Modified Atmosphere Packaging Maintains Sweet Cherry Quality After Harvest

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Sweet cherry growers in New York are at a disadvantage compared to their Western US counterparts because the cherry varieties produced here typically have shorter storage potential and shelf life. Modified atmosphere packaging (MAP) appears to offer cherry growers a tool for maintaining quality during storage and marketing. Our work shows that MAP maintains fruit color and intensity, preserves green stem color, maintains fruit firmness, prevents water loss and shriveling, and keeps cherries in excellent condition during four weeks of storage.

Sweet cherries can be highly profitable for growers in the Northeastern United States due to the strong demand for locally grown quality products. A major limitation is their short shelf life even under ideal cold storage conditions. Over-production in any given year and gluts in the market restrict the growers' ability to competitively sell fresh cherries compared to other crops with extended storage capacity. In many cases, cherries must be sold at low prices to expedite movement and prevent complete losses that can occur once the fruit falls out of condition. In the worst case scenario, the cherries are discarded after the grower has incurred all production costs including harvesting and packing. Growers in New York are at a disadvantage compared to their Western United States counterparts because the cherry varieties produced here typically have shorter storage potential and shelf life. Clearly, any method to preserve postharvest quality would help New York cherry growers compete in wholesale and high end retail markets.

Postharvest practices such as proper handling and cooling, notably hydrocooling, are essential to maintaining sweet cherry quality after harvest. The most important factors which help minimize water loss and prolong shelf life of cherries are careful control of temperature and humidity.

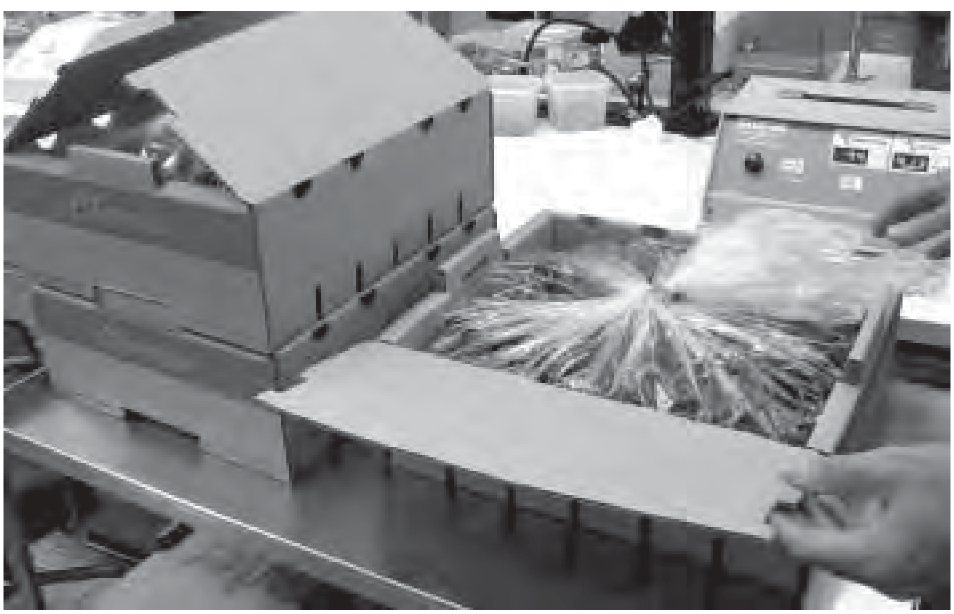

Figure 1. Lapins cherries were put in modified atmosphere bags and placed in cardboard boxes, similar to the way cherries are packed loose fill in boxes.

In recent years, sweet cherry quality has been extended by the use of Modified Atmosphere Packaging (MAP), especially in the large production areas in the Western United States. Storing fruit in semi-permeable polyethylene bags can lower respiration rates and maintain quality by altering the oxygen and carbon dioxide concentration inside the bags. The atmosphere is changed as the fruit consumes the oxygen through respiration and gives off carbon dioxide as a by-product. This is similar to storing apples in a controlled atmosphere room, except the bags are gas permeable and the process is passive. MA bags can also prevent water loss and fruit shriveling by maintaining a high relative humidity environment. One of the most important attributes of MAP is that it can preserve green stem color and fruit firmness, both critical attributes for marketing cherries

Figure 2. Gas measurements were taken weekly to determine the oxygen and carbon dioxide concentrations in the bags.

Figure 3. Lapins control cherries (left) got darker after four weeks of storage and stems turned brown. Cherries in LifeSpan 208 bags (right) maintained green stems and fruit color was similar to that at harvest.

in retail stores. The success of MAP depends on the physical properties of the film which determine permeability to oxygen and carbon dioxide, and the respiration rate of the product which is partially dependent on harvest date, maturity, variety, temperature and other factors. Incorrect use of MAP could result in anaerobic (low oxygen) conditions leading to product spoilage.

We conducted two studies to investigate the potential for MAP to maintain quality and prolong shelf life of Hedelfingen and Lapins sweet cherries. The trials used two different MA films to evaluate possible differences depending on gas permeability. Hedelfingen is a popular sweet cherry variety commonly grown in New York State. The trial with Lapins was done in collaboration with a commercial farm in Wayne County, NY. There has been no prior documented research with MAP on sweet cherries in New York.

Materials and Methods

Sweet cherries var. Hedelfingen were obtained from the New York State Agricultural Experiment Station in Geneva, courtesy of Dr. R. Andersen and Dr. T. Robinson's programs. The cherries were hydrocooled with chlorinated water within three hours of harvest. The treatments compared regular air storage with modified atmosphere storage in low-density polyethylene bags (LDPE). Each treatment replicate contained 10 lbs. of cherries that were graded by hand to exclude cracks and defects. For MAP storage, cherries were placed in two different kinds of microperforated, polyethylene bags with different oxygen transmission rates (OTR): LifeSpan L204 and LifeSpan L208 (Amcor Ltd). The modified atmosphere (MA) bags selected for the trial are presently available for commercial use on cherries. The bags were closed tightly using plastic sealing clips, and then placed in small plastic crates. All the samples were placed in a storage chamber maintained at 38°F and 90 percent relative humidity. The study was designed for a four-week storage period; with evaluations performed every seven days.

Figure 4. Cracking was a problem in LifeSpan 204 and 208 bags in the Hedelfingen trial. This problem can be minimized by ensuring the fruit are not wet at the time of packing.

In the second trial, Lapins cherries were harvested at Fowler Farms Inc., hydrocooled and left in cold storage overnight before packing using the two LifeSpan bags L204 and L208. The bags were filled with 19-20 lbs. of cherries and sealed tightly. The cherries were then transported to Geneva where they were stored for four weeks and evaluated after that time.

Various parameters were measured, including: oxygen and carbon dioxide concentrations in the bags, firmness, color, acidity, pH, soluble solids, weight loss, and stem color. Each week, the amount of decayed and cracked cherries was recorded.

Hedelfingen Trial Results

The Oxygen (O_2) concentration in LifeSpan L204 bags quickly dropped from 21 percent to 7 percent after two days under MA conditions. Between the 3rd day and 28th day in storage, O_2 concentration fluctuated between 3.8 percent and 4.8 percent, well above the level that could induce low oxygen injury. The O_2 concentration in L208 bags decreased, but not nearly as much as in the L204 bags. In the L208 bags, O_2 dropped to 14 percent by day two, and tended to fluctuate between 14.5 percent and 15.7 percent from 7 to 28 days in storage. The higher O_2 concentration indicates a higher permeability of L208 bags compared to L204 bags. The CO_2 concentrations in both L204 and L208 bags increased initially over time, and then tended to stabilize after five days in MAP. L204 bags were able to achieve

TABLE 1

Mean concentration of O_2 and CO_2 in the headspace of MAP bags containing sweet cherries and stored at 38°F for 4 weeks.

Hedelfinger	L204		L208	
	% O_2	% CO_2	% O_2	% CO_2
Initial	19	1.1	19	1.6
Week 2	3.9	8.5	15	5.9
Week 4	4.6	7.4	15	5.9
Lapins				
Week 4	10	8.1	10	8.0

TABLE 2

Quality changes for control and MA stored Hedelfingen cherries over 4 weeks at 38°F.

Quality Attributes	Week 2		Week 4	
	Control	MAP	Control	MAP
Fruit color	bright	bright	dull	bright
Stem color	< 50% green	> 75% green	< 25% green	> 75% green
Soluble solids	1% increase	constant	16% increase	constant
Acidity	slight decrease	slight decrease	slight decrease	slight decrease
Firmness	constant	constant	constant	constant
% cracked + decayed	4	12	9	10
% water loss	8	0.5	13	0.5
Eating and marketing quality	acceptable	acceptable	marginal	acceptable

TABLE 3

Quality changes for control and MA stored Lapins cherries over 4 weeks at 38¡F.

Quality Attributes	Week 4		
	Control	L204	L208
Fruit color	less bright	bright	bright
Stem color	> 50% green	100% green	100% green
Soluble solids	10% decrease	10% decrease	10% decrease
Acidity	slight decrease	slight decrease	slight decrease
Firmness	6% increase	constant	13% decrease
% cracked	0	0.2	0.3
% decayed	4.7	2.6	1.4
% water loss	6	0	0
Eating and marketing quality	marginal	acceptable	acceptable

higher CO_2 levels compared to L208. Carbon dioxide concentration fluctuated between 6.5 percent and 8.5 percent between 7 and 28 days in storage in L204 bags. In L208 bags, CO_2 fluctuated between 4.9 percent and 6.0 percent from day 7 to 28 (Table 1).

The physical appearance of the control cherries was darker in color after four weeks (lower Lightness color value), whereas the MAP cherries maintained a lighter appearance (Table 2). Brightness, as measured by chroma, showed a significant decrease over time in control cherries. A less pronounced decrease was observed in both the MAP treatments, and by the end of the four-week storage period, MAP cherries still had a bright shiny appearance. Hue angle decreased for the control cherries, which means red color increased over the storage period. Hue angle did not change for either of the MAP treatments suggesting color was maintained similar to harvest. Overall, MAP had a positive effect on preventing the cherries from getting a dull or over mature appearance. At the end of the experiment, the cherries still appeared in marketable condition.

A slight increase in pH was observed for all three treatments during storage. Consequently, titratable acidity (TA) declined over time for all the treatments as well. By the end of the four-week storage period, TA declined most in the L208 bags, whereas TA was similar in the L204 and control cherries. Decrease in acidity is one of the factors that cause loss of flavor during storage, a common occurrence in sweet cherries. It appears MAP will not prevent acidity loss, however, it has been shown to maintain volatile flavor components in other studies. The soluble solids content of control cherries increased over time, which can be attributed to water loss from the fruit resulting in the concentration of sugars. The soluble solids content for the MAP treatments increased in some weeks but not in others, and there was no clear trend over time. Considering that MAP minimized water loss from the cherries, it is unlikely that soluble solids would increase in storage.

There were no differences in firmness among treatments and it tended to remain fairly constant over time. Control cherries maintained their firmness over the duration of the experiment, which was most likely the result of water loss giving the cherries an elastic texture that resisted penetration by our firmness measuring device. Other researchers have reported this phenomenon as well. No loss in firmness was observed in L204 or L208 cherries throughout the four-week storage period.

Major differences were seen in stem color change among treatments. After two weeks in storage, stem color of control cherries had deteriorated noticeably, and by the end of four weeks, all the cherries had brown shriveled stems. Green stem color was maintained in both MAP treatments, and, after four weeks of storage, the majority of the stems were still green, healthy, and hydrated. This finding is consistent with reports by other researchers and commercial users of MAP. Maintaining green stem color appears to be one of the major benefits of MAP.

Water loss was greatly reduced by both MA bags regardless of gas permeability. Control cherries lost 13 percent of their weight over the four-week storage period, which was evidenced by noticeable shriveling even under high relative humidity (90 percent). Both the MAP treatments lost only 1 percent of their weight over that same time. Shriveling is a common problem in sweet cherries in storage due to their ability to easily lose water through the skin. MAP appears to be one method to help resolve this issue.

Cracking was significantly higher in both MAP treatments compared to the control on each evaluation date. There was no clear trend in cracking over time, but on certain evaluation dates, cracking was as high as 14 percent in the MA bags. The increase in cracking with MAP was most likely caused by not allowing sufficient drying of the cherries after hydrocooling and then packing wet cherries into the bags. Decay was similar among all treatments during the first two weeks of storage and remained relatively low. During the third and fourth week evaluations both MAP treatments had more decay than control cherries. The increase in decay over time for MAP treatments was apparently due to the higher amount of cracked cherries in MA bags, making the fruit more susceptible to invasion by spoilage microorganisms. Other researchers also found increased cracking and mold growth in MAP bags due to high humidity and water condensation in the bags. In commercial practice, it is likely this problem can be avoided by ensuring that the cherries are properly cooled and dry at the time of packing.

Lapins Trial Results

There appeared to be little difference in atmospheric composition between L204 and L208 in the Lapins trial. After two weeks in storage the O_2 concentration in L204 bags was reduced to 8.4 percent, and crept up to 10.4 percent by week four. Carbon dioxide in L204 was stable at 8.0 percent to 8.4 percent between weeks two and four. Oxygen concentration in L208 bags was 9.8 percent after two weeks and rose to 10.3 percent by the fourth week of storage. Carbon dioxide fluctuated between 8.0 percent and 9.0 percent between weeks two and four (Table 1).

Control cherries became darker and redder in storage (Table 3). They also lost their bright and shinny appearance by week four. Cherries in the L204 and L208 bags did not get darker, but they did increase in redness, and maintained their shiny luster after four weeks in storage.

The pH of cherries in all treatments increased, and titratable acidity decreased after four weeks in storage regardless of treatment. Soluble solids decreased after four weeks in storage and was not affected by treatment. Control cherries and L204 bagged cherries maintained their firmness after four weeks in storage similar to firmness levels at harvest. The L208 bagged cherries experienced a slight reduction in firmness. Stem color of control cherries showed considerable browning after four weeks in storage. The MAP cherries did not experience any stem browning showing stems as green as when they were packed in the bags.

Control cherries lost a significant amount of water in storage, about 6 percent of their total weight after four weeks. The two MAP treatments did not lose any water in storage over the four-week period. The control cherries had shriveled skin whereas the MAP cherries were still turgid and firm. Cracking was not a significant problem with the MAP treatments in this trial and it was less than 0.5 percent after four weeks in storage. This is probably due to packing the cherries after allowing sufficient drying time after hydrocooling. The control cherries did not crack either, but they had significantly more decay than the two MAP treatments. Control cherries had 4.7 percent decay compared to 2.6 percent in L204 bags and 1.4 percent in L208 bags. The lesser amount of decay with MAP in this trial was probably a result of having fewer cracked cherries.

Conclusions

Modified atmosphere packaging appears to offer cherry growers a tool for maintaining quality during storage and marketing. In this trial, MAP treatments maintained fruit color and intensity, preserved green stem color, maintained fruit firmness, prevented water loss and shriveling, and kept cherries in excellent condition during four weeks of storage. On the downside, we observed increased cracking and decay with MAP on Hedelfingen, and MAP failed to maintain fruit acidity. It is likely that the cracking and decay issues can be resolved by ensuring that the cherries are dry at the time they are packed into the bags.

Maintaining a safe atmosphere in which O_2 does not get too low or CO_2 does not get too high is critical for the successful use of MAP. In the Hedelfingen trial, different atmospheric compositions were achieved within the two types of bags; the L204 bag was much tighter than L208 resulting in greater reduction of O_2, and higher levels of CO_2. However, both bags maintained quality similarly regardless of O_2 and CO_2 levels. In the Lapins trial, there were similar atmospheres in both bags and quality was also similar. In both trials, L204 and L208 bags maintained atmospheres that were considered "safe", however the atmosphere in the bags is highly dependent on temperature. At low temperatures, the respiration rate of the fruit is lower and therefore less oxygen is used. At warmer temperature respiration rate increases and the oxygen in the bag can be depleted leading to fruit injury. This could be particularly important during transportation and delivery if the fruit is allowed to warm up. If this is perceived to be a potential problem then the bags should be opened or punctured prior to shipment.

Growers who are interested in using MAP on sweet cherries should consider experimenting on a small scale at first. The L204 bags appear to provide a more ideal atmosphere with some varieties, however they are also more likely to result in low oxygen damage if the cold chain cannot be maintained. Since L208 bags provided similar benefits at higher oxygen concentration, they might be a safer option. A good way to start might be to try both MA bags on small quantities of several varieties.

Certain rules must be followed to have successful results with MAP. It is important to harvest cherries before they are too mature since best results occur with cherries harvested in the early to mid maturity stage. MAP will not be a rescue treatment for over-mature fruit that is past its prime. It is critical to remove the damaged, cracked or decayed cherries at the time of packing since these cherries will not respond to MAP. If hydrocooling is used to remove field heat, make sure to allow sufficient drying time in the cooler before packing since this will minimize cracking and decay problems. The sooner the fruit is packed in MA bags after harvest, the better the results since quality only deteriorates after harvest. Also, it is important to be aware of the danger of fruit injury caused by too low oxygen under warm conditions. The bottom line is that MAP can be an effective tool if all the other things are done correctly, but it will not make poor quality fruit better. Similar to the storage of most commodities, you need to put good fruit in to get good fruit out.

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