2004 Asparagus Research Progress Report

This report summarizes the 2004 research activity on fresh pack asparagus at the Postharvest Physiology Laboratory at WSU, Pullman, Washington.

Summary

Modified atmosphere (MA) packaging was examined at the laboratory and commercial scale to study effects on quality attributes and storage life of fresh pack Washington asparagus. Application of MA packaging to 28-lb crates of early and mid-season asparagus was successful in slowing deterioration and extending storage life of asparagus. Quality improvements were significant to warrant additional testing at the commercial scale of production. Similar results in improvements were obtained with small-scale MA packages when applied to early and mid-season harvested asparagus. Late season harvest of asparagus, however, developed severe tiprot infections in both MA and nonpackaged asparagus.

Asparagus kept in MA packages showed only a 2% fresh weight loss over the trial period. This was significantly less that the unpackaged asparagus, which lost between 8-20% of original fresh weight.

Toughness measured by shear force was slightly less for packaged verses nonpackaged asparagus. Sensory analysis or taste tests found a preference for MA packaged over nonpackaged asparagus based on a sweeter and more flavorful taste. The sweet taste may be due to the low respiration rate of MA asparagus, which allows concentration of sucrose in spear tips.

Commercial application of hot water treatment (HWT) was simulated by immersing 14-28 lb crates of asparagus in 48ºC water for 5 minutes and storing at 2ºC for 13-18 days. HWT were partially successful in slowing deterioration of quality in asparagus. Fresh weight loss was 7% in HWT asparagus and 20% in untreated after 13 days storage in low relative humidity (65%) condition. Severe stem wilt (droopy/limp stems) occurred within 5 days of treatment, either from the HWT or from low relative humidity during storage. In a second study, HWT-asparagus was stored under a well-perforated plastic bag, which maintained a higher level of relative humidity. HWT-asparagus lost only 2% and untreated lost 7% fresh weight plus stem wilt was absent. Relative humidity continues to be one of the primary factors in retaining overall asparagus quality regardless of the type of treatment.

Prior research at the laboratory has determined that HWT-asparagus has a significantly lower respiration rate than untreated asparagus when stored at 20ºC. Therefore, HWT may have greater application to circumstances where abusive storage conditions prevail such as the market shelf, where in some instances, temperatures periodically reach 20ºC.

Introduction

Research continued to examine the effectiveness of hot water treatments (HWT) and modified atmosphere (MA) packaging in extending the shelf life of Washington fresh pack asparagus.

A primary objective this year was to develop and test a large scale MA packaging and HWT at the commercial scale of asparagus production. Previous Laboratory research determined an environment of 10% oxygen and 10% carbon dioxide was more successful in slowing deterioration of asparagus than a normal atmosphere. This atmosphere falls within the range of 5-15% oxygen and 5-15% carbon dioxide, which is the range proven by research to be effective in retaining asparagus quality.

The second objective focused on the continued evaluation of MA packaging materials such as commercial MA packaging and breathable labels and their potential to extend shelf life of asparagus.

MA Packaging Studies

Current MA technology does not entirely rely on perforations to modify the internal atmosphere of a package. Perforations are somewhat limited by the fact that they are limited to developing a 1:1 ratio of O_2 to CO_2 within a package. Because of this limitation, industry commonly use advanced polymers that develop various atmospheres such as a 3:8 ratio of CO_2 to O_2. The ratios are based on the approach taken by fresh produce industry, which is to avoid very low levels of O_2 and high CO_2 because the packaging must function effectively at the highest temperatures typically encountered in the distribution chain. The safe work atmospheres have been adopted by most of the industry because temperature has a much more significant influence on preserving quality than MA packaging.

Simulation of Commercial MA Packaging

The objective of this study was to simulate MA packaging at the commercial scale and evaluate its effectiveness at slowing deterioration of asparagus quality. The MA packaging would be used on 28 lb crates of asparagus typically used in commercial processing. The MA crates would be placed in cold storage for 18 days to simulate the time spend at the fresh packinghouse, transportation, and at market shelf.

Materials and Methods

The MA packaging used in this study was the PEAKfresh RPC Liner®™. This liner is designed to preserve vegetables and fruits during shipping and supermarket display (Table 1, Photo 1). The Chantler Company recommended it as appropriate for high respiration products. Another MA bag was constructed of polymeric sheet film from Dupont Company with an Oxygen Transmission Rate of 75 (with additional perforations added).

On April 22, 2004, one 28-lb pyramid was placed in each MA package. Three pre-weighed bundles of asparagus from each crate served as the samples. Controls consisted of three bunches weighed and visually assessed for quality. The crates and controls were stored at 2ºC for 18 days. The controls were placed on moistened pads. Relative humidity in storage averaged 65%.

Atmospheric samples were drawn daily for 18 days with gas tight syringe through septum secured to surface of each bag. The internal O_2 and CO_2 were monitored and upon duration of study, the packages were opened and assessed for weight loss and quality.

Visual ratings determined the percent of spears in the sample with symptoms of tip and base rot and stem shrivel. The overall quality of the spears was based on a combination of these attributes and overall physiological appearance.

Table 1. Product name and description of various modified atmosphere packages tested in this report.

Product	Technical Description
Chantler - PEAKfresh RPC Liner®™ E-400 Poly Bags	Maintain adequate humidity levels, reduce moisture build-up on the bag surface. Removes damaging ethylene gas. Chantler Packaging Inc. 880 Lakeshore Road East Mississauga, Ontario L5E 1E1 Canada.
CVP Fresh Vac®™ Bag	CVP Fresh Vac® produce and fruit bags are designed with a ratio of respiration permeability of CO_2 to O_2 at a range of 3.8:1 to 5:1. Ability to Vary Transmission within Same Gauge. 2518 Wisconsin Ave, Downers Grove, IL 60515.
Smart Label®™ Breathable Seal	Accommodate high respiration rates and compensate for modest ranges of temperature abuse. Membranes regulate the transmission of oxygen and carbon dioxide gases at optimum relative humidity.
FRESHHOLD®™ Packaging System- Breathable Seal	The FRESH HOLD Packaging System is a gas permeable membrane applied over a vented hole in a produce package. Breathable membrane controls the O_2 and CO_2 levels inside the package.

Photo 1. 28 lb crate a PEAKfresh RPC Liner®™.

Results and Discussion

Visual assessment

There was a distinct difference in physiological appearance and weight loss between the MA packaged asparagus and control (Photo 2 and 3). Less than 10% of MA packaged asparagus developed tip feathering and stem shrivel, compared to 85% of control spears

(Table 2). No tiprot was observed in the MA packaged crates, which suggests the high humidity conditions in MA packaging did not encourage mold and bacterial growth

Table 2. Visual assessment of MA and control spears after 18 days at 2ºC.

Name	Decay Tip/Base	Stem Shrivel	Feathering	Overall Rating
Chantler PEAKfresh RPC Liner®™	none	10%	10%	Very good
Dupont polyfilm	none	10%	10%	Very good
Control	none	85%	50%	Poor

Sensory Assessment

Sensory quality of spears was based on serving steamed spears as unknowns to a taste panel. They rated the spears in terms of off-flavors, texture, and overall acceptability. Most individuals preferred MA spears and found them to be sweeter in taste and have less offensive bitter taste than the nonpackaged spears. The sweeter taste may be attributed to the reduction in respiration of MA asparagus, which conserves sucrose in the tips.

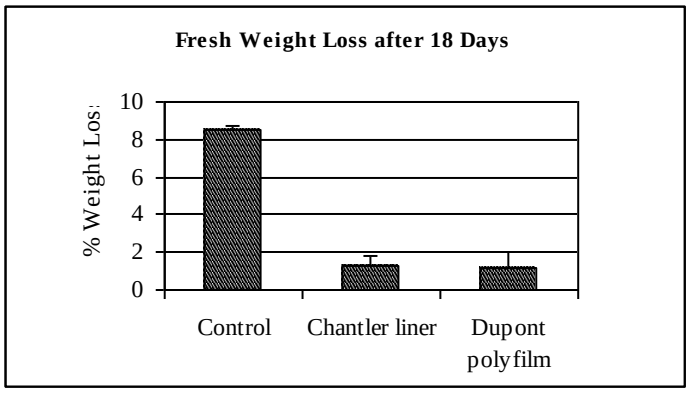
Photo 2. PEAKfresh -MA asparagus after 18 days at 2ºC.

Photo 3. Control asparagus after 18 days at 2ºC.

Fresh Weight Loss

Fresh weight loss of asparagus from MA crates averaged 2% while controls lost 8% (Figure 1). The low respiration rate and near optimum relative humidity in the MA crates are responsible for minimal weight loss.

Figure 1. Weight loss of fresh asparagus in MA bags after 18 days at 2ºC storage. n=3. Error bars=S.D.



Internal Atmosphere in Packaged Crates

The PEAKfresh RPC Liner®™ developed and maintained an internal atmosphere of 12% O_2 and 14% CO_2 throughout the study (Figure 2 and 3). The Dupont bag developed dangerous levels of CO_2 and O_2 by the seventh day. This was corrected by creating several small perforations in the bag (Figure 2, 3). Subsequent atmospheres returned to appropriate concentrations, and despite the prolonged low atmosphere, the asparagus quality was not compromised and was rated visually as being in very good condition.

Figure 2. Oxygen concentration in MA crates. n=1.

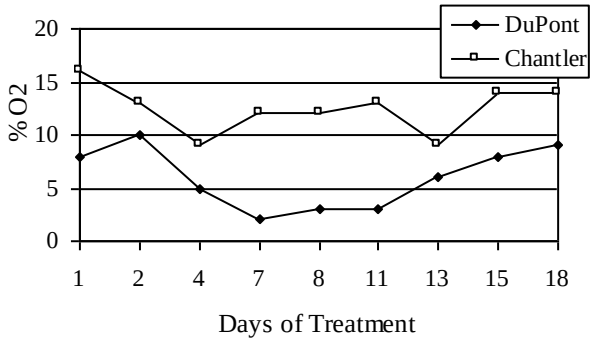
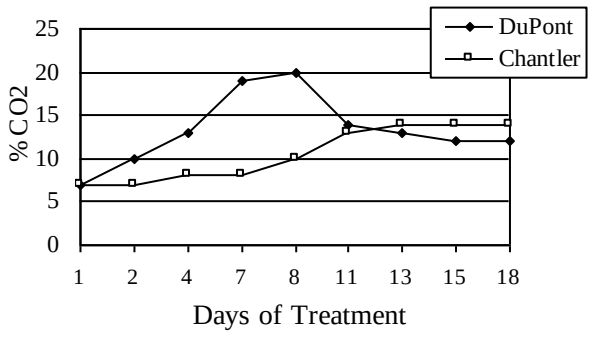


Figure 3. CO_2 concentration in MA crates. n=1.



Evaluation of New MA Packaging Materials

Smaller MA packages and breathable labels were evaluated for their application to asparagus (photo 4. Left- Smart bag® with breathable label, center- CryoVac®, right- FreshHold® breathable label. Most of these MA packages were designed for use on products with high respiration rates.

Materials and Methods

The Smart packages were filled with asparagus according to specifications and the CryoVac and CVP were overfilled with the intention of creating a low atmosphere (Table 4). Three control bunches were weighed and stored on a moistened pad. The MA packages and controls were placed in 2ºC storage for a period of 13 days to simulate accumulated time spend at the fresh packinghouse, transportation, and final destination at market shelf. Relative humidity in storage averaged 65%. Each package was replicated two times.

Atmospheric samples of were drawn daily as described previously. At the end of the 18 days, the bags were open and the samples weighed and assessed for visual quality.

Table 4. Fill weights of MA packaging.

Name	Weight (g)
CryoVac-1	778
CryoVac-2	1552
CVP	2248
Smart Label	908

Photo 4. Several MA packages evaluated this year.

Results and Discussion

Visual Rating

Visual assessment of the spears showed only minor signs of deterioration in the MA packaged asparagus (Photo 5, 6, and 7). Only about 5% of the MA spears showed signs of stem shrivel or tip feathering. In contrast, control spears were rated in poor condition and suffered dehydration from lack of proper humidity. Symptoms of their condition included severe stem wilt, shrivel, and feathering of the tips. No tiprot or basal decay was detected in the MA or control asparagus.

Sensory Assessment

The sensory quality of spears was rated in a similar fashion as the previous study. The majority of the taste panel found MA spears sweeter and having less offensive bitter taste than control spears. There were no differences in taste between the spears maintained at different atmospheres.

Photo 5. Control asparagus after 18 days at 2ºC.

Photo 6. CryoVac package at start of study.

Photo 7. CryoVac at end of study.

Atmosphere Concentrations in MA Packages

All the MA packages developed atmospheres below normal (Figure 4, 5). The Smart bag internal CO_2 concentration was probably close to design specification. The CVP and CryoVac were filled heavier than recommended to create low atmospheres. Both developed high levels of CO_2 but never exceeded the 15-18% level commonly referred to as the critical limit for asparagus. Similarly, the two bags developed marginally low levels of O2, but the levels did not remain below the critical limit of 2-3% for asparagus.
In general, the CO_2 and O_2 values of the four packages were within the range of 5-15% CO_2 and 5-15 % O2, which are ranges commonly accepted as appropriate to extend quality in asparagus.

Figure 4. CO_2 levels for MA asparagus. n=2.

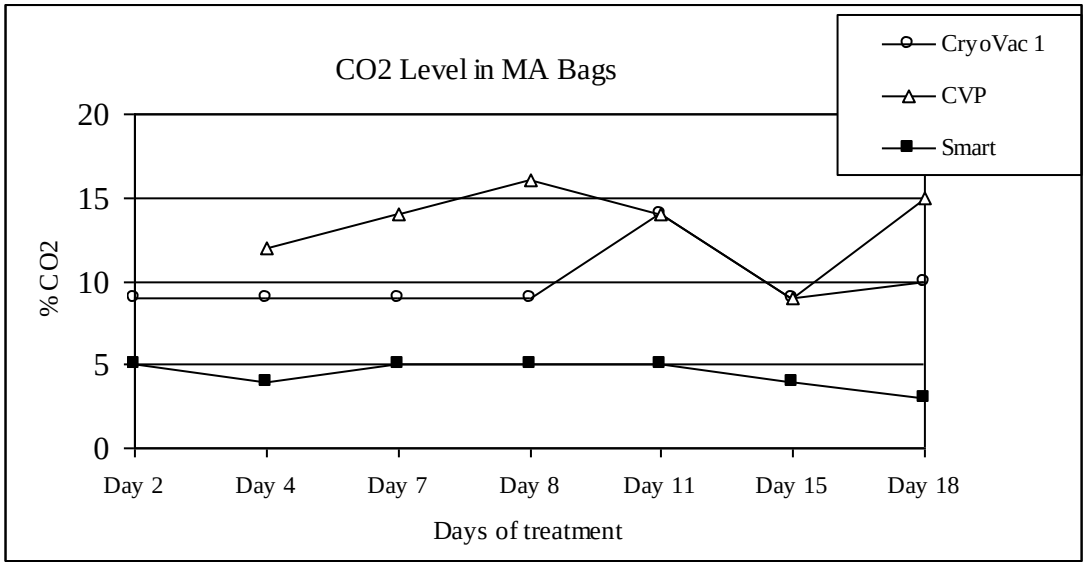
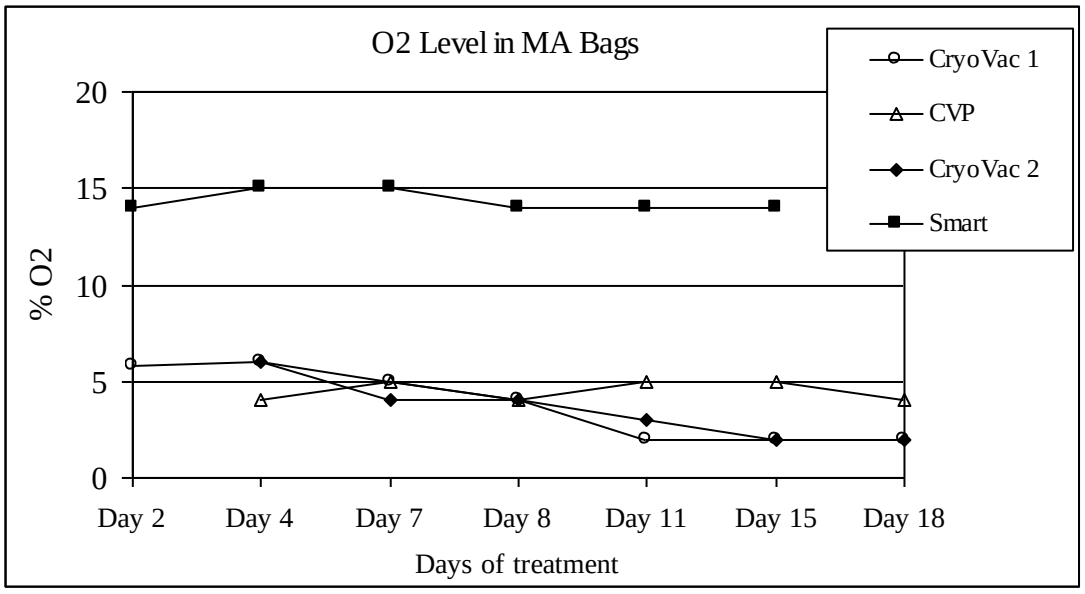


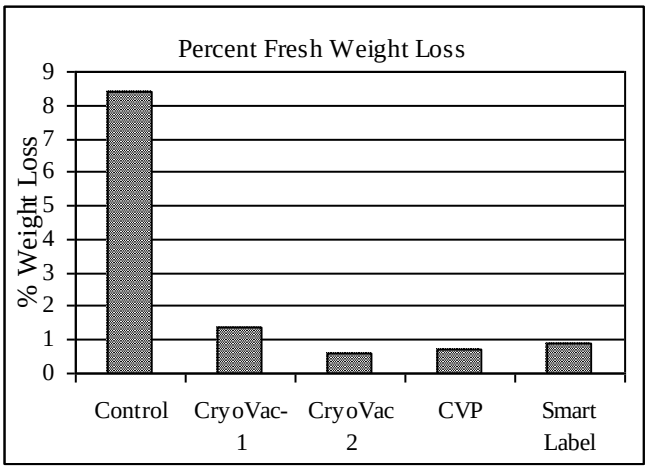
Figure 5. O_2 levels for MA asparagus. n=2.



Weight Loss

Fresh weight loss was about 2% for the MA and 8% for the control asparagus (Figure 7). All MA packages successfully minimized weight loss by lowering the respiration rate and establishing a high level of relative humidity within the packaging.

Figure 7. Percent weight loss of fresh asparagus MA packages after 18 days at 2ºC storage.



Influence of Harvest Date on MA Performance

The objective of this study was to determine the response of late harvested asparagus to MA packaging. In addition, the Smart bags were filled with two different weights in order to produce different atmospheres and determine the effects on asparagus quality.

Materials and Methods

Fresh asparagus graded "Fancy" was purchased toward the end of the asparagus harvest season on May 25, 2004. The asparagus arrived packed a cardboard box with spears loose and arraigned horizontally in the box. They were rated in excellent in quality and appearance.

The samples were as followed:

- Three Smart packages were filled with 2 lbs and three filled with 2.5 lbs of asparagus.
- Three CryoVac bags were filled with 2 lbs of asparagus.
- Three Freshpack® (FreshHold, FH700) breathable labels were attached to plastic bags and filled with 1 lb of asparagus.
- Covered/plastic - A well-perforated plastic bag was placed over three bundles to allow airflow, but maintain a moderate level of humidity within the bag. Simple design to observe effects of adequate humidity under normal atmospheres on asparagus quality.
- Controls- Three bundles placed on a pad and kept moist but not wet throughout the study.

All controls and treatments were stored at 2ºC and relative humidity of 65% for 13 days.

Toughening, or shear stress was determined weekly by taking five spears from each HWT and control and cutting cross sectionally at 6 cm, 12, and 18 cm from tip.
Maximum shear stress, maximum shear force/cross-sectional area was measured with a TA-XT2 Texture Analyzer (A single blade (10 cm x 0.3 cm) and a test cell (8.8 cm x 10 cm)). Cross-head speed was 3.0 mm/s. The maximum shear stresses were calculated using the following equation:

$$\mathbf{Sm=Fm/2(\pi D/4),}$$

Where Sm is the maximum shear stress (Pa), Fm the measured maximum shear force (N) that cut through the specimen and D are the diameter (m) of the test segment of an asparagus spear.
Each treatment was replicated three times.

Each day 0.25 ml of sample were drawn from the bags and analyzed for CO_2 and O_2 content with a gas analyzer. One MA package was opened each week and inspected for decay and tiprot and then weighed.

Results and Discussion
Unexpectedly, tiprot developed in nearly 50% of the MA packaged and control spears within the first week. Tiprot is a disorder that is characterized by spear tips becoming soft, watery, slimy, and having a foul odor. The secondary invasion by bacteria into a wound on the tip is the critical point where the tiprot begin to manifest those symptoms. The MA packaging could not be fully responsible for the tiprot because it also was found on the control spears. The development of tiprot is in contrast to previous studies where tiprot was absent on MA and control asparagus.

The primary cause of tiprot remains unclear, according to the literature. It can be a physical disorder from inappropriate handling and physical abuse during packing and shipping. The asparagus in this study arrived unbundled and laying horizontally. The weight of horizontally stacked spears during transport may have caused physical damage. Research also points to a correlation between warm temperatures at end of harvest season and tiprot development. Another factor that may play a role is the asparagus grade. The asparagus used in this study was a "Fancy" grade, a relatively delicate grades of asparagus. These grades may be more prone to physical injury and bacterial invasion.

The spears that were absent of tiprot in the MA packaged and the Covered/plastic were visually rated as in very good condition (Photo 8). Both the CryoVac with lower atmospheres and the Freshhold with close to normal atmospheres were very similar in quality to the other packaging, and no differences could be detected from varying atmospheres. In contrast, the controls in open air exhibited desiccated tips from the low humidity and had a high percent of stem shrivel and wilt (photo 8).

Photo 8. Spears without tiprot. Control on left (stored on a wet pad), middle Covered w/plastic (covered with ventilated plastic bag). Asparagus on right is FreshHold Label.

Weight Loss

Asparagus weight loss was 1% in MA packages and 3% in the Covered/plastic bag (Table 6). Unfortunately, weights for controls were not obtained due to oversight during the weighing process. However, based on the photo and controls of other MA studies, an 8% weight loss would be normal. The greater weight loss of the Covered/plastic was expected since no low atmosphere developed. The high relative humidity, however, probably helped minimized weight loss.

Table 6. Fresh weight loss (%) after 13 days at 2ºC . n=3.

Days after Treatment	Sample Name	% Weight Loss (cumulative)
Day 6	Covered w/plastic	2
	Smart 2.0	<1
	Smart 2.5	<1
	Freshhold700	<1
	CryoVac	<1
Day 11	Covered/plastic	3
	Smart 2.0	<1
	Smart 2.5	<1
	Freshhold700	<1
	CryoVac	<1
Day 13	Covered w/plastic	3
	Smart 2.0	1
	Smart 2.5	1
	Freshhold700	1
	CryoVac	1

Shear Stress

Shear stress provides a measurement of ligninification, or toughness of spears. There was a significant amount of variability between and among samples in shear stress value as

shown in Figure 8, 9, and 10. Observations from the graphs suggest that shear stress of the tip, mid-, and basal section decreased through the first seven days, then increased until day 13. The control spears consistently had the highest shear stress value of all treatments. Interestingly, the plain design of the Covered w/plastic had a low shear stress value, suggesting that a simple design that maintains adequate relative humidity may reduce toughness in spears.

Sensory Quality-Taste Panel

The sensory quality of the asparagus was determined only with spears without tiprot and in the same fashion as the previous studies. MA packaged and the Covered/plastic spears were rated as sweeter in taste than the controls and having less offensive bitter taste. There were no differences in taste of spears due to the varying atmospheres. These results support the previous study where MA packaged spears were rated higher in quality than nonpackaged controls.

Atmospheres

All MA packages established CO_2 concentrations between 5-9% with little fluctuation throughout the study (Figure 11,12). The Smart 2 and 2.5 showed no difference in CO_2 levels due to the different loads, possibly because MA plastics are usually designed to allow CO_2 to exit a film 3 times faster than O2.

The O_2 concentrations within the different packages fluctuated throughout the study. The Smart 2.5 with 0.5 lb over fill reflected this in the sudden drop in O_2 the first few days, followed by equilibrium the fourth day of the study.

Figure 8. Shear stress of spear tips. n=5. Error bars=S.D.

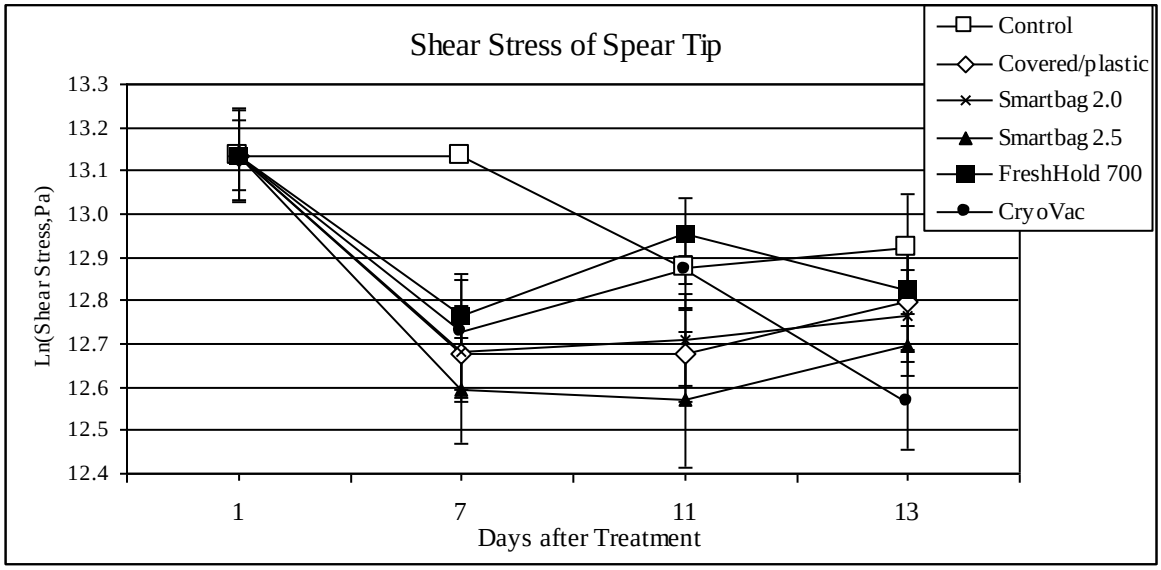


Figure 9. Shear stress of spear mid section. n=5. Error bars=S.D.

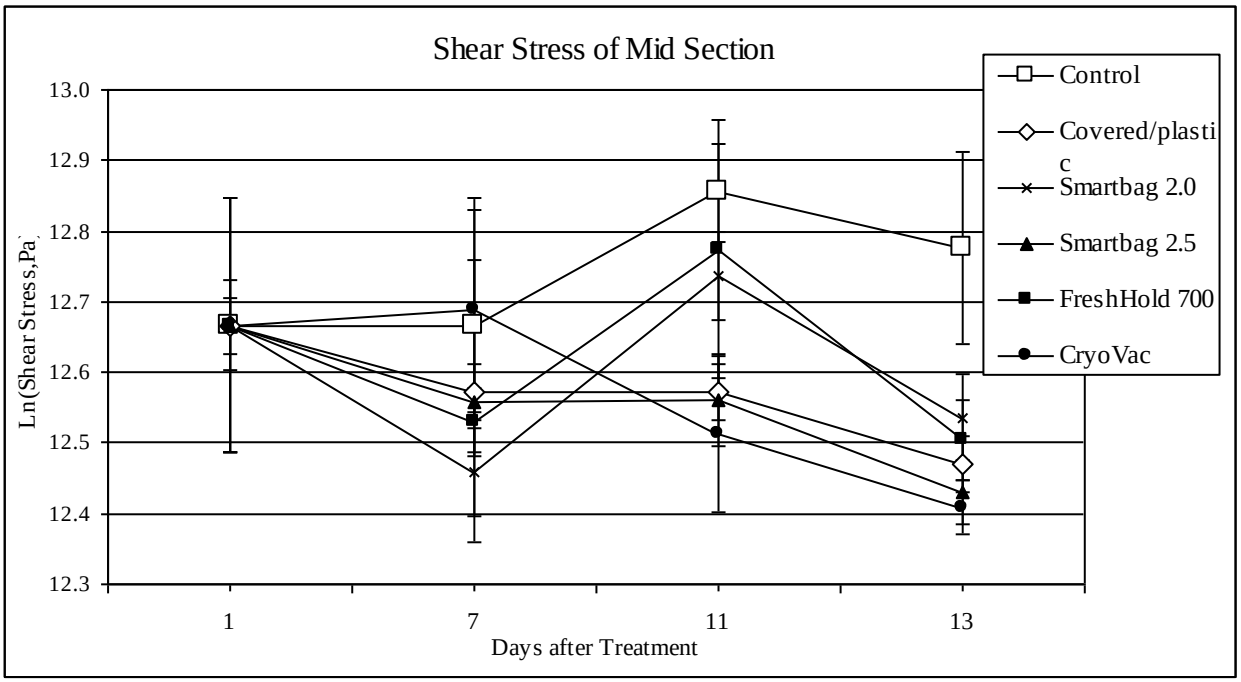


Figure 10. Shear stress of spear base. n=5. Error bars=S.D.

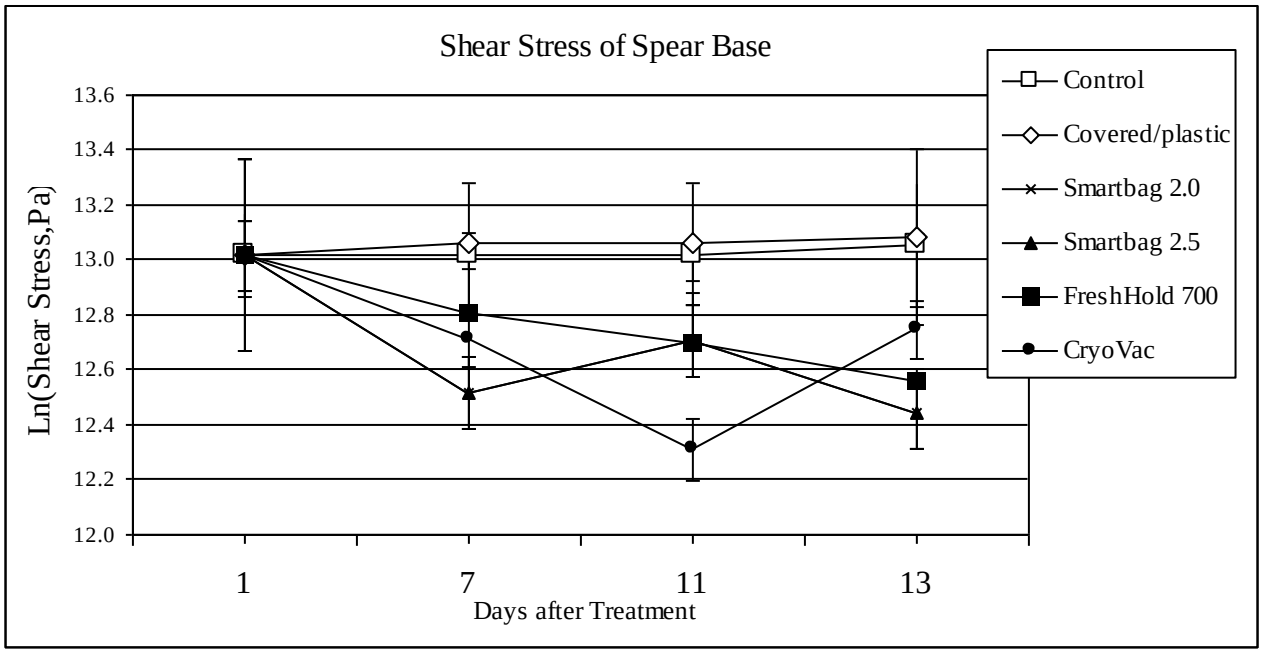


Figure 11. . Percent CO_2 in MA packages.

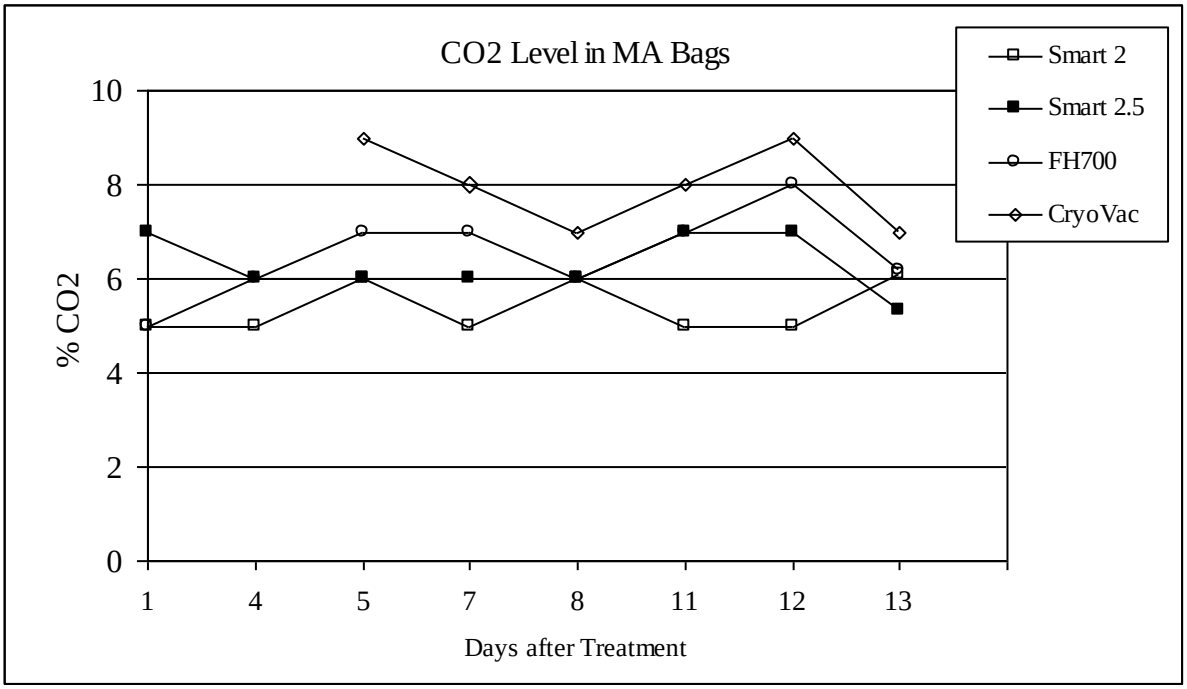
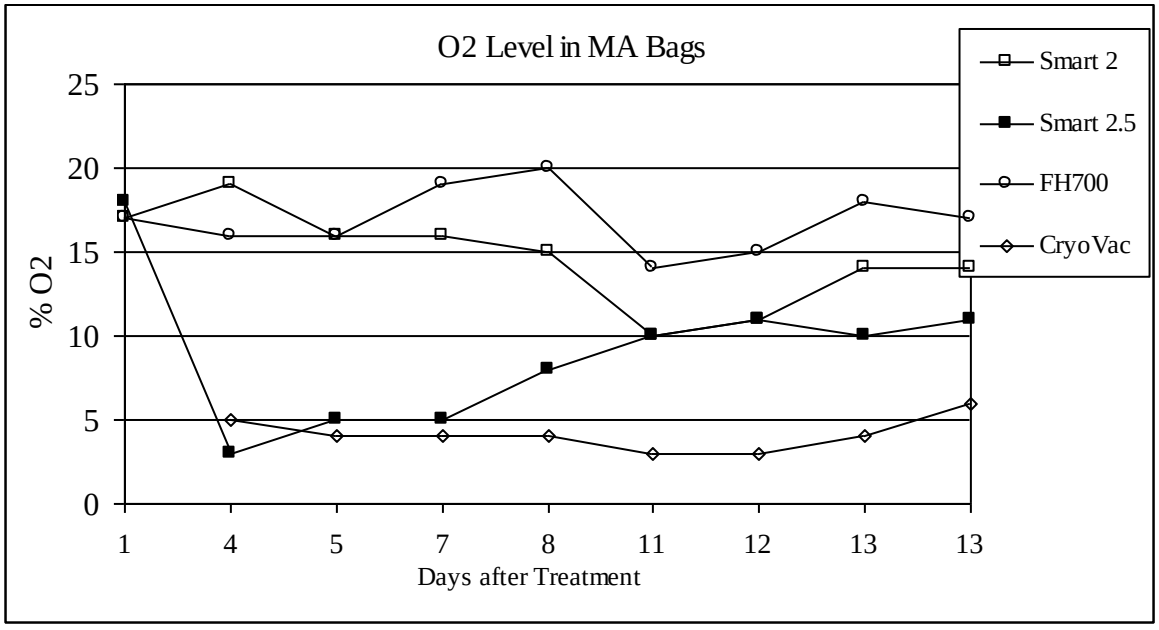


Figure 12. Percent O_2 in MA packages.



Discussion

Simulation of large-scale HWT was partially successful in extending the shelf life in asparagus. One study showed HWT-asparagus lost 7% in fresh weight compared to 20% for the untreated. Storage of treated and untreated asparagus at low relative humidity may have caused severe stem wilt, described as spears being very droopy and limp. In a second study, HWT-asparagus lost 2% fresh weight compared to 7% for untreated when stored under a well-perforated plastic bag that maintained a high level of relative humidity. In addition, stem wilt was absent. The data emphasizes the fact that relative humidity continues to be a primary factor in maintaining overall quality in asparagus.

Previous research at Laboratory found that respiration rate is about the same for HWT and untreated spears when stored at 2ºC. Therefore, the respiration rate would be a major factor in the low weight loss of treated asparagus.

Shear stress was slightly higher for HWT-spears than controls, but probably not enough to increase toughness. A study in Hawaii found similar results where HWT-asparagus stored at 2ºC were less crisp than untreated spears. However, when stored at 10ºC, the spears were crisper than controls.

In the HWT study, asparagus quality also may also have been affected by the length of treatment, which was less than 5 minutes due to the recovery period for water to return to 48ºC after submersing the asparagus. However, a study in Hawaii showed that a gradient in water temperature and time resulted in a gradient in asparagus quality. In our studies, the recovery period to return to 48ºC was 1.5 minutes for the propane heater unit and one minute for spears on outside row with Wapato electric tank. In the Wapato unit, asparagus located in the crate center may have failed to reach the target temperature.

Data from these studies show that MA packaging slows physical deterioration, dehydration, weight loss, and perhaps produces more flavorful asparagus. The development of tiprot in late season asparagus presents more of a problem in MA packaging because the high humidity and low oxygen within MA packaging creates a favorable environment for the growth of bacteria, some of which may pose a serious health risk to consumers.