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STORAGE QUALITY OF FLORIDA CRISPEAD LETTUCE

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Abstract. In 8 laboratory storage tests, Florida crisphead iceberg lettuce (*Lactuca sativa*) was stored at 36°F (2.2°C) for 7 and 14 days followed by 50°F (10°C) for 3 and 5 days to simulate domestic and export shipment and retail handling. After storage, the lettuce was weighed and evaluated for weight loss, firmness, bruising, rib discoloration, decay, and percentage of trim. Decay was minimal after 7 or 14 days' storage at 36°F, but generally increased following simulated retail handling at 50°F. Preharvest conditions, packing, and bruising were related to amount of decay and percentage of trim loss after storage. Results indicate that good-quality Florida lettuce can be delivered to market with minimal decay if: 1, growing and preharvest weather conditions are ideal, 2, lettuce is harvested and packed carefully, and 3, lettuce is promptly vacuum-cooled and held at a temperature of 34-36°F (1.1-2.2°C).

The production of Florida crisphead iceberg lettuce (henceforth, crisphead iceberg lettuce is referred to as "lettuce") has increased rapidly in the last 10 years (3). During the 1979-80 season, almost 10,000 acres (4,047 ha) of lettuce, valued at ca. \$25 million, were planted in the Belle Glade area of Florida (3). Florida is the third leading state in production of lettuce. Florida lettuce is vacuum-cooled to 36-40°F (2.2-4.4°C) immediately after harvest and stored in cold rooms until shipment. Most shipments terminate east of the Mississippi River. Exports of U.S. lettuce have been increasing and currently total \$38.1 million per year (13). At least 5 van-container shipments of Florida lettuce have been sent to Europe during the past 2 years. Three of the shipments arrived in excellent condition, and the other 2 shipments arrived in poor condition with high incidence of decay.

The postharvest quality of western lettuce has been studied for many years (4, 5, 6, 7, 9, 11, 12). However, very little research has been published on the postharvest quality of Florida lettuce. In this study, the quality of Florida-grown lettuce was studied under simulated domestic and export conditions, and retail handling. Lutz (10) stated that, ideally, lettuce should be stored at 32°F (0°C); but for practical purposes, most storage and transit vehicles maintain somewhat higher temperatures. Therefore, 36°F (2.2°C) was the storage temperature selected for simulated transit, and 50°F (10°C) was selected as a retail handling temperature.

The lettuce was stored for 7 and 14 days to simulate domestic and export transit times.

The objective of this research was to evaluate the storage quality of Florida lettuce under simulated conditions for domestic and export shipments.

Materials and Methods

Eight tests were conducted at ca. 2-week intervals from early February through late April 1980. The tests were made with naked or unwrapped heads of lettuce grown in the Belle Glade, Florida, area and were packed 24 heads per corrugated, regular-slotted fiberboard box. The predominant cultivar grown in Florida, 'Montello', was used in these tests. The fiberboard box was the conventional box which the industry uses, with inside dimensions of 21 1/2 x 16 x 10 1/2 inches (54.6 x 40.6 x 26.7 cm). The lettuce was harvested, packed, and vacuum-cooled commercially. For each test, 1 to 5 samples were collected such that the total number of samples for the 8 tests was 22. Each sample consisted of 4 randomly selected boxes of lettuce. Test samples were transported by air-conditioned automobile to the Horticultural Research Laboratory at Orlando.

On arrival at Orlando, ca. 4 hr after vacuum cooling, the boxes of lettuce were immediately weighed and placed in rooms held at 36°F (2.2°C) and 85 to 90% relative humidity. Two of the 4 boxes of lettuce per sample were removed from storage after 7 days. The boxes were weighed, and 8 heads of lettuce were removed from each box, weighed, and evaluated. The remaining 16 heads in each box were then stored at 50°F (10°C). At the end of 3 days' storage at 50°F, 8 heads were removed, weighed, and evaluated. At the end of 5 days' storage, the remaining 8 heads were weighed and evaluated. The same procedure was used with the 2 boxes which remained in storage for 14 days at 36°F.

At each evaluation, the total weight of 8 heads was recorded and each head was then evaluated on a rating scale developed by Kader et al. (8) for the following factors:

Appearance	Firmness	Crushing and Bruising
9—Excellent	1—Soft	1—None
7—Good	2—Fairly firm	3—Slight
5—Fair	3—Firm	5—Moderate
3—Poor	4—Hard	7—Severe
1—Not salable	5—Extra hard	9—Extreme

Butt discoloration, crushing and bruising, and decay were the main defects evaluated. Most unwrapped lettuce is trimmed at the wholesale or retail level to remove wrapper leaves and damaged or decayed leaves. In this test, the lettuce heads were rated for appearance, firmness, and defects, and then trimmed as a retail produce clerk would do to make them presentable for sale. These trimmings were weighed and referred to as "retail trim loss." After trimming to salable condition, the lettuce heads were cut in half and

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further evaluated. Any leaves that had internal decay, bruising, or rib discoloration were removed and were referred to as "consumer trim."

All data were subjected to analysis of variance and mean separation by Duncan's multiple range test.

Results and Discussion

Lettuce stored for 7 days at 36°F rated highest for appearance, and lowest for decay and percentage trim (Table 1). The rating for appearance decreased and the rating for decay and percentage trim increased with additional storage of 3 and 5 days at 50°F. The ratings of lettuce stored for 14 days at 36°F were similar to those of lettuce stored for 7 days at 36°F plus 3 additional days at 50°F. Lettuce stored for 14 days at 36°F plus 5 additional days at 50°F rated the lowest for appearance and the highest for decay and percentage trim. The rating for firmness remained the same during storage. The rating for crushing and bruising increased slightly during storage, although the actual amount probably did not increase during storage, but became more visible.

Butt discoloration increased with storage time (data not shown), particularly during the additional holding periods of 3 and 5 days at 50°F. Generally, the rating for butt discoloration increased from 3 after initial storage at 36° for 7 and 14 days to 5 and 5.5, respectively, for additional holding periods of 3 and 5 days at 50°F. Other defects, such as internal rib necrosis, pink rib, rib discoloration, rusty brown discoloration, and russet spotting, were minimal during storage. Amount of shrinkage or moisture loss of lettuce during initial storage at 36° for 7 and 14 days ranged from 0 to 0.3%.

The percentage of retail trim was high, ranging from 29 to 42%, but most of the retail trim consisted of the outer

wrapper leaves, which are normally removed by retail produce clerks. The retail trim also included crushed and bruised leaves, decayed tissue, and a small portion of the butt. According to a recent article (2), ca. 12 lb. (5.5 kg) per box, or 25%, of naked lettuce shipped to chain stores is normally trimmed off by the retail produce personnel. If this trim is all waste or leaves consumers normally would not use, consideration should be given to more field trimming so that transportation costs might be reduced. Most of the increase in percentage of retail trim during extended storage periods was caused by increases in decay. Consumer trim varied only slightly during storage, but was generally minimal and included leaves with discoloring, with russet spotting, and, in a few cases, with internal decay which was not apparent during the removal of wrapper leaves.

The ratings for appearance, crushing and bruising, and decay, the percentage of retail trim, and the average weight per box differed significantly between storage tests (Table 2). However, the firmness of lettuce was about the same in all tests except test 7. In that test, the lettuce heads were slightly firmer and denser than those in the other tests. Generally, the rating for appearance was inversely related to the ratings for crushing and bruising, and decay, and to the percentage of retail trim. Crushing and bruising and the resultant decay during storage lowered the rating for appearance and increased the percentage of retail trim. Staple damage to lettuce heads on the top layer of most boxes of lettuce was noted in this study. About 60% of the boxes of lettuce sampled were overpacked, bulging from 1/2 to 2 1/2 inches (1.3 to 6.3 cm). Most of the crushing and bruising occurred during harvesting and packing, and this finding agrees with that of earlier studies on California lettuce (5, 6). Crushing and bruising of lettuce are among the major problems on arrival at market (1, 12).

The lettuce harvested and packed in March and April

Table 1. Evaluation of Florida-grown 'Montello' lettuce stored for 7 and 14 days at 36°F, plus 3 and 5 days at 50°F (means of 8 tests—352 heads of lettuce), 1980.^z

Storage time and temperature	Ratings						% Trim	
	Appearance		Firmness	Crushing and bruising	Decay	Retail	Consumer	
	Before trim	After trim						
7 Days at 36°	5.6a	6.8a	2.8a	3.4a	1.3a	29a	4a	
+ 3 Days at 50°	5.1b	6.4b	2.8a	4.0b	1.7b	31bc	5a	
+ 5 Days at 50°	4.7c	6.0c	2.9a	4.0b	2.5d	33c	5a	
14 Days at 36°	5.0b	6.4b	2.8a	3.6a	1.9bc	31ab	5a	
+ 3 Days at 50°	4.6c	5.9c	2.8a	4.0b	2.0c	37d	4a	
+ 5 Days at 50°	4.3d	5.3d	2.8a	4.5c	3.5e	42e	4a	

^zValues in a column followed by the same letter are not significantly different at the 5% level.

Table 2. Evaluation of Florida-grown 'Montello' lettuce according to test 1980.^z

Test No.	Avg box wt lb. (kg)	Ratings						% Trim	
		Appearance		Firmness	Crushing and bruising	Decay	Retail	Consumer	
		Before trim	After trim						
1	48(22)c	3.8e	5.4d	2.8b	5.2d	3.9d	44c	6c	
2	48(22)c	4.5cd	6.2bc	2.9b	3.7bc	2.2b	31b	4a	
3	48(22)c	4.9bc	6.2bc	2.8b	3.5b	2.0b	33b	4a	
4	46(21)b	4.6cd	5.6d	2.6b	4.4c	3.3c	44c	5b	
5	46(21)b	4.9bc	6.1c	2.9b	4.1c	2.1b	34b	4a	
6	50(23)c	5.1b	6.3bc	2.9b	4.0bc	1.3a	30b	5b	
7	52(24)d	5.3b	6.6ab	3.2a	3.4b	2.0b	27a	4a	
8	43(20)a	6.2a	6.9a	2.7b	2.7a	1.0a	26a	4a	

^zAverage of all 3 inspections for 7 and 14 days' storage at 36°F plus 3 and 5 days at 50°F.

^yValues in a column followed by the same letter are not significantly different at the 5% level.

developed less decay during storage than that harvested and packed in February. Preharvest growing conditions appear to influence the postharvest holding quality of Florida lettuce. In test 8, the holding quality of lettuce was excellent, as shown by the rating for decay and the percentage of retail trim. Even after 14 days' storage at 36°F and 5 additional days at 50°F, decay was nil. This lettuce was harvested in late April and had the lowest average box weight and the lowest rating for crushing and bruising. In tests 6 and 8, the lettuce would have arrived in excellent condition in export markets, assuming that temperatures were maintained at 36°F during transit. However, the lettuce in tests 1 and 4 would not have arrived at export markets in good condition. These tests indicate that the holding quality of Florida lettuce varies considerably during the season, but that certain factors affecting holding quality can be controlled. Lettuce should not be overpacked into the fiberboard boxes; overpacking results in excessive crushing and bruising, which may lead to decay during storage.

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INJURY TO AVOCADOS BY INSUFFICIENT OXYGEN AND EXCESSIVE CARBON DIOXIDE DURING TRANSIT¹

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Abstract. European receivers have complained of injury to avocados (*Persea americana* Miller) shipped by surface transport from the United States. The injury was reported only in fruit from containers that had been charged with a modified atmosphere prior to shipment. Injury to fruit was apparent on arrival in Europe as regular to irregular areas of brown discoloration of the rind. Underlying flesh was not discolored and the fruit were still firm to hard. The flesh of some fruit deteriorated during softening and had a fermented odor. Similar injury to avocados developed during laboratory storage in atmospheres of low-oxygen (0.5%) and high-carbon dioxide (25%).

During the 1980 avocado marketing season complaints of injury to avocados shipped to Europe from California and Florida in refrigerated containers (seavans) were received by USDA personnel in the Netherlands and Florida.

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In each instance of fruit injury the container was found to have been charged before shipment with a mixture of oxygen (O₂), carbon dioxide (CO₂) and inert nitrogen (N₂) designed to decrease the rate of respiration and extend the storage life. The use of this system of modified atmosphere (MA) has been reviewed by Lipton (6). Once the initial atmosphere modification has been made, further changes in O₂ and CO₂ concentrations depend on the respiration rate of the commodity, the temperature and tightness of the container, and the time in transit. Unlike a controlled atmosphere (CA) system, the MA is not controlled and no adjustments are made during transit to maintain a particular atmosphere. The MA service as provided by commercial sources is designed to supplement the benefits of refrigeration and is presently most widely used for lettuce shipments (4).

Avocados are not injured when held in an atmosphere containing 1% O₂ (5), but are very sensitive to O₂ deficiency (1). In this paper, we present evidence suggesting that the rind injury which occurred in the commercial MA shipments to Europe could have been caused by insufficient O₂ or a combination of insufficient O₂ and excessive CO₂.

Materials and Methods

Avocados, obtained from a local packinghouse in Miami, Florida, were randomized into similar lots and placed in 5-gallon (18.9-liter) widemouth glass jars. Ten fruit of a given cultivar were placed in each jar together with 1 liter of water. Two jars were placed in series when more than 1 cultivar was used. The lid of each jar was fitted with a teflon gasket, a fitting for gas sampling, and a copper tubing inlet and outlet for gas flow. In a test with 'Simmonds' and