EQUIPMENT & ENERGY TECHNOLOGY TEAM
DEPARTMENT OF DEFENSE – COMBAT FEEDING DIRECTORATE
US ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMAND

Test and Evaluation Report

[Ethylene Control Unit]

Shubham Chandra & Pete Lavigne
April 3, 2008

[To determine the Premier Control System's ability to decompose ethylene and extend the shelf life of fresh fruits and vegetables.]

The information in this report is based on data generated by Equipment & Energy Technology Team.

Table of Contents

1. Introduction

Fresh Fruits and Vegetables (FF&V) are an essential dietary supplement to standard operational rations. Mixed cases of FF&V are transported and stored in refrigerated containers. As FF&V ripen, they produce and release ethylene which accelerates ripening and spoilage. Some fruits, such as bananas and apples, produce very high levels of ethylene which leads to the acceleration of ripening and spoilage of other FF&V within the container. Concentrations as low as 0.1 ppm can affect the ripening process and ethylene gas levels as low as 1 ppm can destroy an entire shipment in a single day (see Reference 1). By controlling ethylene, the storage life of FF&V can literally be extended from days to weeks. For example, the shelf life of bananas can be extended from 3 days to 15 days or more. The FF&V industry currently uses blankets and packaged pellet sachets of an ethylene adsorbent to control this problem. The Navy has used adsorbent blankets in the past but has since determined that the logistics of stocking, using, and disposing of these materials is too much trouble and their use has subsequently been discontinued. The logistics of maintenance and disposal of these products is also not practical for Military field feeding applications. Current ethylene control technology is based on the use of ethylene adsorptive materials that are one time-use, relatively bulky and heavy, and pose a considerable environmental and cost burden as the spent permanganate-based materials are considered a hazardous waste. Furthermore, these products are not suited for use in a military environment, where storage space and logistic support is very limited. Accordingly, a non-consumable device that can be installed or placed in a refrigerated container that will automatically control the level of ethylene is needed to ensure that FF&V can be stored long enough to be served.

1.1 Background

The Equipment & Energy Technology Team, Combat Feeding Directorate, has been evaluating potential shelf extension of broccoli with the use of Premier Control System for its Ethylene Detection and Control Tech Based Program. This test is two-fold. First it shall evaluate the effectiveness of this technology in eradicating ethylene, and second it shall evaluate the extension of the shelf life of bananas. Based on test and the test results, a report to evaluate the effectiveness and performance of this technology will be documented.

1.2 Objectives

Determine to what extent, if any, the use of Premier Control System can extend the shelf life of bananas. To meet this objective, proper refrigerated temperature of 55° F shall be used, and bananas shall be evaluated on a daily basis to determine the ethylene concentrations.

2. TEST OVERVIEW

For testing purposes, two Polar King trailers (Figure 1) were used. One of the trailers was packed with 5 Premier Control System based panels, and the other without these panels. Each trailer was loaded with bananas to simulate loading in either a Single Temp or Multi Temperature Refrigerated Container System.

Figure 1: Polar King Trailers – Test Platform

2.1 Test Equipment: Premier Control System

Produce growers, whole sellers and distributors can potentially use Premier Control System, (See Figure 2) air purifying systems to slow down deterioration and extend the shelf life of fruits, vegetables and other perishable foods. This so-called “shrink-reduction” not only adds money to

the bottom line of food industry professionals, but also helps reduce waste in an ever-increasing green economy. Food safety and security are added bonuses to this industry that is seeing an increased awareness of food safety issues. Premier absorbs excess humidity from the air but also releases moisture back into the air, always maintaining the optimal food storage conditions. Premier Panels contain Clensite, a mineral which absorbs and desorbs moisture, (and absorbs ethylene gas, pectin gas and acid molecules from the air of your cooler and freezer).

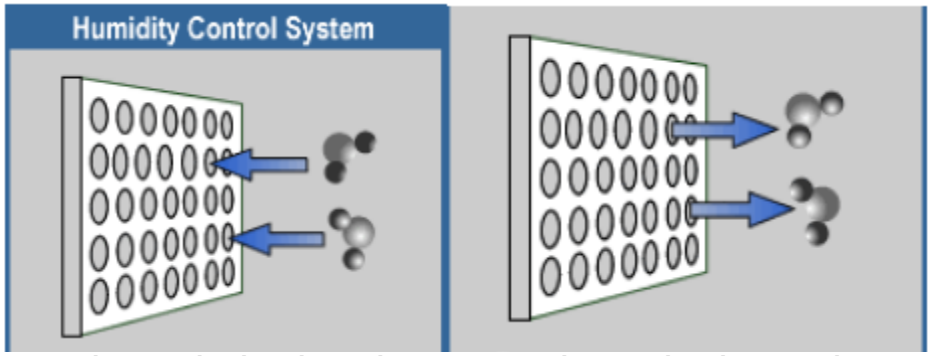


Figure 2: Premier Control System

2.2 Test Item: Banana

Bananas are moderately sensitive to ethylene exposure. Most commercial cultivars of bananas require exposure to 100-150 ppm ethylene 24-48 hours at 15-20°C (59-68°F) and 90-95% relative humidity to induce uniform ripening. Carbon dioxide concentration should be kept below 1% to avoid its effect on delaying ethylene action. Use of a forced-air system in ripening rooms assures more uniform cooling or warming of bananas as needed and more uniform ethylene concentration throughout the ripening. UC Davis – (http://postharvest.ucdavis.edu/Produce/ProduceFacts/Fruit/banana.shtmlE

2.4 Test Set Up Description

The test setup consisted of a refrigerator at 55° F (with longer defrost cycles, to reduce excessive fluctuations in temperatures) to simulate ship board refrigerated temperatures, and 5 Premier Control System based panels.

Figure X: Trailer with Premier Panels

Banana Initial Inspection:

Maturity Indices

Degree of fullness of the fingers, i.e., disappearance of angularity in a cross section. Bananas are harvested mature-green and ripened upon arrival at destination markets since fruits ripened on the plant often split and have poor texture.

Optimum Temperature and Relative Humidity

13-14°C (56-58°F) for storage and transport
15-20°C (59-68°F) for ripen 90-95%

Rates of Respiration
Temperature 13°C(56°F) 15°C(59°F) 18°C(65°F) 20°C(68°F)
ml CO2/kg.hr1, 2 10-30 12-40 15-60 20-70
1 Low end for mature-green bananas and high end for ripening bananas
2 To calculate heat production multiply ml CO2/kg.h by 440 to get Btu/ton/day or by 122 to get kcal/metric ton/day.

Bananas:
Temperature 13°C(56°F) 15°C(59°F) 18°C(65°F) 20°C(68°F)
ul C2H4/kg.hr 0.1-2 0.2-5 0.2-8 0.3-10
(44 pounds/box x 1kg/2.2pounds x 5 boxes x 5 ul C2H4/kg.hr)/6767.7 L (6.5' X
7.125' X 5.167') (amount of liters in Polar King container) = 73.88 ppb/hr

Physical Injury

Rough handling at harvest can damage the bananas and increase decay.

2.5 Test Procedures

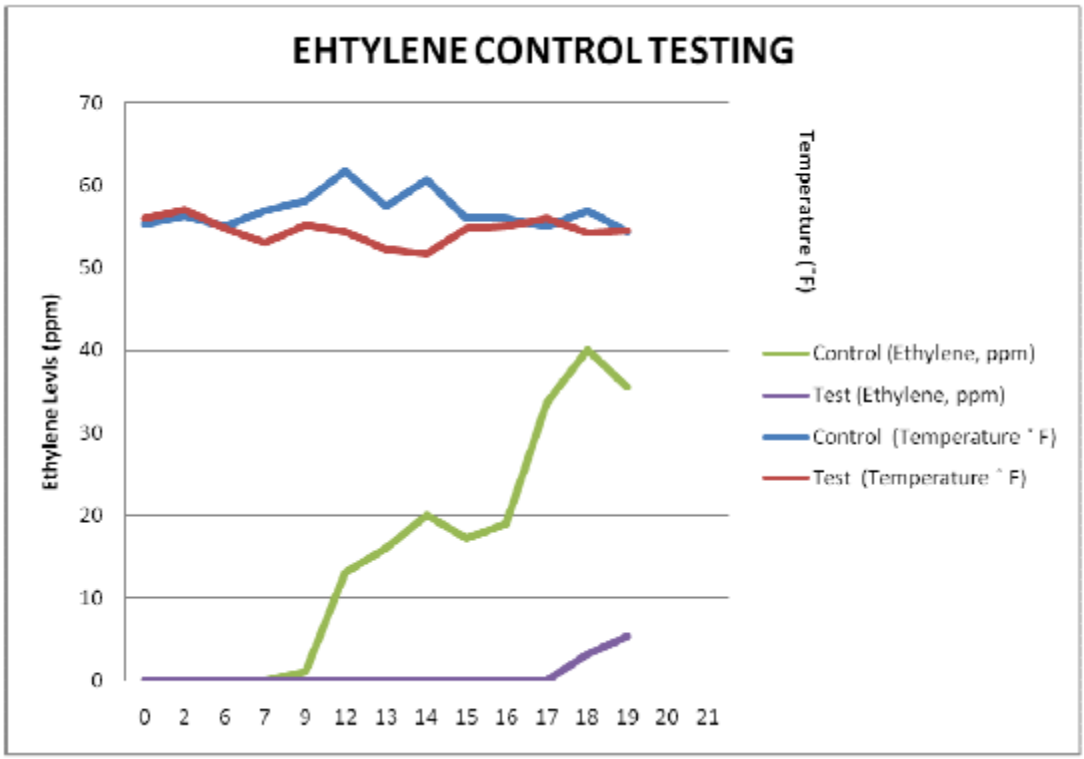
Equipment Protocol:

Turn on ppb RAE Plus and allow it to warm up. Press yes when “ready?” appears and then allow it to finish warming up. Place tubing on the sensor to give it extra reach so it can penetrate the trailer. Measure ethylene twice per day for as long as deemed necessary. Turn on N9008 Thermometer and measure temperature.

3. Result

3.1 TEST DATA

Control (Temperature ˚ F)	Test (Temperature ˚ F)	Control (Ethylene, ppm)	Test (Ethylene, ppm)	Days
55.3	56	0	0	0
56.3	57	0	0	2
55.1	54.7	0	0	6
56.9	53	0	0	7
58.1	55.1	1.1	0	9
61.7	54.4	13.1	0	12
57.5	52.2	16.1	0	13
60.6	51.7	20.1	0.01	14
56	54.7	17.3	0	15
56	55	19	0	16
55	56	33.7	0	17
56.9	54.2	40.1	3.13	18
54.4	54.5	35.6	5.29	19



In Chart 1, the growth of ethylene levels for the storage protocols is plotted. The storage temperature for bananas was maintained at 55 °F. For the first nine days, the ethylene levels within the two protocols increased at the same rate, however after day 9, the ethylene level in the control protocol increased, and the ethylene level in the Premier protocol remained negligible. This slight modification in ethylene levels between the two protocols resulted in Figure 4. Increased ethylene levels resulted in Fusarium roseum, a kind of mold growth See Figure 2. Minor skin abrasions, shown in Figure 2 was also seen on the control protocol.

DAY 0

CONTROL PREMIER

Figure: Control Setup

DAY 0

Figure: Premier Setup

DAY 15

Figure: Premier Protocol (Day 15)

Figure: Control Protocol (Day 15)

Day 16

Figure: Premier Protocol (Day 16)

Figure: Control Protocol (Day 16)

Day 19

Figure: Premier Protocol (Day 19)

Figure: Control Protocol (Day 19)

Day 20

Figure: Premier Protocol (Left) Vs. Control Protocol (Right) (Day 20)

Day 20

Figure: Premier Protocol (Left) Vs. Control Protocol (Right)

Day 22

Figure: Premier Protocol (Left) Vs. Control Protocol (Right) (Day 22)

Day 26

Figure: Premier Protocol (Day 26)

Figure: Control Protocol (Day 26)

4. Conclusions

In order to keep ethylene concentrations at the appropriate level the container could not be opened regularly to see how the bananas were fairing. Thus, this test was more focused on the levels of ethylene that were being produced and the Premier's ability to destroy it and less focused on the quality of bananas overtime. That being said, the control was still opened about once a week just to make sure that the bananas were not completely spoiled, especially since the ethylene levels produced were higher than expected.

The data clearly shows that the Premier model was able to keep the ethylene concentrations lower than what we saw in the control. On average the ppm levels in the Premier container were about 20 to 37 ppm lower than the levels in the control. Results clearly indicate the Premier panels are effectively in controlling the ethylene levels generated by banana containing container. By controlling the ethylene, data suggests shelf life extension of bananas can be
achieved.

5. References

A Glossary