California Avocado Society 1966 Yearbook 50: 128-133

THE EFFECT OF ETHYLENE UPON RIPENING AND RESPIRATORY RATE OF AVOCADO FRUIT

Irving L. Eaks
University of California, Riverside

Avocado fruits will not ripen while attached to the tree. This is a definite advantage to the grower, the packinghouse operator, the shipper and the retailer, because the harvest period can be extended over a comparative long period and at all stages of handling the fruit are firm, therefore less susceptible to mechanical damage. However, the consumer is normally confronted with hard inedible avocados which require a wait after purchase to ripen. The advantage of impulse buying for tonight's guests is lost. Other fruits as bananas, mature-green tomatoes and honey-dew melons are ripened during transit or at the terminal market before going to the retailer. An operation of this nature seems desirable for the avocado.

The present study was initiated to determine conditions for uniform and rapid ripening of avocados. Thus, the operator can control ripening rates, minimize the time required to ripen the fruit, which would reduce inventory and reduce the number of inspections during ripening.

The fact that ethylene will accelerate the rate of ripening is well established. Previously reported experiments supplied ethylene at various concentrations continuously throughout the ripening period. However, the literature is essentially devoid of information on the duration of exposure required to "trigger" ripening and the effect of fruit maturity on the response. The experiments reported here correlate the respiratory rate with the rate of softening and with various periods of exposure to ethylene on early and late season avocado fruit.

Materials and Methods

The avocado fruits used in these experiments were harvested from trees locally and placed under experimental conditions within two hours. The harvested fruits were transported to the laboratory, weighed, placed in the respiratory chambers and connected to an air flow of water-saturated, CO_2-free air metered through glass capillary tubes. The ethylene was metered to the air stream by means of glass capillary tubes. The concentration of ethylene delivered to the fruit was verified by means of gas chromatographic techniques before and during the exposure period. All experiments were conducted in a constant temperature chamber at 68°F, a temperature within the range of generally accepted optimum ripening temperatures (3).

The rate of carbon dioxide production of the fruit was used as the estimate of its respiratory rate. Two methods were used, The first was the colorimetric method of Claypool and Keefer (2) which was used for the study relating the respiratory rate with softening. Readings were taken twice daily on 12 individual fruits. The second method

was an infrared CO analyzer connected to a Leeds and Northrup strip chart recorder which was used to study the response to ethylene. This method provided a continuous record of the fruit response.

The softening of the avocado tissue was determined by recording the grams required to cause a probe 1.14 mm in diameter to penetrate the flesh (skin removed) (3). The average of four penetrations on each fruit at each testing date was used as the penetration pressure for each fruit. Depending upon use and individual preferences, pressures between 10 to 20 grams must be reached before the fruit is considered ready to eat.

Results and Discussion

The average respiratory rate of 12 Hass avocado fruits shown in figure 1 is typical of curves published previously (1) where composite samples of fruit were used. The decrease in pressure required to penetrate the tissue was related to the climacteric rise, but reached about ten grams (eating condition) about three days after the climacteric peak. Among the 12 fruits, the time to reach the climacteric peak ranged from 12 to 19 days. Therefore, the average does not truly represent the response of individual fruits.

To provide a clear picture of the individual fruit response the data were summarized according to time before and after the climacteric peak (figure 2). Here the time from the preclimacteric level to the climacteric peak was three days and was associated with a sharp decrease in tissue firmness. The fruit reached edible condition and the climacteric peak simultaneously. This may be compared to figure 1 where the climacteric required six days to reach the peak which had a lower value and complete softening occurred three days after the climacteric peak.

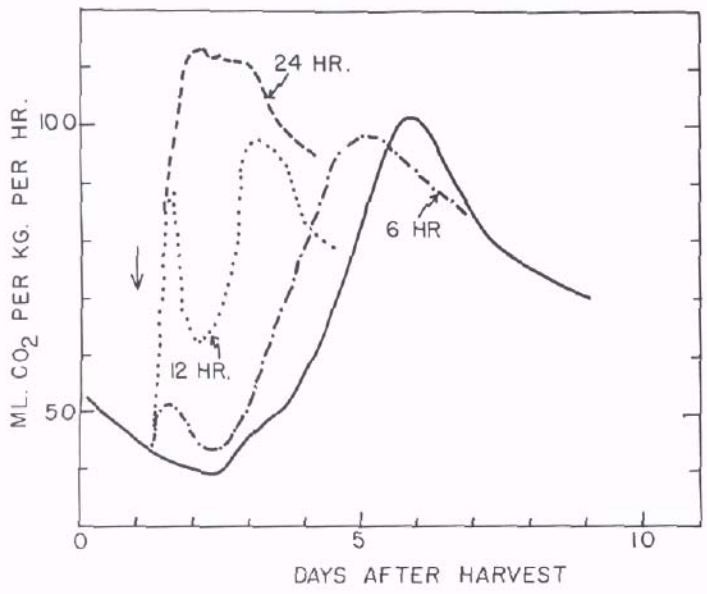
The effect of 0, 6, 12 and 24 hours exposure to 100 ppm of ethylene upon the respiratory rate of mature but early season (April) Hass avocado fruits is illustrated in figure 3. The 6-hour exposure caused only a small, but reversible stimulus in the respiratory rate, but did not influence the climacteric nor the rate of softening. The 12-hour exposure caused a substantial respiratory rise, but not sufficient to "trigger" the climacteric or softening immediately. However, the climacteric peak and softening did occur two days earlier than for fruit receiving no ethylene on the 6-hour exposure. Irreversible stimulation occurred with the 24-hour exposure and all fruits softened to a table ripe condition by the fifth day.

Late season Hass avocado fruit (September) (figure 4) ripened in six days compared with 10 days for the early season fruit (figure 3). The response to the various ethylene exposure periods was, in general, similar to that of the early season fruit, except that the 6-hour exposure did reduce the time to the climacteric peak by one day.

A more detailed illustration of the initial response of early season Hass avocado fruits to ethylene is shown in figure 5. Note that for a period of six hours after the beginning of the ethylene treatment (gas analysis verified that 100 ppm of ethylene passed over the fruit) no respiratory response occurred. At that time all treatments caused a sudden increase in the respiratory rate. However, fruits exposed for only 6 hours showed only a temporary stimulation and soon returned to essentially the level of the untreated fruits.

Similarly, fruits exposed for 12 hours continued to show an increasing respiratory rate for three or four hours after the ethylene was turned off and then the rate decreased. Late season fruit show the same delay. The delay in the response of fruits and vegetables to ethylene has not been previously reported, primarily because techniques were not available to continuously monitor the respiratory rate.

Preliminary studies with Fuerte avocado fruits indicate that, in general, the response to ethylene is similar to those of the Hass avocado fruits. Also, ethylene concentrations between 10 and 500 ppm produced essentially the same response on both varieties. Previous studies of the influence of ethylene on the respiratory rate and softening used continuous exposure to the ethylene. The present study clearly indicates that 6 and 12 hours exposure to ethylene is not sufficient to trigger the ripening process. A twenty-four hour exposure initiates ripening which is completed three to four days after the treatment is begun. Continuous exposure gives the same respiratory and softening response. Therefore, ready to eat avocados can be made available at the retail level through the use of ethylene which shortens the time required to ripen the fruit, and all fruits in a group will soften at essentially the same time. Shelf life in the retail store can be maintained in refrigerated display cases.



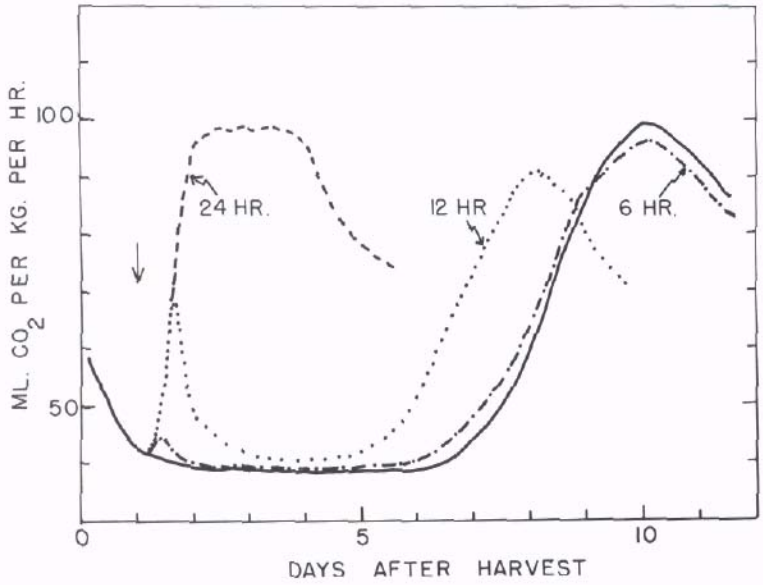


Figure 3. (Lower). The effect of 0, 6, 12 and 24 hours exposure to 100 ppm ethylene on the respiratory rate of mature but early season Hass avocado fruits.

Figure 4. (Upper). The effect of 0, 6, 12 and 24 hours exposure to 100 ppm ethylene on the respiratory rate of late season Hass avocado fruits. (Arrow indicates beginning of ethylene exposure. Solid line represents no ethylene treatment.)

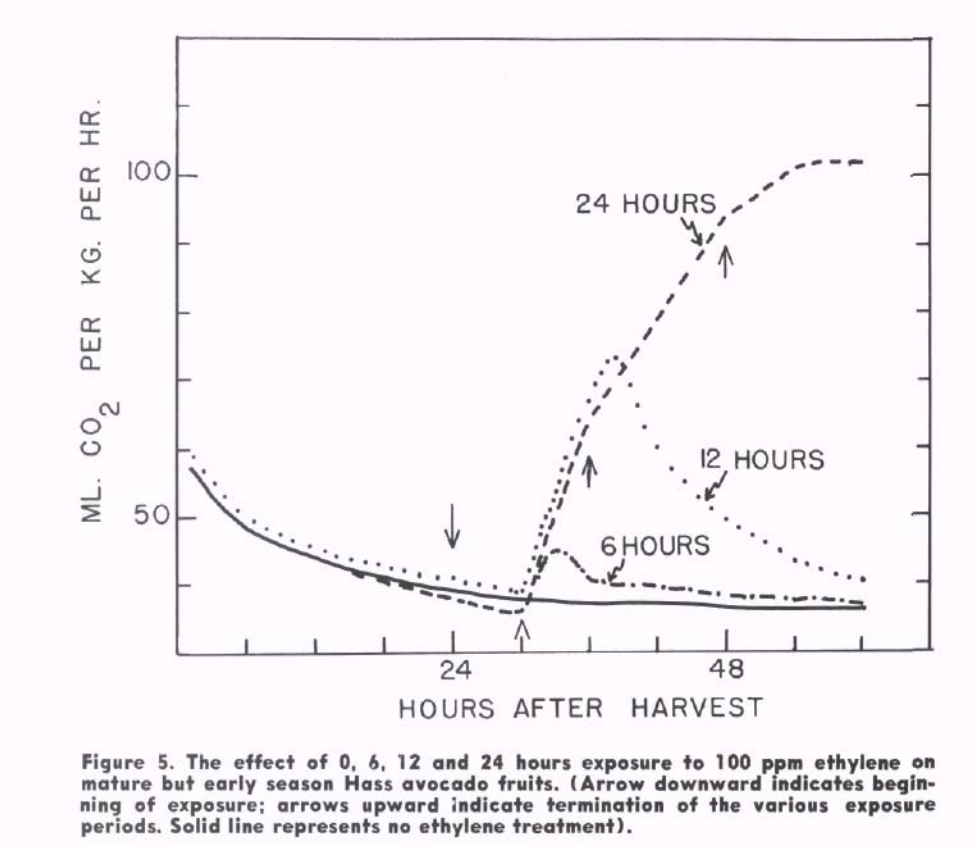


Figure 5. The effect of 0, 6, 12 and 24 hours exposure to 100 ppm ethylene on mature but early season Hass avocado fruits. (Arrow downward indicates beginning of exposure; arrows upward indicate termination of the various exposure periods. Solid line represents no ethylene treatment).

Summary

The softening of avocado fruits is associated with the climacteric rise in respiration. On an individual fruit basis, the fruit softens to an edible condition just as the fruit reaches the maximum respiratory rate of the climacteric. When avocado fruits are exposed to 100 ppm of ethylene, no respiratory response is observed during the first six hours. Six and 12-hour exposure to 100 ppm of ethylene does not initiate ripening. A twelve hour exposure does hasten ripening by about one day compared with untreated fruits. A 24-hour exposure initiates ripening and all mature fruits, both early and late season fruits will ripen in three to 4 days after the beginning of the ethylene treatment.

LITERATURE CITED

1. Biale, J. B. 1941. The Climacteric Rise in Respiration Rate of the Fuerte Avocado Fruit. Proc. Am. Soc. Hort. Sci. 39:137-142.
2. Claypool, L. L. and R. M. Keefer. 1942. A Colorimetric Method for CO Determination ¡n Respiration Studies. Proc. Amer. Soc. Hort. Sci. 40:177-186.
3. Erickson, Louis C. and Tadaaki Yamashita. 1964. Effect of Temperature on the Ripening of Mass Avocados. Calif. Avocado Soc. Yearbook. 48:92-94.