Delays to Cool Affect Visual Quality, Firmness and Gloss of Bell Peppers and Eggplants

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Temperature management is key to marketing high quality produce. We recently summarized our recommendations regarding allowable delays to cool for different commodities (see Perishables Handling #105). Although our general recommendation is "cool as soon as possible", we estimate that a few hours delay would generally not affect the postharvest quality and shelf-life of most products. However we lack specific data for different products. Here we summarize 2 studies that evaluate the impact of water loss and delays to cool on quality attributes of bell peppers and eggplants. We report objective measurements of gloss and firmness, but these objective values were also highly correlated with subjective scoring of both attributes.

Our main conclusions from work on bell peppers and eggplants are:

1. Delays to cool reduced visual quality, glossiness and firmness, and increased visible symptoms of dehydration for both bell peppers and eggplants.
2. Acceptable delays to cool vary according to ambient temperatures.
3. For bell peppers, delays to cool should be less than 9 hours at 20-25°C (68-77°F) and less than 6 hours at 37°C (99°F).
4. For Japanese eggplants, delays to cool should be less than 6 hours at 20-25°C (68-77°F) and less than 3 hours at 37°C (99°F).

Mature-green Bell Peppers

Experimental details. Peppers were obtained from harvest crews in the field, packed into waxed boxes and cooled in a high humidity room to 7°C (45°C) within 1 hour of harvest, then placed in perforated plastic bags in coolers and transported to the laboratory (water loss under these conditions was less than 0.2%). Some fruit were held at 20°C (68°F) on trays to determine quality attributes in relation to % weight loss. For the delay to cool test, we subjected fruit to periods at 37°C (99°F), 35-38% RH and 25°C (77°F), 47-50% RH. After the delays, peppers were weighed, hydrocooled for 15 min, and reweighed. Peppers were evaluated for visual quality, glossiness, color change, weight loss, symptoms of dehydration and texture after completing all delays and cooling, and again after 7 days at 7.5°C (45°F).

Results. A weight loss of 2 to 4% reduced bell pepper firmness, gloss and visual quality (Table 1). Hydrocooling peppers resulted in significant weight gain, which did not benefit pepper quality after storage (Table 2). Average weight loss with cooling delays at 37°C and 25°C was 0.13 and 0.06% per hour, respectively (Table 3). Total weight loss during storage at 7.5°C averaged 1.9% over 7 days. The overall visual quality of the peppers after a 7-day storage period was significantly less with a 9-hour delay to cool compared to that of peppers with shorter cooling delay periods (Table 3). Significant increases in decay were observed with a 12-hour delay at 37°C (data not shown), but no increase in decay was noted with up to 18 hours delay to cool at 25°C. Significant decreases in gloss scores (data not shown) and gloss meter values (Table 3) were observed with cooling delays of 9 hours at both 25°C and 37°C. Important decreases in firmness scores (data not shown) and compression values (Table 3) occurred after a 9 hour delay at 37°C, but not until after an 18 hour delay at 25°C. No color change occurred in the peppers held at 25°C for up to 18 hours, but after 12 hours at 37°C, some peppers were beginning to color (data not shown).

Table 1. Quality attributes of mature-green bell peppers in relation to weight loss at 20°C. Data are averages from 16 fruits per treatment.

Actual Wt Loss, %	Visual Quality Score [1]	Dehydration Score [2]	Firmness, Newtons [3]	Gloss Meter Value [4]
0.3	8.4	1.1	23.3	6.7
2.0	7.2	2.3	16.2	5.8
2.8	5.9	2.8	12.5	4.7
3.9	4.8	3.1	7.1	3.4
LSD.05	0.4	0.4	2.8	1.0

[1] Visual quality was scored on a 9 to 1 scale, where 9=excellent, fresh appearance, 7=good, 5=fair (limit of salability), 3=fair (useable but not salable), 1=unuseable.

[2] Dehydration was scored on a 1 to 5 scale, where 1=none, 2=slight, 3=moderate (would result in price adjustment commercially), 4=moderately severe, 5=severe.

[3] Firmness measured as force in Newtons to compress the fruit at the equator with a 25 mm diameter flat probe to a depth of 5 mm. 1 Newton= 9.81 kg-force or 4.45 pounds-force.

[4] Gloss was measured with a BYK-Gardner gloss meter; the higher the value, the glossier.

Table 2. Impact of cooling delays at 25°C on weight loss, visual quality and firmness of mature-green bell peppers. Fruit were stored in waxed cartons and evaluated after 10 days at 7.5°C (45°F) [1]. Data are averages of 24 fruits per treatment.

Delay to Cool (hours)	% Wt. Loss after Delay	% Wt. Change during Cooling	Final % weight Change	Visual Quality Score [2]	Dehydration Score [2]	Firmness, Newtons [2]
HUMID AIR COOL						
0	0	0[3]	0	7.4	2.2	23.8
3	0.4	0	-0.4	7.5	2.2	25.9
6	1.2	0	-1.2	6.9	2.4	26.8
9	1.5	0	-1.5	6.5	2.8	23.5
12	2.2	0	-2.2	6.5	2.8	20.7
HYDROCOOL						
0	0	+1.2	+1.2	7.1	2.4	26.9
3	0.4	+0.8	+0.4	6.4	2.9	28.9
6	1.5	+0.8	-0.7	6.5	2.5	23.8
9	2.0	+1.7	-0.3	6.1	2.8	25.4
12	2.4	+2.1	-0.3	5.8	3.0	22.9
LSD.05				0.4	0.3	4.1

[1] Weight loss during storage was 2.4-2.7%.

[2] See Table 1 for details of analysis.

[3] Below the limit of detection.

Table 3. Mature-green bell pepper weight loss and quality in relation to delays to cool at 25°C (77°F) or 37°C (99°F). After delay periods, fruit were hydrocooled and stored at 7.5°C (45°F) in waxed cartons and evaluated after 7 days. Data are averages from 24 peppers per treatment.

Hours Delay to Cool	% Wt. Loss after Delay	% Wt. Gain after Hydrocool	% Weight Loss After Storage	% Final Weight Loss	Visual Quality Score [2]	Dehydration Score [2]	Firmness, Newtons	Gloss [2]Meter Value [1]
None	0	1.09	2.06	0.97	8.5	1.2	19.7	6.1
at 37°C								
3	0.25	0.68	1.62	1.19	8.6	1.2	20.9	6.3
6	0.60	0.76	1.66	1.50	8.3	1.5	19.9	5.4
9	1.33	0.69	1.67	2.30	7.5	2.3	16.6	4.9
12	1.80	1.39	2.10	2.52	6.0	2.8	14.2	4.5
18	3.25	1.82	1.64	3.07	3.6	3.4	10.7	4.0
at 25°C								
3	0.15	0.67	1.91	1.39	8.1	1.2	21.0	5.4
6	0.36	0.75	1.87	1.48	8.1	1.5	22.5	5.4
9	0.52	1.09	2.35	1.78	7.5	2.4	21.5	4.9
12	0.69	1.82	2.93	1.86	7.2	3.0	19.3	4.4
18	1.04	0.57	1.61	2.08	7.3	3.0	17.4	4.1
LSD.05	0.07	0.31	0.42	0.13	0.6	0.4	2.5	1.1

[1] See Table 1 for details of analysis.

Eggplants

Experimental details. Japanese eggplants were harvested and packed commercially in the field (rinsed, sized) into waxed cartons, cooled in humid air at 7-8°C (45-46°F) within 0.5 hours of harvest, and transported to the lab in coolers under humid cool conditions. Weight loss was negligible and arrival at the lab was considered 0 time. Some fruit were held at 20°C (68°F) on trays to determine quality attributes in relation to % weight loss. For the delay to cool test, eggplants were placed in waxed cartons after weighing (2 boxes per delay containing 10 fruit each), and subjected to delays to cool at 25°C (77°F), 48-50% RH and at 37°C (99°F), 38-40% RH. After delays, fruits were hydrocooled, reweighed, and stored in waxed boxes at 7.5°C (45°F). Eggplants were evaluated for final quality after 7 days of storage.

Results. Table 4 shows changes in quality attributes of eggplant in relation to weight loss. Visual quality scores were significantly decreased with a 3% weight loss, but significant differences in firmness were measurable with a 2% weight loss. Gloss values were not significantly affected until weight loss exceeded 8% (Table 4), although the visual quality scores were very low. Weight gain after hydrocooling averaged 0.8% for a 15-minute dip (Table 5). Weight loss during the storage period averaged 3.7%. Visual quality scores were decreased by a 6-hour delay to cool at either 25°C or 37°C (Table 5). Decreased visual quality with increased cooling delays was associated with increased dehydration and decay scores and decreases in whole fruit firmness and gloss scores. Firmness and gloss were not affected as rapidly as the visual quality scores by delays to cool. Firmness values decreased significantly after 9 and 12 hours at 37°C and 25°C, respectively (Table 5). Gloss values did not decrease significantly until delays of 9 hours at either temperature.

Table 4. Quality attributes of Japanese eggplants in relation to weight loss at 20°C (68°F). Data are averages of values from 24 fruits per treatment.

Weight Loss, %	Visual Quality [1]	Dehydration Calyx [1]	Dehydration Fruit [1]	Firmness, Newtons [1]	Gloss Meter Value [1]
0.7	8.2	1.6	1.4	30.8	7.1
2.1	7.5	1.1	1.5	24.2	6.2
3.4	6.8	1.3	1.2	25.0	6.0
6.8	5.0	3.7	3.6	21.0	6.4
8.4	2.9	4.0	4.2	21.9	5.4
LSD.05	0.7	0.6	0.5	3.1	1.2

[1] See Table 1 for details of analysis.

Table 5. Japanese eggplant weight loss and quality in relation to delays to cool at 25°C (77°F) or 37°C (99°F). After delays, fruits were hydrocooled and stored at 7.5°C (45°F) in waxed cartons. Quality was evaluated after 7 days. Data are the averages from 20 fruit per treatment.

Hours Delay to Cool	% Wt. Loss after Delay	% Wt. Gain after Hydrocool	% Weight Loss After Storage	% Final Weight Loss	Visual Quality Score [2]	Dehydration Score [2]	Firmness, Newtons	Gloss [2]Meter Value [1]
None	0	0.77	3.16	2.41	7.8	1.8	29.0	7.6
at 37°C								
3	0.81	0.83	3.51	3.49	7.2	1.8	26.7	7.6
6	2.74	0.78	3.88	5.78	5.8	2.4	25.3	7.0
9	3.78	0.65	3.66	6.69	4.6	2.6	24.9	4.8
12	4.98	1.36	3.89	7.42	3.2	3.5	23.8	3.6
18	6.18	0.37	3.31	8.95	2.2	4.2	21.6	3.4
at 25°C								
3	0.46	0.71	3.71	3.47	7.4	1.8	30.0	7.7
6	0.70	0.76	3.94	3.88	6.4	2.0	27.8	6.3
9	1.24	0.71	4.18	4.69	5.8	2.2	25.0	5.5
12	1.94	1.24	4.45	5.13	4.4	2.5	23.1	4.6
18	2.73	0.41	3.50	5.75	3.7	3.6	21.1	4.1
LSD.05	0.24	0.09	0.26	0.30	0.6	0.5	3.6	1.8

[1] See Table 1 for details of analysis.