EFFECT OF ETHYLENE ON THE POST-HARVEST RIPENING OF TOMATOES

There are numerous reports on the effect of ethylene on the ripening of tomatoes but they are not all in agreement. Heinze and Craft (1953) extensively reviewed contradictory literature on this subject. Radspinner (1954) reported that daily applications of 200 p.p.m. ethylene to mature-green tomatoes at 68°F ripened the fruit in 4–5 days, compared with 6–7 days without ethylene. However, ethylene had little effect on tomatoes approaching the stage of turning colour. Eaves (1953, pp. 89–96) stated that preliminary trials with ethylene gas (1000 p.p.m.) at 70°F indicated that high temperature was as effective as ethylene in accelerating tomato ripening. Emmert and Southwick (1954) reported that only green-mature fruits and possibly fruits which showed incipent red colouring were stimulated in ripening by emanations from ripe apples. Stevenson (1954) recommended the use of ethylene (1000 p.p.m.) three times daily in tomato ripening rooms.

In view of the amount of contradictory literature on tomato ripening, a trial was carried out to investigate the effect of ethylene on the respiration rate and colour changes of tomatoes after harvest.

Experimental Details

The trial was carried out in three stages, each involving the daily measurement of the rate of carbon dioxide evolution (respiration rate) and observation of colour changes of 10 fruit samples over a number of days. Each sample consisted of two fruit which were contained in an air-tight gas chamber through which air was passed at the rate of 300 ml/min. The chambers used were 5 in. x 4 in. glass dressing jars fitted with air-tight lids. The carbon dioxide percentage of the effluent air was measured with a Grubb-Parsons Model SB2 infra-red gas analyser, and the fruit weight was recorded. The respiration rate was expressed as mg CO_2/Kg/hr.

The fruit was selected from a trial in which the flowering date of each fruit from a limited number of bushes had been recorded. The variety was a Grosse Lisse (Q2) x Salads Special hybrid. Unfortunately, sufficient tagged fruit was available for the first stage only.

Details of the 20 fruit harvested and the respiration measurements for each stage are as follows:—

Stage 1.—Flowers opened 7–8 weeks prior to harvesting. Fruit small and judged on appearance to be green-mature. Recorded over a 7-day period but no record on the sixth day.

Stage 2.—No flowering data available. Fruit small and selected on appearance to be green-mature. Recorded over a 7-day period.

Stage 3.—No flowering data available. Fruit medium size and selected on appearance to be advanced green-mature. Recorded over a 5-day period.

The first of each of the daily readings for each stage was taken 24 hr after the fruit samples were placed in the jars.

Results

Tables 1–3 are daily records of the colour changes in each of the two fruit comprising each sample. Samples 1–5 in each table were treated with ethylene. The approximate area showing colour is designated as follows:—

No colour = green
Tinge of colour = tinge
$\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, $\frac{2}{3}$, and $\frac{3}{4}$ colour = $\frac{1}{4}$C, $\frac{1}{3}$C, $\frac{1}{2}$C, $\frac{2}{3}$C, and $\frac{3}{4}$C.
Full light red = FLR
Full red = FR

TABLE 1

DAILY COLOUR CHANGES IN FRUIT FROM STAGE 1

Sample No.	1st day	2nd day	3rd day	4th day	5th day	7th day
1				tinge–tinge	FLR–$\frac{3}{4}$C	FR–FLR
2				$\frac{1}{3}$C–$\frac{1}{3}$C	FR–FR	
3				tinge–tinge	FR–FR	
4	All	All	All	almost FLR–tinge	FR–FR	
5	fruit	fruit	fruit	FLR–$\frac{1}{4}$C	FR–FR	
6	green	green	green	green–green	$\frac{1}{4}$C–green	FR–green
7				$\frac{1}{4}$C–green	FR–green	FR–tinge
8				green–green	tinge–$\frac{1}{3}$C	$\frac{1}{4}$C–$\frac{3}{4}$C
9				tinge–green	$\frac{1}{4}$C–tinge	$\frac{3}{4}$C–$\frac{3}{4}$C
10				green–green	no record	no record

TABLE 2

DAILY COLOUR CHANGES IN FRUIT FROM STAGE 2

Sample No.	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day
1		green–green	green–green	tinge–green	$\frac{1}{4}$C–tinge	$\frac{3}{4}$C–tinge	FR–$\frac{1}{2}$C
2		green–green	green–green	tinge–$\frac{1}{2}$C	$\frac{1}{2}$C–$\frac{3}{4}$C	$\frac{1}{3}$C–tinge	$\frac{1}{2}$C–FR
3		$\frac{1}{3}$C–green	FLR–green	FR–$\frac{1}{4}$C	FR–$\frac{3}{4}$C	FR–FR	
4	All	green–green	green–green	tinge–green	$\frac{1}{3}$C–tinge	FLR–$\frac{3}{4}$C	FR–FR
5	fruit	tinge–green	$\frac{1}{2}$C–tinge	FLR–$\frac{1}{4}$C	FR–$\frac{3}{4}$C	FR–FR	
6	green	green–green	green–green	green–green	green–green	green–green	green–green
7		green–green	green–green	green–green	green–green	green–green	$\frac{1}{4}$C–green
8		green–green	green–green	green–green	green–green	tinge–green	$\frac{1}{4}$C–green
9		green–green	green–green	green–green	tinge–green	$\frac{1}{4}$C–green	$\frac{1}{2}$C–green
10		tinge–green	tinge–green	$\frac{1}{4}$C–green	FLR–green	FR–green	FR–green

TABLE 3

DAILY COLOUR CHANGES IN FRUIT FROM STAGE 3

Sample No.	1st day	2nd day	3rd day	4th day	5th day
1	green–green	green–green	tinge–tinge	$\frac{1}{2}$C–$\frac{1}{2}$C	FR–$\frac{3}{4}$C
2	tinge–green	$\frac{1}{3}$C–green	$\frac{3}{4}$C–tinge	FR–$\frac{1}{4}$C	FR–FR
3	green–green	green–green	tinge–green	$\frac{1}{3}$C–$\frac{1}{4}$C	FLR–FLR
4	green–green	tinge–green	tinge–tinge	$\frac{3}{4}$C–$\frac{1}{2}$C	FR–FLR
5	green–green	tinge–tinge	$\frac{1}{4}$C–$\frac{1}{4}$C	FR–$\frac{1}{2}$C	FR–FR
6	green–green	green–green	tinge–green	$\frac{1}{2}$C–tinge	FR–$\frac{3}{4}$C
7	green–green	tinge–green	$\frac{1}{4}$C–tinge	FR–$\frac{1}{4}$C	FR–FLR
8	green–green	green–green	tinge–green	$\frac{1}{3}$C–tinge	$\frac{3}{4}$C–$\frac{1}{2}$C
9	green–green	tinge–green	$\frac{1}{4}$C–green	FR–green	FR–tinge
10	tinge–green	$\frac{1}{4}$C–green	$\frac{1}{3}$C–tinge	FLR–$\frac{1}{2}$C	FR–FR

When both fruit of a sample reach full red colour, no further record appears in the table.

The respiratory curves (mg CO_2/Kg/hr plotted against time) are shown in Figures 1–3.

Discussion

The stimulating effect of ethylene on tomato ripening is clearly indicated by both the respiratory curves and the colour changes of fruit used in Stages 1 and 2, and to a markedly lesser extent in Stage 3. In Stage 1, all ethylene-treated samples reached the peak of the climacteric rise in respiration within 2–4 days. In the five control samples, two samples reached the climacteric peak on the fourth day, one sample reached it on the fifth day, while the remaining two samples had not passed through the climacteric on the seventh day at the termination of Stage 1.

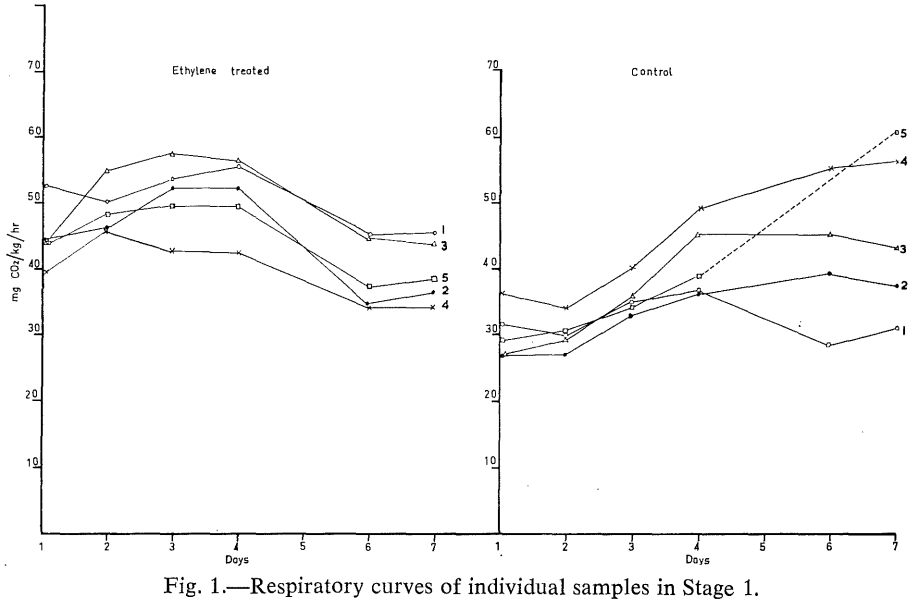

Fig. 1.—Respiratory curves of individual samples in Stage 1.

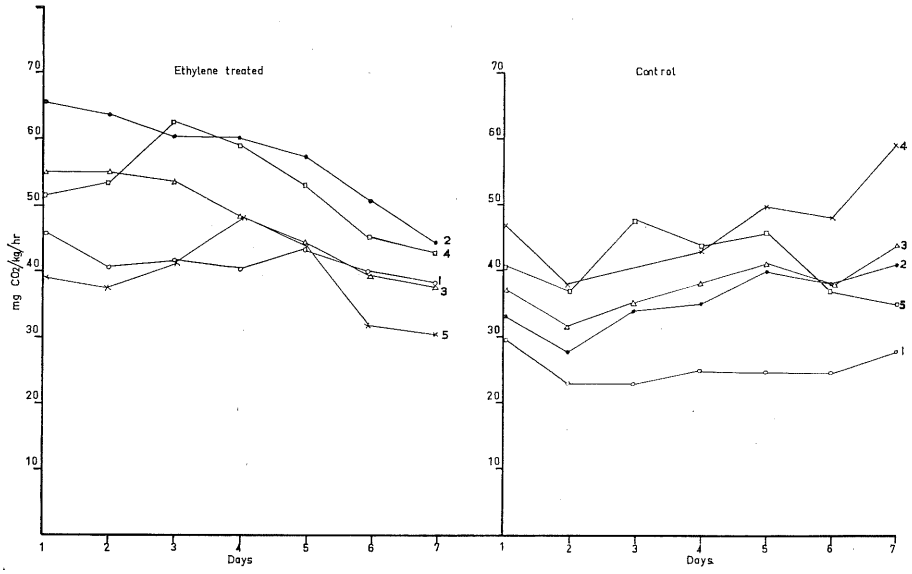

Fig. 2.—Respiratory curves of individual samples in Stage 2.

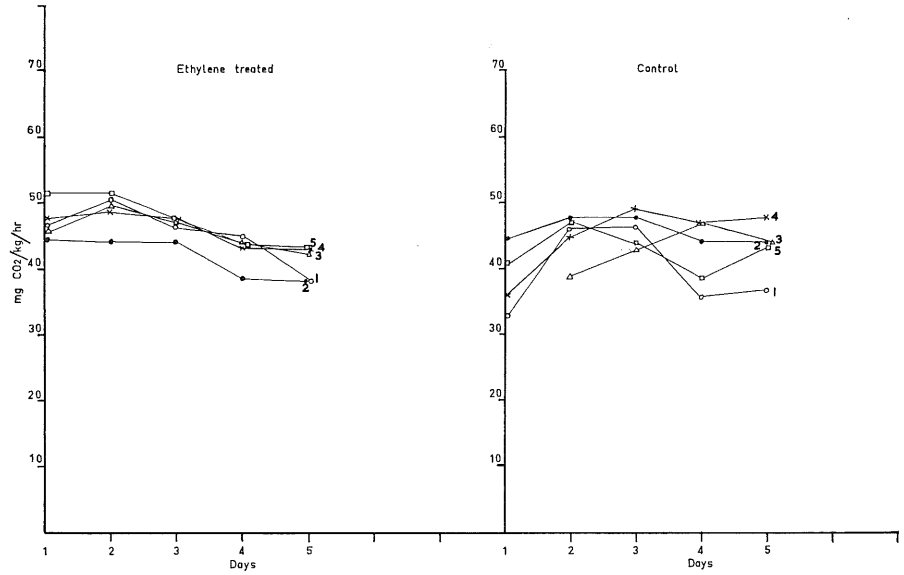

Fig. 3.—Respiratory curves of individual samples in Stage 3.

The most marked differences between ethylene-treated and control fruit occur in Stage 2. With one exception, all ethylene-treated samples reached the climacteric peak within 1–4 days. The atypical curve of the one exception shows no certain climacteric peak although the highest level of carbon dioxide evolution was reached on the fifth day. In the control fruit two samples exhibited no colour change during the seven days and in a third sample one fruit showed a tinge of colour only on the seventh day. In these three samples, the carbon dioxide level was still rising on the seventh day. In the remaining two samples, one fruit in each sample was still green on the seventh day.

In Stage 3, all ethylene-treated fruit had reached the climacteric peak within 1–2 days. In the control fruit, four samples reached the climacteric peak within 2–4 days. In the remaining samples, the carbon dioxide level was still rising on the fifth day.

Colour changes also show obvious differences between ethylene-treated and control fruit. The most marked effect appears in Stage 2. Fruit selected for this stage was apparently less mature than the fruit used in Stages 1 and 3. The effect of ethylene on the colour changes in the advanced green-mature fruit selected for Stage 3 was less obvious than in Stages 1 and 2.

Throughout the three stages, the variability in colour changes in the two fruit comprising a sample was greater in the control fruit than in the ethylene-treated fruit. The smaller amount of variability in the ethylene-treated fruit suggests that ethylene has a more pronounced effect on the more immature fruit. Conversely, as the fruit approaches the climacteric rise, ethylene has a less pronounced effect on the reduction of time taken to reach the climacteric peak.

A comparison of the colour change with the respiratory curves shows that in almost every sample the fruit colour was still green at the climacteric peak. Any sample of green-mature tomatoes could therefore include pre-climacteric fruit, fruit which has entered the climacteric rise stage, and fruit which is at the peak of the climacteric rise. A small percentage may include post-climacteric fruit.

Conclusions

The results of this trial indicate that contradictory results of the effect of ethylene on tomato ripening could well be attributed to a considerable variation in the respiratory state of the fruit selected for experimentation. A sample of backward green-mature fruit could be expected to give results comparable with those of Stages 1 and 2, which show a marked response to ethylene. On the other hand, advanced green-mature fruit, if more advanced in maturity than fruit selected for Stage 3, could well exhibit no marked response to ethylene.

The commercial harvesting of mature-green tomatoes in the field, particularly where inexperienced seasonal labour is employed, must include a wide range of green-mature fruit. The application of ethylene at a concentration of 1000 p.p.m. will undoubtedly result in a more even and earlier colouring of this fruit.

It is probable that other tomato varieties would give similar results to those obtained in this trial. If varietal behaviour does differ markedly, this would certainly account for some of the contradictions in the literature. This could be a subject for future investigation.

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