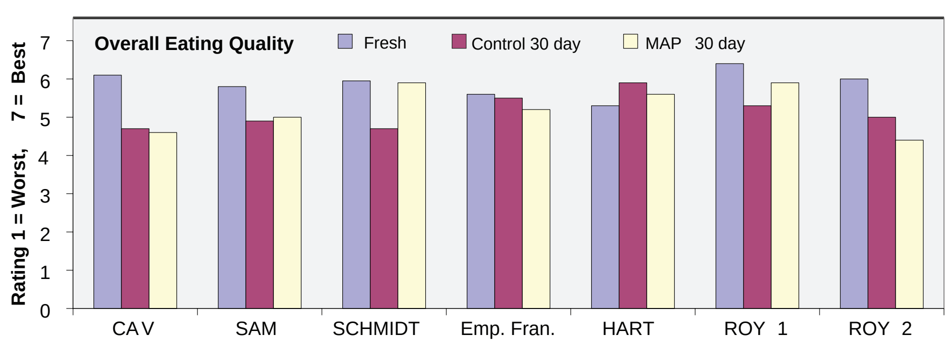

Figure 3. Overall eating quality ratings by a taste panel. These ratings are the average of taste and texture ratings of refrigerated sweet cherries. Ratings are on a scale of 1 to 7, 1 = disliked very much, 4 = neither liked nor disliked, and 7 = liked very much.

as the sanitizer is consumed during disinfection. A pH above 7 will reduce the antimicrobial capacity of sodium hypochlorite drastically. Since sodium hypochlorite added to neutral tank water naturally raises pH well above 7, adjustment is critical. In addition, the regularity at which the tank water is changed and/or the amount of debris in the tank also greatly influence chlorine levels. Growers in this study were aided in maintaining/adjusting chlorine levels with the information given above along with the use of simple swimming pool test kits and pH adjustment with citric acid.

While it would be ideal to believe that with proper preharvest treatments, cooling, sorting, and grading prior to MAP, most any variety would respond well, and therefore storage life would be significantly increased while maintaining acceptable quality, that is not the case. However, some growers are excited about the performance in certain cultivars, and plan to expand use in the 2009 season. For example, a local grower bought some extra MAP bags and tried out several varieties, and found an early season cultivar that responded very well. After the last late variety was picked and sold, the grower was able to market this early variety after the season had all but ended, satisfying customers who wanted more local cherries but were unable to do so because the season was over.

Nonetheless it must be stressed that care should be taken when selecting varieties for MAP, as we found MAP affected flavor and texture of Cavalier and Emperor Francis, along with accelerating stem loss for Sam. This could be due to the variety, but also maturity at harvest, rate of cooling, etc. Proper cooling and disinfecting (fungicide or sodium hypochlorite) by more participants will no doubt aid quality and storage life, and results may be different with the same varieties.

In 2009 and beyond we will focus on doing small trials with growers on cultivars they think would be good candidates for MAP. Thus far, these have been varieties that they have in abundance and either cannot be harvested at ideal maturity or marketed in an acceptable period of time. They also tend to be consumer favorites in which they would like to extend the marketing window. Extension educators and researchers will continue to aid growers in the trials, and we plan to help them optimize harvest maturity timing, sorting/grading and cooling efficiency/methods, and extended storage conditions.

Acknowledgements

The authors thank the many sweet cherry growers for contributing fruit to this research. This research funded by Federal Formula Funds Initiative Program "Consistent Production of High Quality Sweet Cherries in New York for Eastern Markets"

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