Performance of Modified Atmosphere Films on Cherry Quality

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Introduction
A number of films have been introduced that modify the atmosphere within a box of cherries. This experiment compares the most popular cherry films in use in Washington State at this time. Each film manufacturer has developed a recommended method of closure. A comparison of the attributes of these films and their effect on cherry quality would be useful to both commercial suppliers and the fruit industry.

Executive Summary

Goal 1: Determine the Atmospheres Generated:

This study compared five top selling films against a standard poly-liner and two of the films were compared in a Twisted or Folded over configuration. Elevated carbon dioxide (CO_2) levels are important in modified atmospheres for preservation of cherry fruit quality; oxygen (0_2) should remain above 5% to avoid anerobic conditions.

- PEAKfresh Long Twisted developed higher CO_2 levels than the other PEAKfresh films but slightly lower than LifeSpan and PrimePro.
- In the PEAKfresh films: PEAKfresh Long Twisted developed high CO_2 levels while PEAKfresh Short Folded developed levels comparable to the Control (non-MA film).
- Twisted closures performed better than Folded closures. The Folded closures modified carbon dioxide levels, but to a lesser degree.
- Carbon dioxide levels rose, but not to a dangerous level, when the fruit temperature rose from 33 to 44 °F. Ranking of films remained the same under the warmer conditions.

Goal 2: Determine the Effect of the Films on Fruit Quality

Cherry quality was assessed after two weeks at 33 F followed by one week at 44F and 24 hours at 70F to determine the effect of the storage atmosphere on the shelf life. The performance of the PEAKfresh films was in same range as the other major MA films tested in this experiment. They were not vastly superior or inferior to the other films. Fruit quality in the MA films was superior to fruit held in the Control (non-MA).

- There was no difference in cherry firmness in the different films after 3 weeks in cold storage.
- PEAKfresh Long Folded cherries retained weight better than most of the other films.

- PEAKfresh Long Folded cherries retained soluble solids better than the PEAKfresh Short Twisted film.
- PEAKfresh Long Twisted retained acidity significantly better than any of the other films.
- There was no significant difference in red color of the fruit after storage; PEAKfresh Long Twisted retained slightly more red color than the other films.
- There was no significant difference in stem color or the amount of fruit with pits.
- PEAKfresh Long and Short Folded had more decay than the other MA films.
- PEAKfresh films had more splits than the other films

Goal 3: Rate of Establishment of High CO_2 Atmosphere by PEAKfresh Short Folded

- PEAKfresh Short Folded developed steady state oxygen and CO_2 levels within 3 hours of closure. However, these levels were not sufficient to conserve fruit quality at the level affected by other films.

Methods

Goal 1 –Rate of Establishment of Atmosphere (MA) and the Steady State of MA.
This study compared a number of the top selling films and two of the films (PEAKfresh Long and Short) were compared in a Twisted or Folded over configuration. The only difference between PEAKfresh Long and Short films is the length of the bag. The following eight films were compared:

1) PEAKfresh Long (Folded over), PEAKfresh USA
2) PEAKfresh Long (Twisted),
3) PEAKfresh Short (Folded over),
4) PEAKfresh Short (Twisted),
5) PrimePro (Twisted), Chandler Packaging
6) Lifespan (Twisted), Amcor
7) FreshLok (Twisted), Shields Bag
8) Control: white poly liner (Folded).

On July 19, 2010 (10:30 AM) a commercial packer (McDougall & Sons) filled the test boxes with 18 lb of Bing cherries size 11 row and larger from the July 18 harvest (Grower ID 894).

Each film was replicated 4 times for a total of 32 boxes of fruit. Immediately after the boxes were prepared they were transported to the WSU-TFREC lab, a distance of 3 miles. Temperature of the fruit ranged from 37 to 43 °F at time of packing.

Technicians measured the rate of establishment of modified atmosphere by determining oxygen and carbon dioxide levels at regular intervals using a Check Point O_2/CO_2 analyzer (PBI Dansensor, Denmark). As the atmosphere reached a steady state the testing interval was lengthened. Boxes were held at 33 °F for a total of two weeks (August 2).

Goal 2 – Effect of MA films on cherry fruit quality following three weeks storage.
Fruit was sampled from the boxes used in Part 1 at time of packing to establish initial quality. Following two weeks of storage at 33 °F the boxed fruit was moved to a chamber held at 44 °F and held for an additional 7 days. The atmosphere in each box was measured. At the end of the three weeks fruit were sampled from each of the films and evaluated for quality attributes after being held an additional 24 hours at 70 °F.

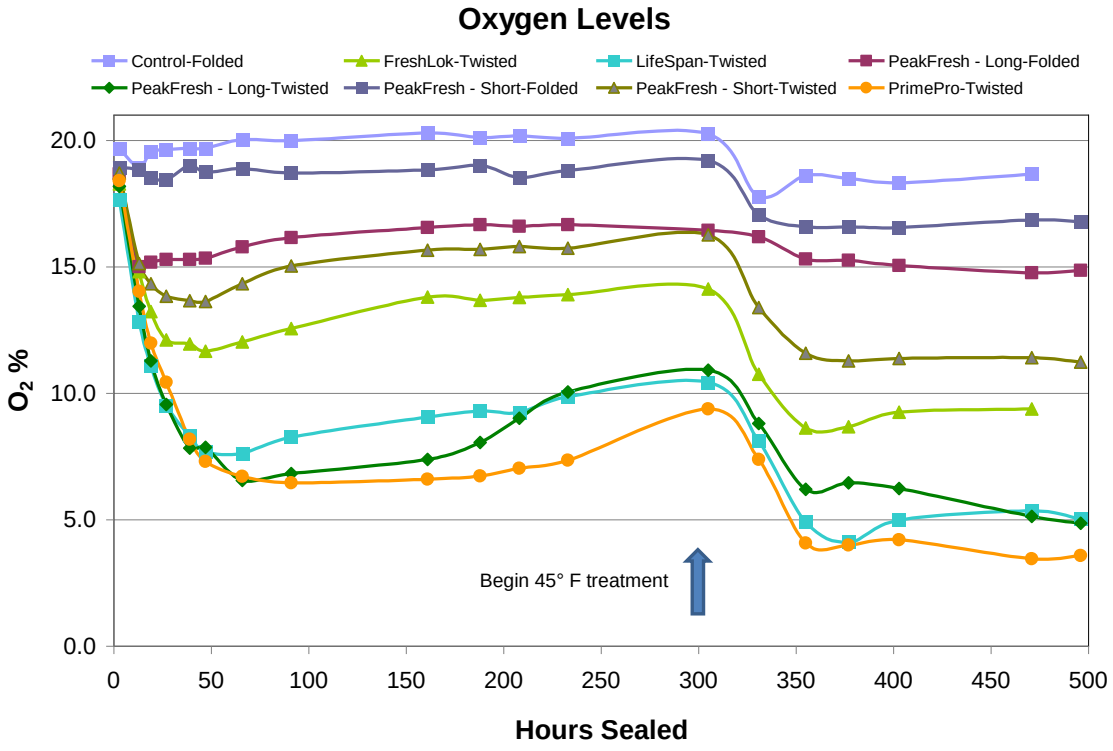
Goal 3 – Effect of repeated opening and closing of boxes using the PEAKfresh liner.
Five additional boxes of cherries were packed using the PEAKfresh Short liner in Folded over configuration. After the fruit was acclimated to 33 °F and MA established, the liner in each box was opened for five minutes then folded over again. Using the Check Point O_2/CO_2 analyzer it was possible to determine how quickly MA was re-established within the liner. This was repeated three times.

Results

Goal 1 –Rate of Establishment of Atmosphere (MA) and the Steady State Of MA

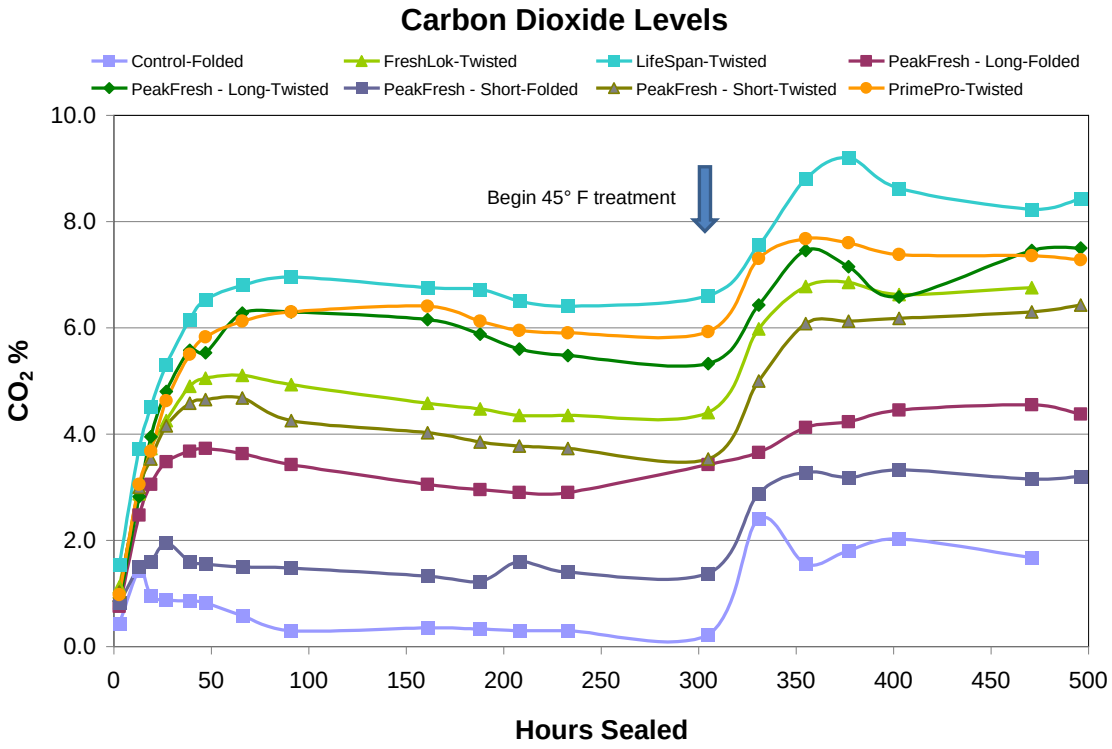
Oxygen: the rate of establishment and steady state level of oxygen obtained in the boxes is shown in the following graph. When used on cherries MA films should reduce the oxygen present within the bag but not to the point the fruit goes anaerobic. Fruit in the Control film maintained ambient atmosphere oxygen levels until the boxes were moved from the reasonable shipping or storage temperature (33 °F) to a warmer environment (45 °F).

Even the most severe reduction in oxygen, provided by the PrimePro film, did not endanger the fruit from low oxygen even at the warmer temperature. Twisting the PEAKfresh films provided lower oxygen levels than the PEAKfresh Folded films. PEAKfresh Long Twisted had lower oxygen levels than PEAKfresh Short Twisted. PEAKfresh Long Folded had lower oxygen levels than PEAKfresh Short Folded films. The relative ranking of these films remained the same even after the fruit were moved to the warmer environment. The most effective PEAKfresh liner in reducing oxygen levels was the PEAKfresh Long sealed by twisting.



Carbon Dioxide: the rate of increase and steady state of carbon dioxide (CO_2) in an ideal film for cherries would be to increase CO_2 rapidly and have it remain high. This will suppress mold growth and reduce the rate of change of stem and fruit color. As with the oxygen level, the Control film maintained the CO_2 level closest to that of ambient (0.03%).

The LifeSpan film provided the highest level of CO_2 followed by PrimePro then PEAKfresh Long Twisted. The PEAKfresh Long films, whether twisted or folded provided higher CO_2 compared to the PEAKfresh Short film counterparts. The PEAKfresh Twisted films provided higher CO_2 levels compared with the PEAKfresh Folded films. The most effective PEAKfresh film was the Long film sealed by twisting.



Atmosphere Summary

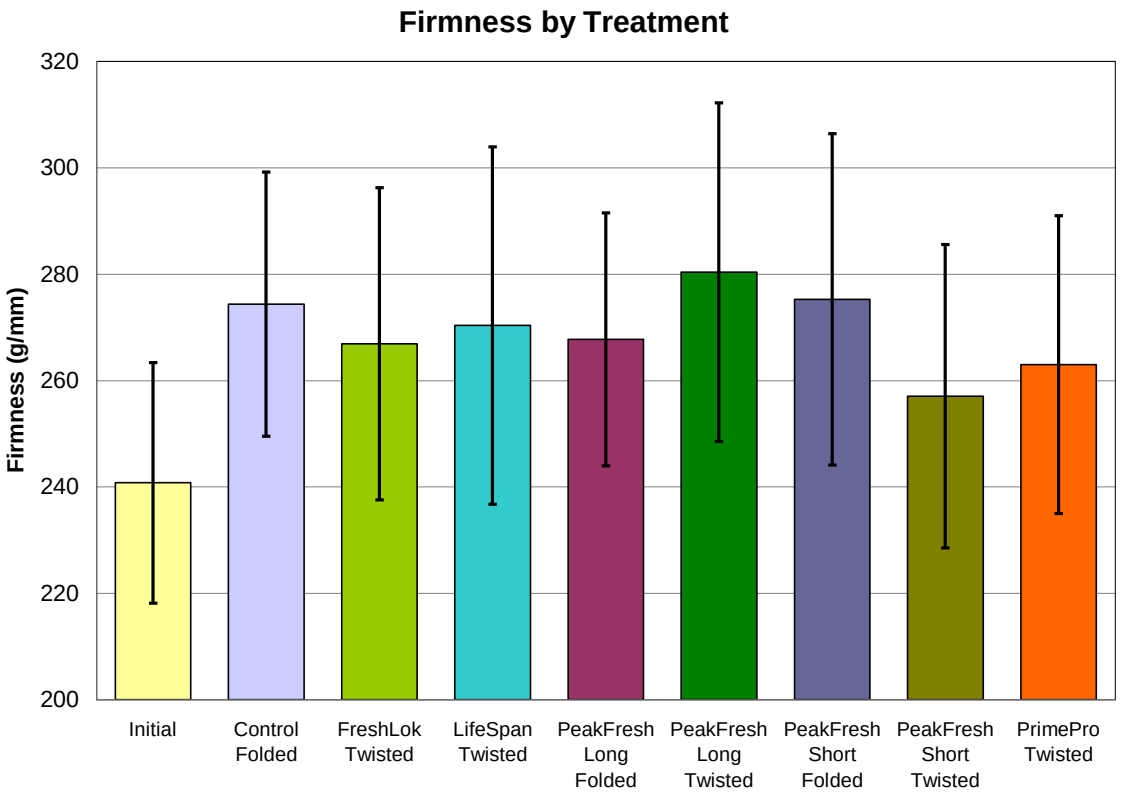
In this experiment the fruit were held for two weeks at 33 °F and an additional week at 44 °F. Carbon dioxide levels during storage broke out into three main categories. The films that developed the highest levels of carbon dioxide were LifeSpan, PrimePro and PEAKfresh Long Twisted. The films that developed the midlevel carbon dioxide were FreshLok, PEAKfresh Short Twisted and PEAKfresh Long Folded. The films that developed the lowest amount of carbon dioxide were PEAKfresh Short Folded and the Control.

Goal 2 – The effect of MA films on cherry fruit quality following three weeks storage.

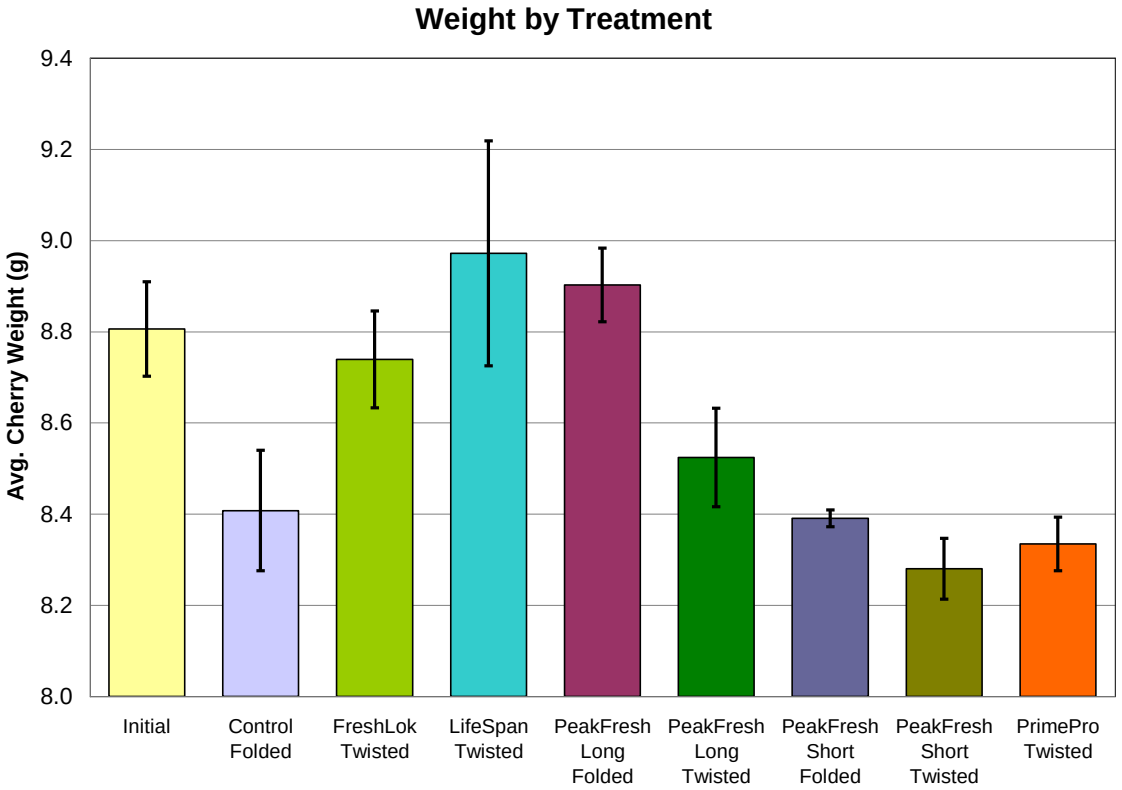
What difference in quality can be expected to be achieved by MA films? In this experiment two overall comparisons can be made:

1) The change in fruit quality at the time of packing (Initial) versus fruit quality after MA storage. These changes included fruit weight, soluble solids, acidity, firmness, pitting, decay, splits and stem color.
2) The comparison between the quality of the fruit stored in the standard film (Control) and the fruit stored in MA. The quality differences were fruit weight, soluble solids, acidity, decay and splits.

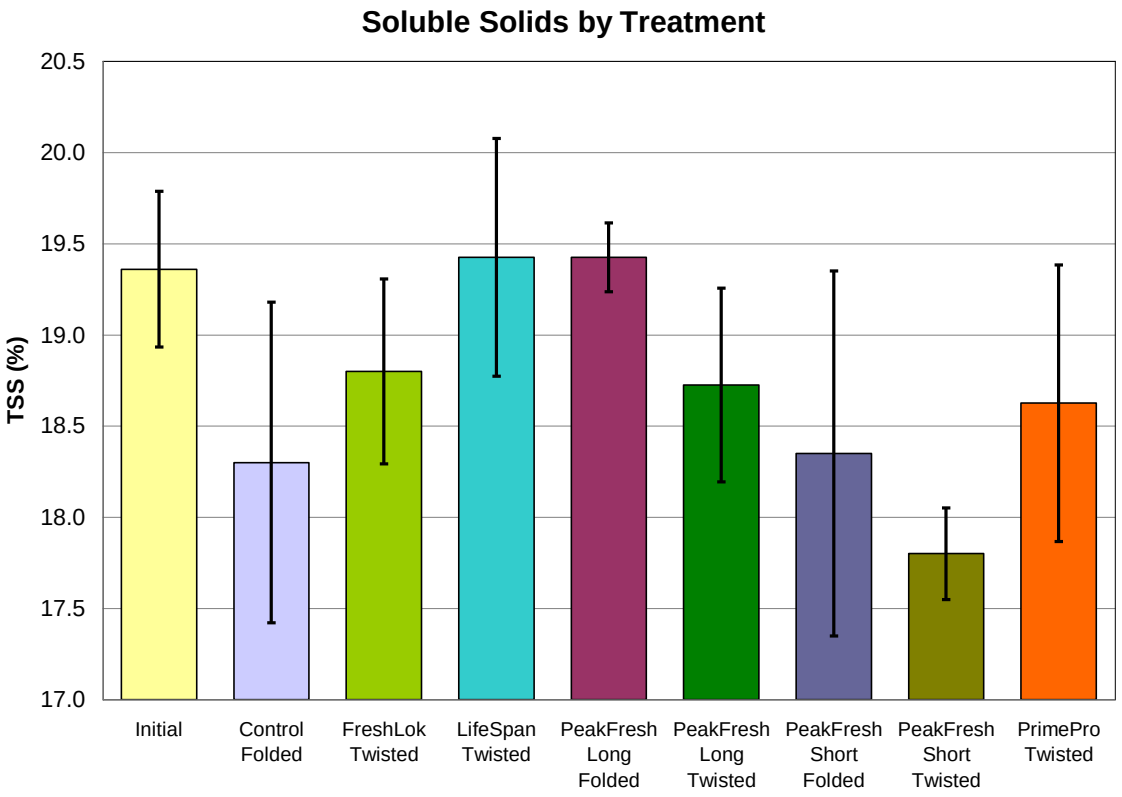
Following two weeks storage at 33 °F, 1 week at 44 °F and 1 day at 70 °F, 25-fruit samples were taken from each of the four replicate boxes and evaluated for quality characteristics.
The summarized data, the average of fruit sampled from 4 boxes per film, are presented in the following series of bar graphs. The thick bars indicate the average values. The vertical thin bars (within the thick bars) show the standard deviation, which is a measure of variability within the samples. A long thin bar indicates a great deal of variability within the samples, conversely a short bar would indicate uniformity in the samples. When the standard deviation bars overlap this indicates, as they do in the next graph (Firmness), that there was no significant difference in firmness. Event though the thick bars are different, the thin bars indicate no significant difference due to the great variability in the one sample box to another.



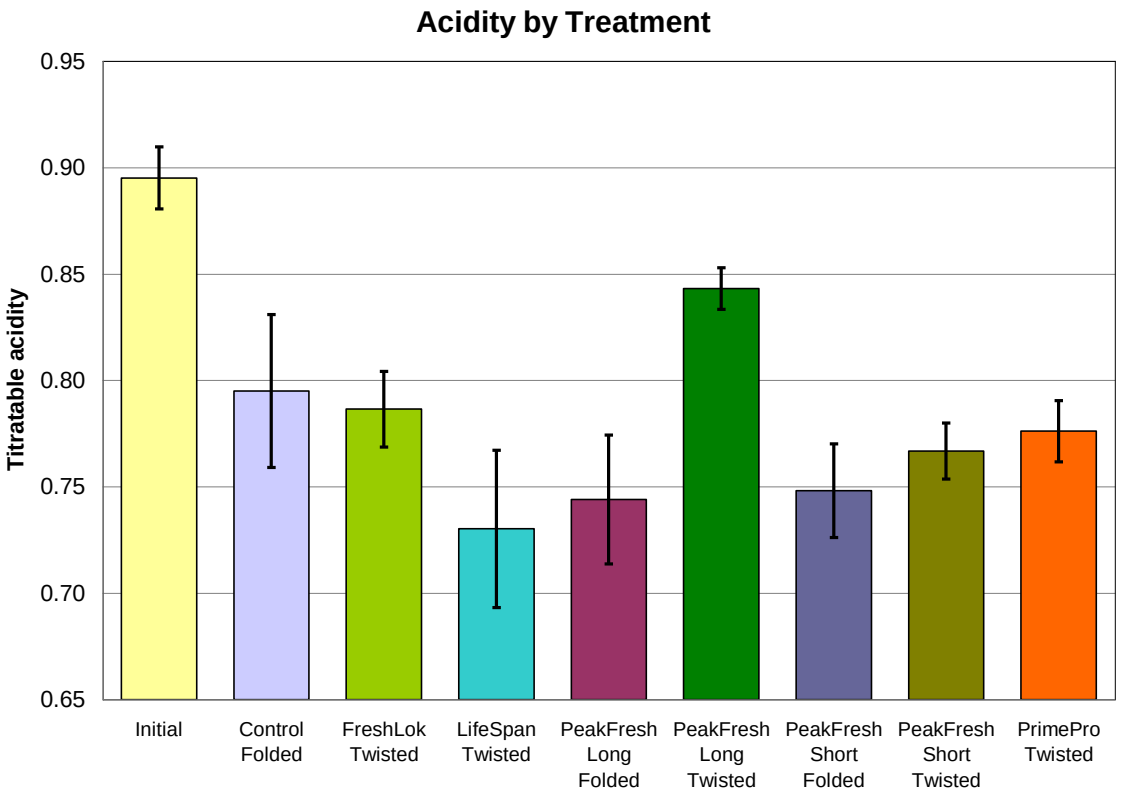
Firmness - Firmness is the key to cherry crispness and crunch. The standard deviation bars show that there was a great deal of variability in the samples, therefore there was no significant difference between the films in retention of firmness. Firmness rose during the three weeks in storage as the fruit lost moisture.



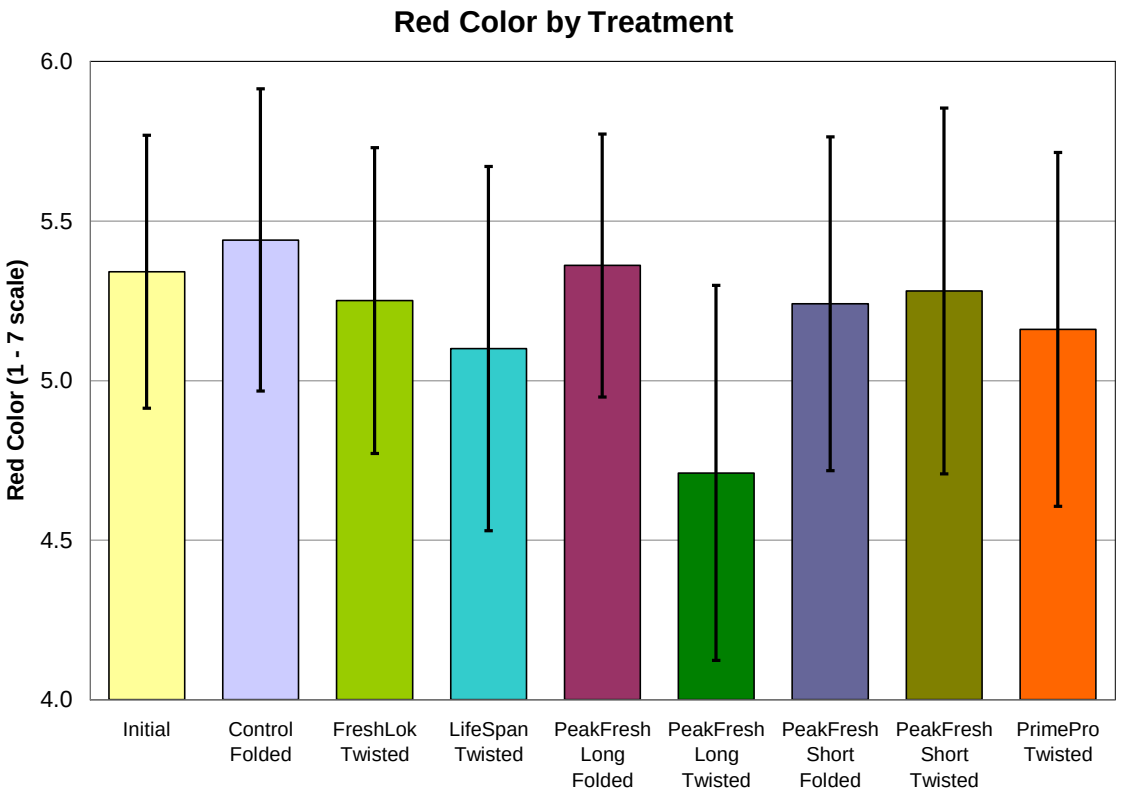
Fruit Weight – Fruit weight is expressed in grams. There was very little difference in the weight (8.3 to 8.9 g) after three weeks in MA. However, fruit in the FreshLok, LifeSpan, PEAKfresh Long Folded films did not lose any weight compared to the fruit at time of packing (initial). The most weight was lost by fruit in the PEAKfresh Short Twisted, PrimePro, PEAKfresh Short Folded, and Control.



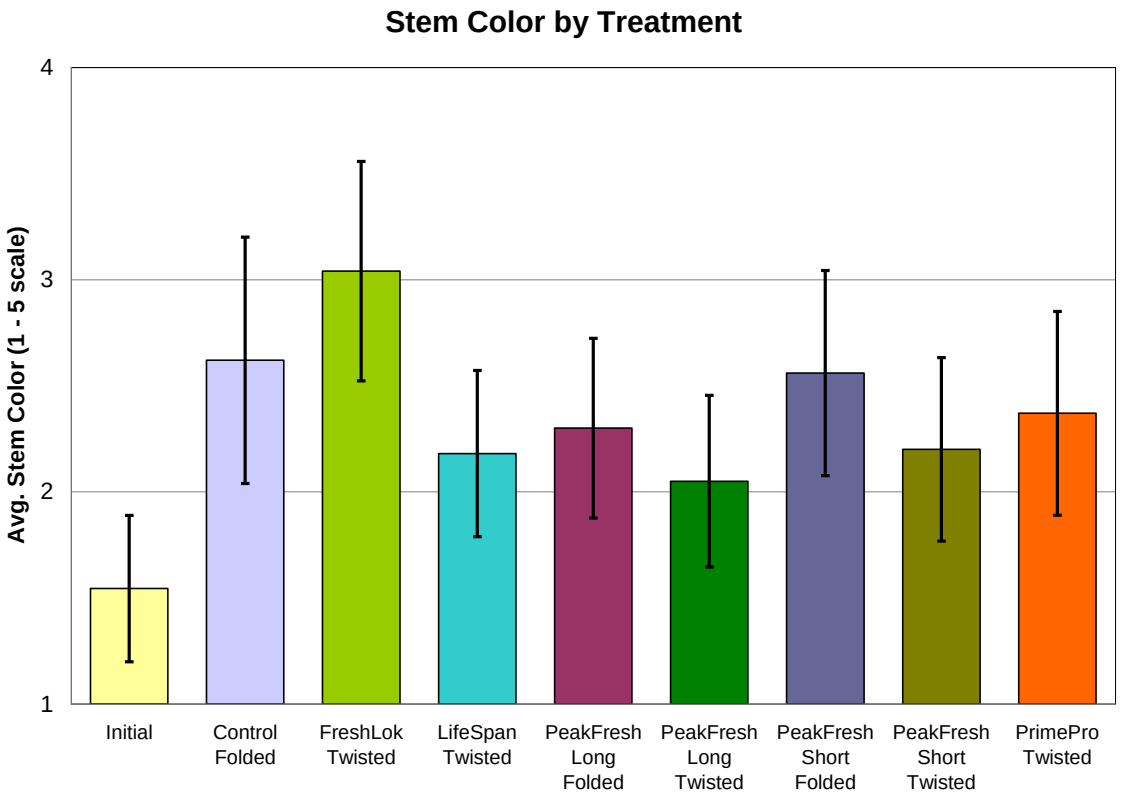
Soluble solids – Soluble solids are a measure of the sweetness of fruit (actual sweetness also depends on the amount of acidity as well as soluble solids). There was a great deal of variability in soluble solids within the samples and as the standard deviation bars show there was no significant difference between films. The highest solids after storage were in the LifeSpan and PEAKfresh Long Folded, which did not lose soluble solids during storage.



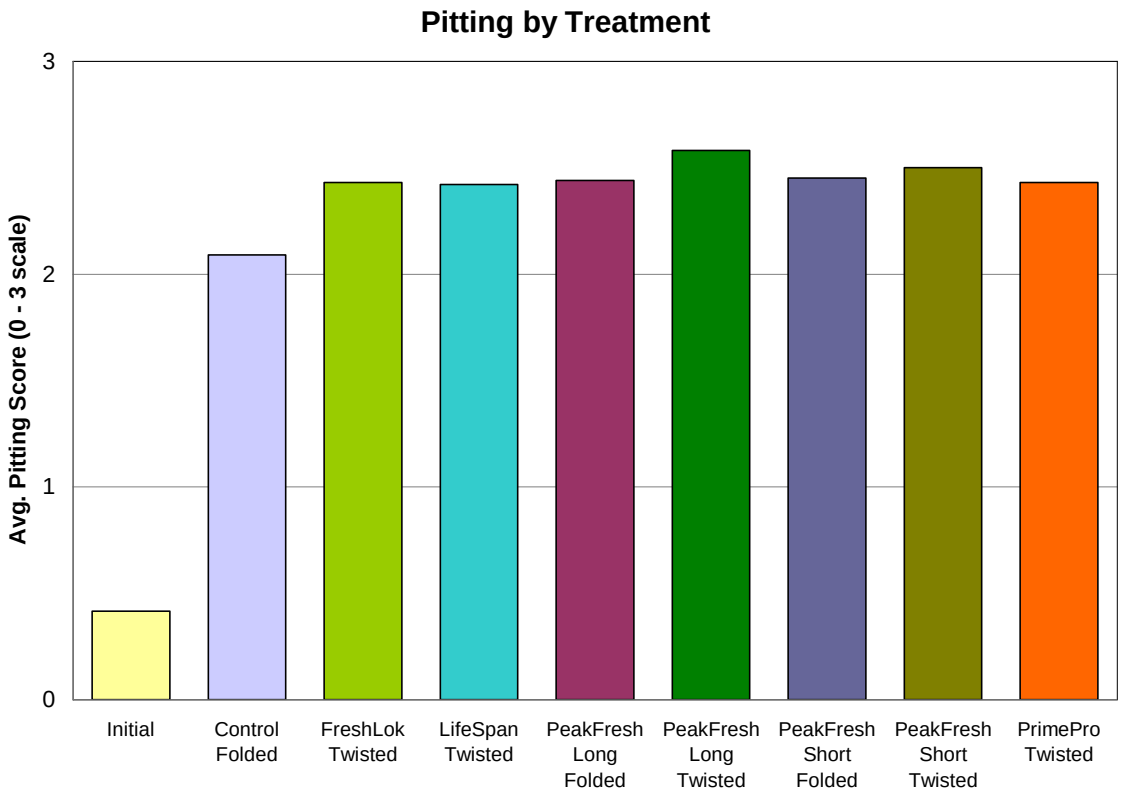
Acidity – Acidity gives the cherry its tartness and is one component of the 'fresh cherry' flavor. However, acidity declines rapidly in storage. Cherries held in the PEAKfresh Long Twisted film retained the most acidity. There was no significant difference in fruit acidity in the other films.



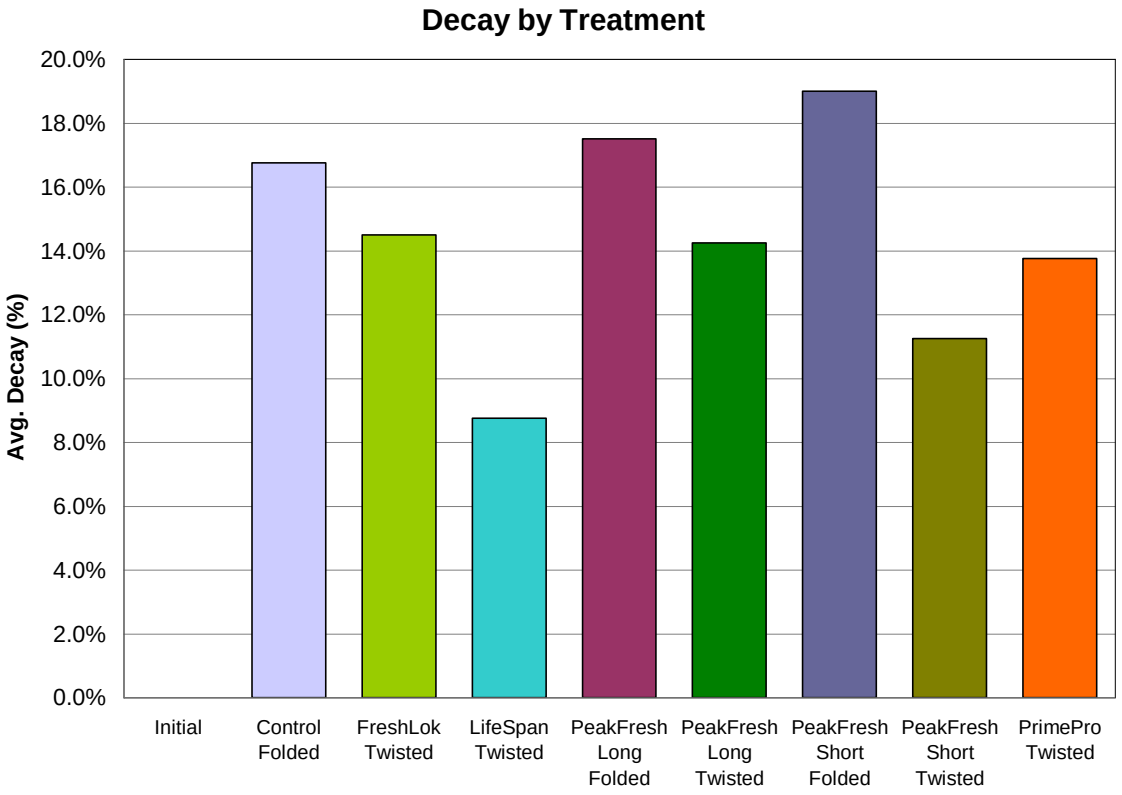
Red color – Cherries were rated on the basis of score card (CTIFL) in which 1 = light red and 7 = black. The PEAKfresh Long Twisted fruit had less red color than the other fruit, but due to huge variability in color within each treatment, there was no significant difference.



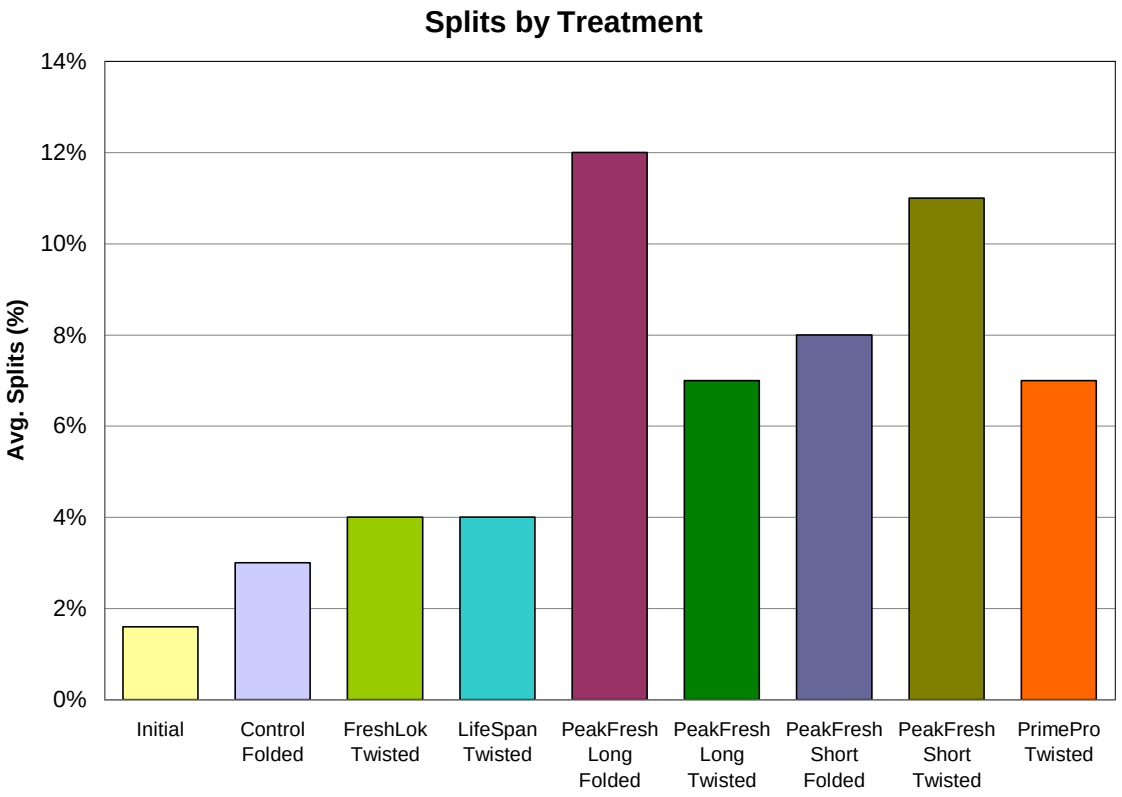
Stem Color – Cherries were rated using a color chart in which 1 = green and 5 = dark brown/black. Cherry stem color darkened from the time of packing in almost all the films. Fruit in the MA films were did not have stems that were significantly greener than those in the Control (non-MA).



Pitting – Pits are indentations in the skin of the cherry that develop from impact damage to the fruit. This can occur on the tree or during packing. Pitting visualizes over time, thus it is typical to see an increase in pitting damage after storage. The graph shows the average scores for pitting with 0 being no pits and 3 being numerous pits (un-saleable). There was no difference in pitting score of any of the MA atmosphere films. PEAKfresh Long Twisted had slightly more pitted fruit than the other films. There was very slightly less pitting in fruit in the Control film.



Decay – Modified atmosphere has been reported to minimize decay by inhibiting the growth of decay organisms with high CO_2.The graph shows the percentage of fruit with decay (100 cherries per box sampled; 400 fruit per film evaluated) after 3 weeks in storage. There was a higher percentage of decayed cherries after storage in PEAKfresh Long Folded and PEAKfresh Short Folded than in any of the other films.



Splits – Splitting can develop from rain on mature fruit or treatment with water. Over time in storage these tiny splits are more easily noticed. The splits encountered in this trial demonstrated that fruit held in the PEAKfresh films developed more splits over time than fruit in the other films.

Fruit Quality Summary Data

The performance of the PEAKfresh films was in same range as the other major MA films tested in this experiment. They were not vastly superior or inferior to the other films. Fruit quality in the MA films was superior to fruit held in the Control (non-MA).

Treatment	Cherry Wt (g)	Soluble Solids (%)	Acidity (%)	Firmness (g/mm)	Pitting (0-3)	Decay (%)	%Splits (%)	Red Color 1-7	Stem Color (1-5)
Initial	8.8	19.4	0.8952	240.7	0.4	0%	1.6%	5.3	1.5
Control Folded	8.4	18.3	0.7950	274.3	2.1	17%	3.0%	5.4	2.6
FreshLok Twisted	8.7	18.8	0.7865	266.9	2.4	15%	4.0%	5.3	3.0
LifeSpan Twisted	9.0	19.4	0.7303	270.3	2.4	9%	4.0%	5.1	2.2
PeakFresh Long Folded	**8.9**	**19.4**	**0.7441**	**267.7**	**2.4**	**18%**	**12.0%**	**5.4**	**2.3**
PeakFresh Long Twisted	**8.5**	**18.7**	**0.8432**	**280.4**	**2.6**	**14%**	**7.0%**	**4.7**	**2.1**
PeakFresh Short Folded	**8.4**	**18.4**	**0.7481**	**275.2**	**2.5**	**19%**	**8.0%**	**5.2**	**2.6**
PeakFresh Short Twisted	**8.3**	**17.8**	**0.7668**	**257.0**	**2.5**	**11%**	**11.0%**	**5.3**	**2.2**
PrimePro Twisted	8.3	18.6	0.7761	263.0	2.4	14%	7.0%	5.2	2.4

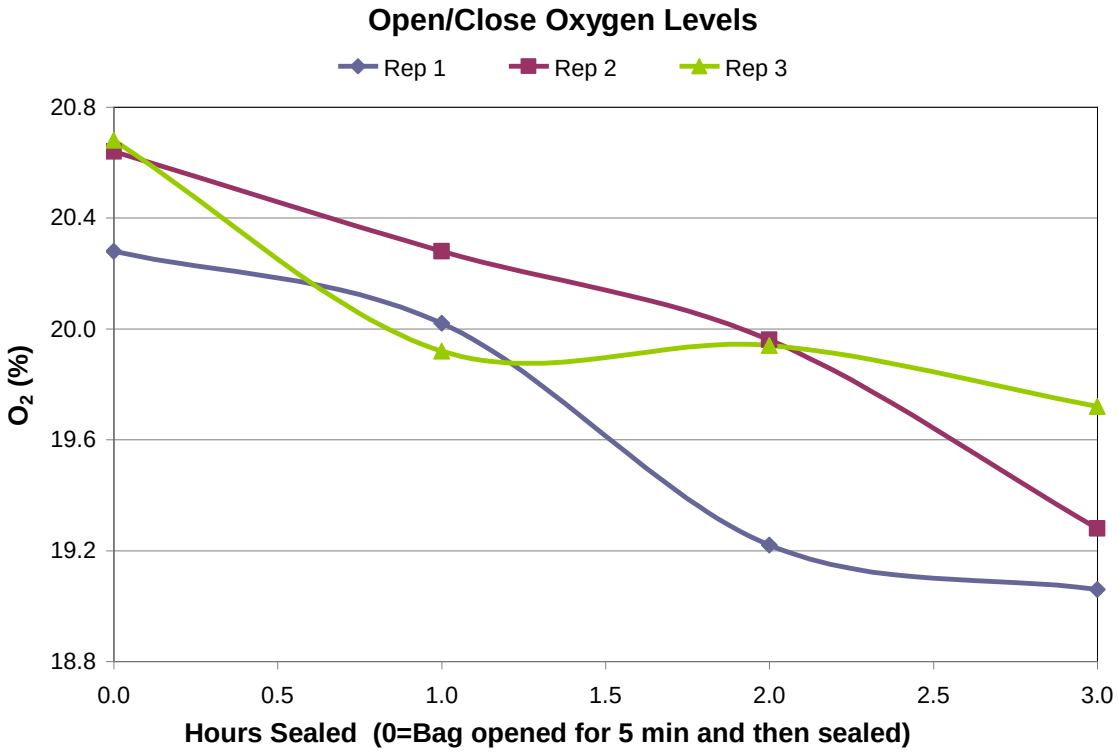
Considering only the PEAKfresh films, the Long films were superior in retaining cherry quality over the Short films. The Long PEAKfresh films conserved cherry weight, acidity, firmness, soluble solids and had less decay and splits compared to the Short PEAKfresh films.

The Folded films conserved weight and soluble solids better than the Twisted films. The Twisted films conserved more acidity, were firmer, had less decay and splits compared with the Folded films.

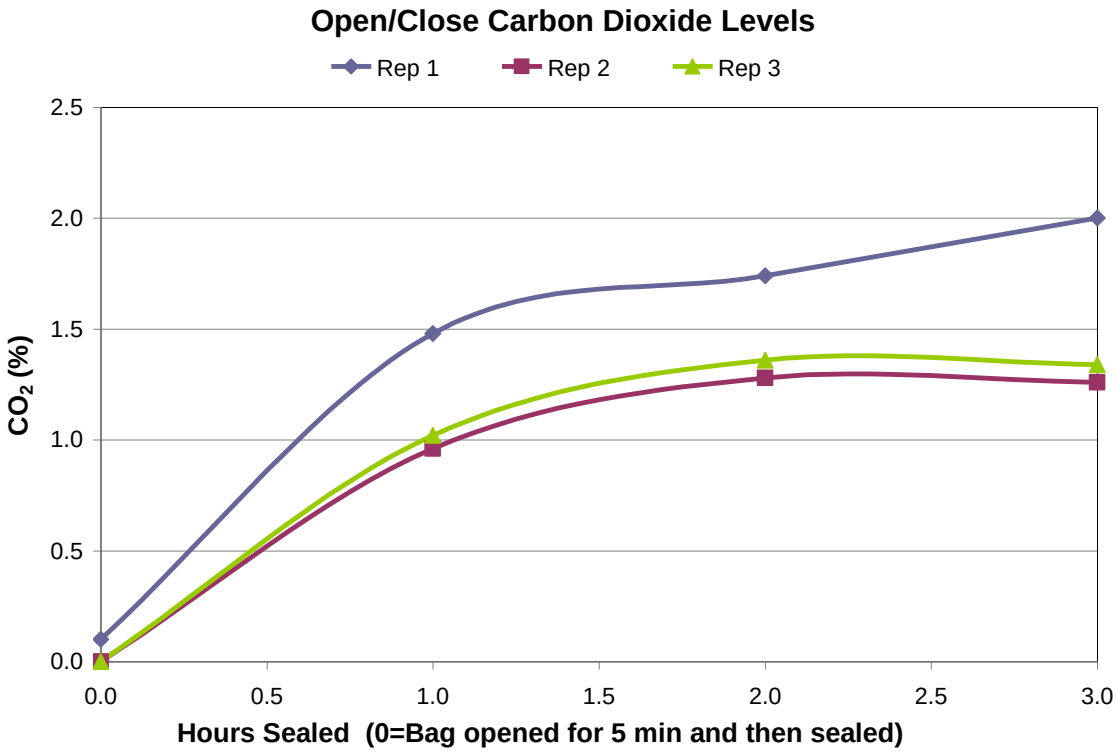
Goal 3 – Effect of repeated opening and closing of boxes of cherries using the PEAKfresh liner.

In this experiment Short PEAKfresh liners were opened then folded over and atmosphere measurements taken after 1, 2 and 3 hours on five boxes of Bing cherries to determine how quickly atmosphere modification occurred. This was repeated three times after allowing the box to be open for at least five minutes. The fruit was at 33 °F when this experiment was performed.

Oxygen: in the 3-hour period oxygen was reduced from ambient to between 19.1 and 19.8%. In my estimation this would not be enough of a change in oxygen to induce a physiological reaction in fruit quality. This was not a significant modification of atmosphere.



Carbon Dioxide: In the 3 hours from the time the box was opened for 5 minutes, the CO_2 rose from ambient (0.03%) to 1.5% in 3 hours. This would not be a sufficient level of CO_2 to affect fruit quality.



Rate of Establishment of MA Conclusion –
This experiment was designed to see how quickly PEAKfresh Short Folded over film would develop an atmosphere sufficient to be considered modified. The fruit was at 33 F and the 5 boxes opened to equilibrate to ambient atmosphere (21% 0_2/ 0.03% CO_2). Then the boxes were closed and held at the same temperature. Atmosphere was measured at hourly intervals for 3 hours. The bags and fruit lowered the oxygen level slightly and raised the carbon dioxide level to about 1.5%. In my opinion these levels would not be sufficient to modify fruit respiration.

How long would it take for this combination of cold fruit and PEAKfresh Short Folded over to reach a steady state?

This can be answered by looking at the data from the first experiment:

1) The oxygen level fell to 19% within 3 hours and remained there for the 2 weeks at 33 °F. When the temperature was raised to 44 °F the oxygen level fell to 17%.
2) The carbon dioxide level rose to 1.5% within 3 hours and remained there for the 2 weeks at 33 °F. When the temperature was raised to 44 °F the carbon dioxide rose to 2.5%.

Therefore, we can observe that the film did reach its steady state within 3 hours of the time it was folded over. However, in my opinion these levels are not sufficient to modify the physiology of the fruit. The Short, Folded PEAKfresh system did not perform as well as the PEAKfresh system in which the Long bag was used.