companied by a decrease in titratable acidity (Table 3). The infected portions of these tomatoes attained pH values as high as 6.37 *G. candidum* (sour rot) had no effect on tomato acidity. Schlösser (8) observed a pH shift from 4.5 to 5.7 in wounded but not infected tomatoes. Subsequent fungus infections by *Corticium rolfsii, Botrytis cinerea,* and *Monilia fructigena* lowered the pH while infection by *Gloeosporium fructigenum* increased the pH to 6.4.

We observed a small elevation (no more than 0.2 unit) in the pH of bruised portions of tomato fruits. However, since this effect was highly localized and did not progress with time, we do not consider it to be relevant to the safety of home canned tomatoes. Home canners have been advised to avoid soft and decayed tomatoes (10).

Table 2. Acidity of ripe tomato fruits from dead vines.

Cultivar	Harvest date	No. fruits analyzed	Mean pH	Sample Distribution (%) pH >4.6	pH >4.7	pH >4.8	Mean titratable acidity (%)[z]
Fireball	Aug 3	15	4.40	0	0	0	0.386
	Sept 20[y]	16	4.68[x]	81	62	38	0.221[x]
San Marzano	Aug 9	15	4.40	0	0	0	0.444
	Aug 20[y]	14	4.50[x]	36	7	0	0.289[x]

[z]Calculated as citric acid.
[y]Vines dead at time of second harvest.
[x]Difference between harvests is statistically significant at .05 level.

Table 3. Acidity of 'Ace 55 VF' tomatoes inoculated with spoilage organisms.

Inoculum[z]	Incubation time (days)	pH of excised portions Inoculated	Remainder	Titratable acidity (%)[y]
Alternaria tenuis	2	4.39	4.38	0.268
	6	4.69	4.55	0.250
	13	6.37	4.62	0.217
Colletotrichum coccodes	2	4.45	4.40	0.314
	6	4.53	4.32	0.342
	13	5.28	4.75	0.226
Geotrichum candidum	2	4.52	4.56	0.256
	6	4.52	4.52	0.268
	13	4.57	4.51	0.269
Control	2	4.35	4.28	0.266
	6	4.40	4.45	0.306
	13	4.48	4.47	0.295

[z]Inoculum applied by puncturing skin with sterile needle; control inoculated with sterile H_2O.
[y]Calculated as citric acid; determined on duplicate whole tomatoes, similar to those analyzed for pH.

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The Effect of Ethylene-induced Ripening on Tomatoes of Different Genotypes[1]

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Abstract. **Mature green 'Homestead' tomatoes (*Lycoperiscon esculentum* Mill.) and 3 advanced breeding lines were treated with ethylene gas and some compositional parameters of the treated fruit were compared with those of control fruit. Tomato breeding line T3702 j_2 showed a greater response to ethylene treatment than 'Homestead' and other advanced breeding lines carrying the crimson (og^c) and high pigment-crimson ($hp\ og^c$) genotypes. Ethylene treatment had negligible effects on the levels of soluble solids, dry matter, ascorbic acid, β-carotene, and lycopene in the genotypes studied. The mean pH of the treated samples was slightly higher than that of the control, but was not statistically significant in all cultivars or breeding lines every year. The data suggest that breeders should pay attention to the response of breeding lines and potential cultivars to ethylene-induced ripening.**

Fresh market tomatoes are commonly picked mature green and ripened by exposure to ethylene, either before transit or at repacking facilities near the major markets. Ethylene treatment induces the mature green fruit to ripen earlier and more uniformly (3, 9, 11, 12). However, tomato cultivars vary in ripening rate whether ripened with (1), or without (14), ethylene treatment. Changes in the final composition of fruits as a result of ethylene treatment have been studied (13)[3], but direct comparisons among different cultivars have not been made.

The purpose of this study was to determine if our advanced breeding lines respond differently from established cultivars when treated with ethylene gas. For these experiments we used: 'Homestead', a widely grown cultivar for the fresh market; T3702, a breeding line with the jointless (j_2) allele; T3790, a breeding line with a combination of the high pigment (hp) and crimson (og^c) alleles; and T3810, a breeding line with the crimson allele.

Tomato fruit were produced in the field for the 1974 experiment and in the greenhouse for the 1975 and

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1976 experiments. Fruit samples were harvested and sorted into 4 or 5 uniform replicate samples of at least 20 fruit. Each sample was divided into 2 equal subsamples; one was treated with ethylene gas at 20°C and the other was used as a control. All samples were held at 20° until full color developed in 1974 and for 14 days after harvest in 1975 and 1976. After ripening, a 5-fruit sample was selected from each subsample according to the procedures suggested by McCollum (8) and subjected to compositional analysis.

The pH, soluble solids, and dry matter were determined by standard laboratory techniques. Ascorbic acid was determined by a modification of the method of Heinze et al. (2) in which the extractant was a 1% solution of oxalic acid (10). This method does not measure dehydroascorbic acid. Beta-carotene and lycopene were determined by chromatographic separation and spectrophotometric measurement of the pigment content according to standard methods (4, 7, 15). A statistical analysis of the data was carried out using a split-plot technique in which cultivars (or breeding lines) were treated as main plots and ethylene treatments as sub-plots.

The times required for treated and untreated fruit to reach full color varied among cultivars and lines (Table 1). Breeding line T3702 gave a pronounced response to ethylene treatment while line T3810 was unaffected. Fruit of the latter characteristically show interior ripening well in advance of exterior color development. We suspect, therefore, that fruit of T3810 were selected inadvertently at a more mature stage than the other cultivars and that they were no longer susceptible to ethylene stimulation (5, 6). In this experiment the stage of maturity at harvest and the time of full color development were determined by visual observation. Subsequent experiments were based on fruit samples of more uniform maturity that were obtained by tagging flowers at anthesis and harvesting the fruit at a known chronological age (6). Both treated and untreated samples were analyzed at a constant time after harvest rather than relying on visual observation for full color development. Consequently, the treated and untreated samples differed in degree of ripeness at the time the analyses were made. In general, treated samples were "red" (no. 6) and control fruits ranged from "pink" to "light red" (no. 4-5) on the U.S. Standard Color Chart.[3] This procedure confounds the effect of ethylene on ripening rate with any effect of ethylene *per se* on the given compositional parameter while it eliminates any effect due to simple ageing. However, we were interested only in the overall effect of the ethylene treatment, whether due to acceleration in ripening rate or other physiological effects.

Table 1. Effect of ethylene-induced ripening on the time at 20°C required to reach full color. 1974 experiment.

Cultivar or breeding line	Mean[z] no. of days to full color		
	Treated	Control	Difference
Homestead	12.0 a	12.5 a	0.5
T3702 (j_2)	11.3 a	15.3 a	4.0*
T3790 (*hp og*^{c})	12.0 a	13.8 a	1.8
T3810 (*og*^{c})	9.0 b	9.0 b	0.0

[z]Means separation in columns by Duncan's multiple range test, 5% level.
*Denotes a significant difference between treated and control for that line.

The pH values for the treated samples were equal to or greater than those for the control samples in all cases (Table 2). The overall mean value for the pH of the treated samples was greater by 0.07 pH units than that of the control in 1974. This difference was statistically significant and was accounted for primarily by the pronounced response by breeding line T3702. There was no significant difference between treated and control samples within entries for soluble solids, dry matter (Table 2), or β-carotene and lycopene content (Table 3) in 1974. Differences among entries for β-carotene and lycopene were significant according to their genetic makeup (Table 3).

The only significant difference in the composition of the treated and control samples in 1974 was a very slight increase in pH of fruits treated at 1000 ppm ethylene. Therefore, we increased the concn of ethylene to 2000 ppm in 1975. The average pH for the treated samples was 0.04 units greater than that of the control. Again, this was statistically significant. In this experiment, 'Homestead', as well as T3702, showed a significant pH response to ethylene (Table 2). Breeding line T3702 also had a significant difference in soluble solids and dry matter while line T3790 showed a significant difference in the opposite direction for dry matter, *i.e.* dry matter was greater in the control than in the treated sample (Table 2).

In 1976 the ethylene concn was reduced to 1000 ppm but the length of exposure was increased to 3 days. In this experiment the mean of treated samples was 0.10 pH units greater than the control and all the cultivars (breeding lines) exhibited significant differences. No significant differences were noted in soluble solids, dry matter, or ascorbic acid content.

The pH values for 'Homestead' and T3810 were higher on the average than those for T3702 and T3790, although significantly so only in 1974 and 1975. Although there were some significant differences among lines in soluble solids and dry matter each year, the rankings were not consistent with year. Almost without exception, the 1975 values for pH, soluble solids and dry matter were lower than in other years. We ascribe this to low sunlight during the period of maturation.

Table 2. Effect of ethylene-induced ripening on pH, soluble solids, dry matter and ascorbic acid content of tomato fruit of different genotypes.

Cultivar or line	Treatment	1974-1000 ppm/1 day			1975-2000 ppm/1 day			1976-1000 ppm/3 days			
		pH	Sol. solids (%)	Dry matter (%)	pH	Sol. solids (%)	Dry matter (%)	pH	Sol. solids (%)	Dry matter (%)	Ascorbic acid (mg/100g fresh wt)
Homestead	Treated	4.42	4.9	5.11	4.17*	5.1	4.61	4.45*	5.2	4.73	15.7
	Control	4.37	5.0	5.05	4.12	5.1	4.71	4.33	5.2	4.91	14.2
	Mean[z]	4.40 a	4.9 b	5.08 b	4.15 a	5.1 a	4.66 ab	4.39 a	5.2 a	4.82 b	14.9 c
T3702 (j_2)	Treated	4.32*	5.5	5.52	4.11*	4.9*	4.60*	4.40*	5.5	5.18	21.6
	Control	4.15	5.2	5.28	4.03	4.6	4.41	4.31	5.2	5.15	21.6
	Mean[z]	4.23 b	5.4 a	5.40 a	4.07 b	4.7 b	4.51 b	4.35 a	5.4 a	5.16 a	21.6 b
T3790 (*hp og*^{c})	Treated	4.25	5.0	5.03	4.02	4.3	4.69*	4.37*	4.8	5.01	29.4
	Control	4.20	5.0	5.07	4.01	4.5	4.85	4.29	4.7	5.04	30.2
	Mean[z]	4.22 b	5.0 b	5.05 b	4.02 c	4.4 c	4.77 a	4.33 a	4.8 b	5.02 ab	29.8 a
T3810 (*og*^{c})	Treated	4.37	4.8	4.80	4.20	4.8	4.58	4.46*	5.4	4.96	17.8
	Control	4.37	4.9	4.89	4.16	4.6	4.44	4.34	5.4	5.08	17.2
	Mean[z]	4.37 a	4.8 b	4.85 b	4.18 a	4.7 b	4.51 b	4.40 a	5.4 a	5.02 ab	17.5 bc

[z]Means separation in column by Duncan's multiple range test, 5% level.
*Denotes a significant difference between treated and control for that line.

Table 3. Effect of ethylene-induced ripening on β-carotene and lycopene content of tomato fruit of different genotypes, 1974 experiment.

Cultivar or line	Treatment	β-carotene (μg/g fresh wt)	Lycopene (μg/g fresh wt)
Homestead	Treated	3.85	30.4
	Control	4.18	23.8
	Mean[z]	4.01 a	27.1 c
T3702 (j_2)	Treated	3.43	30.5
	Control	3.09	28.6
	Mean[z]	3.26 b	29.6 bc
T3790 ($hp\ og^c$)	Treated	3.64	69.7
	Control	3.46	66.2
	Mean[z]	3.55 b	67.9 a
T3810 (og^c)	Treated	2.35	36.5
	Control	2.15	38.8
	Mean[z]	2.25 c	37.6 b

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

There was a significant difference among lines for ascorbic acid content (Table 2). The breeding line T3790 was highest by a substantial margin and the cultivar 'Homestead' was lowest.

Because breeding line T3702 consistently had higher pH values for treated samples as compared to the control, and showed a greater response to ethylene treatment in ripening time, we believe that there is a cultivar response to ethylene induced ripening. The fact that this line also consistently showed higher soluble solids content in the treated vs. the control samples (statistically significant only in 1975) lends support to this conclusion. We suggest, therefore, that breeders should pay attention to the response of breeding lines and potential cultivars to ethylene-induced ripening.

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Photosynthetic Contribution of Cotyledons to Early Development of Cucumber[1]

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Abstract. **The effect of age on CO_2 exchange rates of cucumber (*Cucumis sativus* L.) cotyledons was measured. A biphasic process was noted, with a period of relatively high exchange rates up to 17-18 days from planting, when the first true leaf was nearly fully expanded, followed by a decline in exchange rates thereafter. The relative contribution of cotyledons versus leaves to photosynthesis as a function of age was measured. At 16 days from planting, the cotyledons accounted for 80% of the total net CO_2 exchange and slightly more than 50% of the total foliage area. Twenty-four days after planting, the cotyledons still accounted for about one-fourth of the total net CO_2 exchange and 20% of the total foliage area. The use of cotyledons in chilling injury studies of cucumber is justified by both the large photosynthetic contribution of cotyledons to growth and development, and the presence of cotyledons during early growth when chilling is most likely to occur.**

Recent studies on the effects of chilling temp in the presence of light on chilling-sensitive plants have employed cotyledons of cucumber seedlings (2). A knowledge of the photosynthetic contribution of cotyledons to the early growth of the cucumber plant is necessary in evaluating how chilling injury of cotyledons might affect later development, and at what stages of development injury to the cotyledons might be most critical.

The epigeal cotyledons of many plants become leaf-like and exhibit varying rates of carbon fixation. Such cotyledons are important in the early growth and development of many woody species (6, 7, 8, 12, 13), as well as sweet pepper (11) and sainfoin (1). Members of the Cucurbitaceae, especially cucumber, have remarkably large and long-lasting cotyledons. Previous studies on the rates of expansion and carbon fixation of cucumber cotyledons showed that cotyledons play an important role in the early development of the plant (3, 4, 5). No one, however, has yet measured the relative contribution to photosynthesis of the cotyledons versus the leaves throughout the early development of the cucumber plant.

The purpose of this study was to assess the value of using cotyledons in studying chilling injury of cucumber seedlings, by determining the stages of growth at which the cotyledons contribute significantly to photosynthesis.

Seeds of 'Marketer' cucumber (supplied by Northrup King & Co.) were planted in 10 cm plastic pots in a 1 soil: 1 peat: 1 perlite (by vol) mixture in a greenhouse. Four seedlings

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