AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

CARIBBEAN

FOOD

CROPS SOCIETY

31

Thirty First

Annual Meeting 1995

Barbados

Vol.XXXI

CONTROL OF RESPIRATORY GASES AND RELATIVE HUMIDITY IN POST-HARVEST EXPERIMENTS USING A HUMIDIFIED AIR FLOW SYSTEM.

[1]Majeed Mohammed and [2]E C Lougheed

[1]Department of Crop Science, The University of the West Indies
St Augustine, Trinidad

[2]Department of Horticultural Science, University of Guelph
N1G 2WI, Ontario, Canada

ABSTRACT

Sweet peppers were stored at 4.5 and 13 °C in sealed low-density polyethylene bags (LDPE) and paper bags for 25 and 40 days respectively using air flow chambers (AFC) and storage rooms without air flow chambers (NAFC). Fruits stored in LDPE bags in the AFC system at 13 °C had superior quality ratings, less decay, less chilling injury, higher bioelectrical resistance and lower electrolyte leakage measurements after 40 days of storage compared to fruits kept in the NAFC system. These quality ratings which contributed to a longer shelf-life for fruits in the AFC system were due to the control of relative humidity (90–95%) and reduction of cross-contamination of gases between packages and storage atmospheres which resulted in lower in-package CO_2 and C_2H_4 levels.

INTRODUCTION

The importance of having the same environmental conditions for all treatments in storage experiments is necessary in order to monitor the post-harvest behaviour of horticultural commodities. In modified atmosphere packaging studies for example, the possibility of gaseous cross contamination among packages and between the storage air and the packages can occur. In such circumstances the concentrations of carbon dioxide and ethylene within the packages may very well reflect the general levels in the storage rooms rather than the effect of the packages. It is also essential to ensure that control samples in paper bags are left at a relative humidity similar to that within the sealed packages Failure to provide adequate measures to eliminate these errors can easily lead to misinterpretation of data in experimental investigations.

The objective of this study was to examine the physiological changes in sweet peppers stored in different types of packaging materials when an air flow system was used to control C_2H_4, CO_2 and relative humidity levels.

MATERIALS AND METHODS

Mature-green sweet peppers (*Capsicum annuum*, (L.)), cv. Stardon's Select, were obtained from a greenhouse and transported in plastic crates to the storage laboratory on the day of harvest.

Samples of fruits of uniform size and appearance were submerged in water plus a fungicide for 20 min to simulate commercial pre-storage hydrocooling techniques and to control fungal pathogens. Initial temperature of the water was 2.8 oC and the temperature rose no more than 4 °C during the pre-cooling period. The fungicide used was Benlate (Dupont Canada Inc. guaranteed 50% benomyl WP) mixed to a final concentration of 500 ppm in water. Samples were blotted dry with tissue paper before subjecting them to the packaging treatments.

Fruits were individually seal-packaged on the same day the fruits were harvested in low density polyethylene (LDPE = 0.025 mm thick) bags with an electric heat sealer with a (Promotional Packaging Co. Toronto). The fruits in the paper bags served as unsealed controls. Packages consisted of fruits sealed with packets of calcium hydroxide (50 g) to absorb carbon dioxide, or 50-g packets of Purafil (Marbon Division, Borg-Warner Corporation distributed by Circulaire Eastern Inc., Quebec, Canada) to absorb ethylene, or without inserts. No-insert treatments were used for the non-sealed control in paper bags.

An equal portion of packaged fruits was stored at 4.5 oC and 13 oC in separate rooms. At each temperature air flow chambers (AFCs) were used for holding samples as shown in Figure 1. In another room at the same temperatures samples were kept together with other fruits, e.g. apples, where no air flow chambers (NAFCs) were used.

Where the AFCs were used, air was supplied with a compressor with intake some 8 m above the roof of the laboratory and approximately 15 m above ground level. The compressed air passed through an air line filter, a pressure reducing valve, a flowmeter, a 2,000-mL Erlenmeyer flask containing water and then the chamber outlet. The pressure and flow were sufficiently high to have a measurable flow at the outlet and a slight positive pressure within the chamber.

Each chamber was placed at a slight incline towards the front to allow the drainage of condensed moisture through a small hole (0.6 cm in diameter) bored through the underside of the chamber. This drainage hole was plugged during normal operation. For each chamber the water level in the Erlenmeyer flask was checked and refilled each day.

Data were taken after 25 and 40 days on the following parameters:

- CO_2, C_2H_4 and relative humidity within each storage room and within each chamber
- In-package CO_2 and C_2H_4
- Percentage fresh weight losses
- Chilling injury

- Marketable quality
- Decay
- Bioelectrical resistance
- Electrolyte leakage.

An Abbeon dial hygrometer (Model M2A4, Abbeon Inc., 179-15 Jamaica Avenue, America, NY 11342) was used to measure relative humidity.

A hypodermic needle was inserted into a 15-cm length of copper tubing (3 mm in external diameter), fitted to a 45-mL syringe and used to extract 45-mL samples of the atmospheres inside each chamber through an aperture in the chamber which was normally kept closed. Similar samples were taken from each room in which each chamber was located. Withdrawal of gas samples (3 mL)without causing leaks from within the packages was ensured using a method modified from that of Bussel and Kenigsberger (1975). A drop of RTV-102 silicone rubber cement was placed on a strip of masking tape 4 cm x 2 cm applied to one surface of each package, allowed to cure for 24 h and used on a septum.

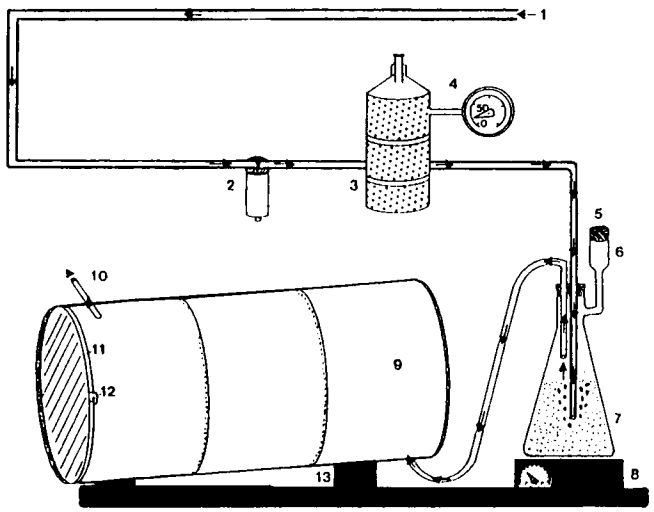

Figure 1 Diagram of the humified air flow system
1 = air inlet; 2 = air line filter; 3 = Nullmatic pressure regulator; 4 = pressure gauge; 5 = water plug; 6 = water inlet; 7 = Erlenmeyer flask; 9 = chamber; 10 = air outlet; 11 = air-tight lid; 12 = cover clip; 13 = chamber support

The simultaneous determination of CO_2 and C_2H_4 was accomplished with a Beckman GC-5 gas chromatograph equipped with a 3 mm x 3 m stainless steel column packed with silica gel (60–80 mesh) and with thermal conductivity (CO_2) and dual-flame ionization (C_2H_4) detectors. Detector and column temperatures were 250 and 120 °C, respectively.

Peak heights of CO_2 readings were measured, compared to a standard calibration gas containing 1,657 ppm, adjusted to standard temperature and pressure, and reported as % in-package or in-fruit CO_2. C_2H4 measurements, estimated by an electronic integrator (Spectra-Physics minigrator) with automatic printout, were compared to a standard calibration gas containing 6.00 ppm, corrected to standard temperature and pressure and recorded as in-package or in-fruit ppm C_2H4.

Weights of fruits were taken before and after storage periods to calculate percentage fresh weight losses. Chilling injury was rated on a hedonic scale of 0–4 with 0= more, 1 = slight, 2 = fair, 3 = moderate and 4 = severe. Marketable quality was rated from 0–4 with 0 = excellent, 1 = good, 2 = fair, 3 = poor and 4 = unmarketable. Decay was rated from 0–5 with 0 = no diseased fruit, 1 = slight deterioration which would not be noticed by the consumer, 2 = moderate deterioration, 3 = extensive (limit to marketabliity), 4 = severely affected fruits, and 5 = complete breakdown.

Measurements of bioelectrical resistance and electrolyte were performed using the methods reported by Lougheed (1981) and Mohammed (1984).

In each experiment each treatment consisted of three replicates with each replicate being an individual fruit. Data were analyzed as a completely randomized design, with a factorial arrangement of variables, and significance tested by the F-test (P= 5%) and Duncan's multiple range test (P = 5%) where applicable.

RESULTS AND DISCUSSION:

Sweet peppers seal-packaged in LDPE bags and stored at 13 °C in chambers with the air flow system (AFC) had the best quality ratings after 40 days (Table 1). In this storage regime fruits had marketable quality and decay ratings of 0.9 and 0.5 respectively compared to samples in the NAFC systems where the same measurements were recorded as 4.0 and 3.1 respectively (Table 1). At the lower temperature (4.5 °C) marketable quality and decay were 2.0 and 2.9 in the AFC system compared to 4.0 and 4.6 in the NAFC system (Table 1). These differences are related to the modified atmosphere within the sealed bags and the influence of storage temperature.

The consistently lower levels of CO_2 and C_2H_4 recorded for AFC versus NAFS systems shown in Table 1 demonstrated the effectiveness of the former system compared to the latter system in securing a storage environment where cross contamination of gases between packaging treatments and the storage atmospheres were eliminated. As such a more accurate reflection of the modified atmosphere was developed within the packages (Table 2). Accordingly, the data presented in Tables 3 and 4 showed significantly ($P \leq 0.01$) lower levels of CO_2 and C_2H_4 after 25 and 40 days respectively in the AFC versus the NAFC systems for both package treatments. The presence of higher C_2H_4 in the NAFC system obviously contributed to accelerated senescence of fruits which is in agreement with other studies reported by Chaplin et. al. (1983), Wang and Adams (1980) and Lougheed (1987).

The visible symptoms of chilling injury manifested by the presence of pitting, appearance of dark-brown discolouration of seeds, stems and calyses as well as secondary infections due to multiple infections were noted after 25 days at 4.5 °C with a greater intensity for fruits in the NAFC compared to the AFC systems (Table 5). Chaplin et. al. (1983) reported in their studies with avocadoes the enhancement of chilling injury as a result of an additive effect due to presence of C_2H_4, similar to that found in our findings described above.

Table 1 Effect of packaging upon marketable quality and decay of sweet pepper using air flow chambers

	Storage period (40 days)			
	Air flow chamber		No air flow chamber	
	LDPE*	PB**	LDPE*	PB**
At 4.5 °C				
Marketable quality[y]	2.0 a	3.1 b	4.0 b	4.0 b
Decay[z]	2.9 a	3.8 b	4.6 c	4.1bc
At 13 °C				
Marketable quality[y]	0.9 a	2.8 b	4.0 c	3.6 c
Decay[z]	0.5 a	0.7 a	3.1 b	3.8 c

* low-density polyethylene bags ** paper bags

[y] Marketable quality: 0–4 with 0 = excellent; 4 = unmarketable

[z] Decay: 0–5 with 0 = no diseased fruit; 5 = complete breakdown

a, b, c: numbers followed by the same letter are not sgnificantly different (P = 5%); Duncan's multiple range test

Table 2 Composition of carbon dioxide, ethylene and relative humidity in air flow chambers and storage rooms

Parameter	Air flow chamber	No air flow chamber
CO_2 (%)	0.04 a	1.49 b
C_2H_4 (ppm)	0.02 a	3.70 b
Relative humidity (%)	All packages 90–95	Polyethylene bags = 80–90 Paper bags = 60–70

a, b, c: numbers followed by the same letter are not sgnificantly different (P = 5%); Duncan's multiple range test

Table 3 Effect of packaging upon in-package carbon dioxide concentrations of sweet pepper using air flow chambers

		In-package CO_2 (%)			
		Air flow chamber		No air flow chamber	
Temp.(°C)	Package	25 days	40 days	25 days	40 days
4.5	LDPE*	0.12 a	0.22 a	1.38 bc	1.37 bc
4.5	PB**	0.07 a	0.04 a	1.01 b	1.46 c
13.0	LDPE*	0.07 a	0.13 a	1.43 c	1.40 c
13.0	PB**	0.05 a	0.05 a	1.11 b	1.33 b

Numbers followed by the same letter are not significantly different P = 5%); Duncan's multiple range test

* low-density polyethylene bags ** paper bags

Table 4 Effect of packaging upon in-package ethylene concentrations of sweet peppers using air flow chambers

		In-package C_2H_4 (ppm)			
		Air flow chamber		No air flow chamber	
Temp. (°C)	Package	25 days	40 days	25 days	40 days
4.5	LDPE*	0.03 a	0.07 a	2.76 c	3.42 d
4.5	PB**	0.03 a	0.04 a	1.07 b	3.77 e
13.0	LDPE*	0.06 a	0.05 a	2.57 c	3.36 d
13.0	PB**	0.04 a	0.08 a	1.76 b	3.41 d

Numbers followed by the same letter are not significantly different (P = 5%); Duncan's multiple range test

* low-density polyethylene bags ** paper bags

The importance of subjecting treatments with fresh humidified air to attain a 90–95% rh across all packages in the AFC system compared to the NAFC system where a 20% rh difference existed between samples held in sealed polyethylene bags and paper bags is confirmed in Table 5 where fresh weight losses are reported. With a 90–95% rh in the AFC system at both temperatures only nominal differences in percentage fresh weight losses were obtained between package treatments (Table 5). The opposite effect is noted in the

NAFC system with a 11–13-fold increase in fresh weight losses between package treatments (Table 5). In addition, it was only in the NAFC system that significant ($P \leq 0.01$) differences were found between packaging treatments at 4.5 °C as a result of chilling injury, the relationship between fresh weight losses and the visible expression of chilling injury symptoms being confirmed (Lurie et. al., 1986).

Table 5 Effect of packaging upon percentage fresh weight losses, chilling injury, bioelectrical resistance and electrolyte leakage of sweet peppers using air flow chambers

		Storage period (25 days)			
		4.5 °C		13.0 °C	
Parameter	Package	AFC‡	NAFC‡‡	AFC‡	NAFC‡‡
Fresh weight	LDPE*	1.51 a	1.70 a	1.73 a	2.01 a
Losses (%])	PB**	2.19 a	20.19 b	3.71 a	26.19 b
Chilling injury	LDPE*	0.8 a	2.0 b	0.0 a	0.6 a
Index†	PB**	1.0 a	3.1 c	0.2 a	0.2 a
Bioelectrical	LDPE*	66.7 d	51.9 c	74.6 c	66.0 ab
resistance	PB**	42.6 b	30.2 a	70.1 bc	61.4 a
Electrolyte	LDPE*	29.7 a	36.6 b	24.6 a	38.6 b
leakage (%)	PB**	36.1 b	40.1 c	29.1 a	41.1 b

Numbers followed by the same letter are not significantly different (P = 5%); Duncan's multiple range test

* low-density polyethylene bags ** paper bags
‡ air flow chamber ‡‡ no air flow chamber
†Chilling injury index: 0–4 with 0 = none, 4 = severe

However, the inverse relationship between bioelectrical resistance and electrolyte leakage as an early indicator of membrane permeability and therefore chilling injury (Lougheed et. al. 1983; Mohammed and Wickham 1993) is supported in this study. The apparent absence of visible symptoms of chilling injury between packaging treatments in the AFC system at 4.5 °C corresponded with significant ($P \leq 0.05$) decreases in bioelectrical resistance and increases ($P \leq 0.01$) in electrolyte leakage. Accordingly, chilling injury damage did in fact take place before visible expression of symptoms, signifying the sensitive nature of these physiological methods to determine the onset of chilling injury.

REFERENCES:

Bussel, J. and Kenigsberger, Z. 1975. Packaging green bell peppers in selected permeability films. J. Food Sci. 40:1300–1303.

Chaplin, G.R., Wills, R.B.H. and Graham, D. 1983. Induction of chilling injury in stored avocadoes with exogenous ethylene. HortScience 8:952–953.

Curie, S., Shapiro, B. and Ben-Yehoshua, S. 1986. Effects of water stress and degree of ripeness on rate of senescence of harvested bell pepper fruit. J. Amer. Soc. Hort. Sci. 111:880–885.

Lougheed, E.C. 1987. Interactions of oxygen, carbon dioxide and ethylene that may induce injuries in vegetables. HortScience 22 (5):791–794.

Lougheed, E.C., Fisher, C.W. and Murr, D.P. 1983. *In situ* measurements of electrical impedance and resistance of fruits: a review. HortScience 18:825–828.

Lougheed, E.C., Miller, S.R., Ripley, B.D. and Cline, R.A. 1981. Electrical impedance of daminozide-acid calcium-treated McIntosh apples. Experientia 37:835–836.

Mohammed, M. 1984. Storage of sweet peppers and tomatoes in polymeric films. M.Sc. Thesis. Univ. of Guelph, Canada. 148 pp.

Mohammed, M. and Wickham, L. 1993. Extension of bitter gourd (Mom*ordica charantia,* L.) storage life through the use of reduced temperature and polyethylene wraps. J. of Food Quality. 16 (5):371–382.

Wang, C.Y. and Adams, D.O. 1980. Chilling-induced ethylene production in cucumbers. Plant Physiology 69:424–427.