HortScience 23(3):588-589. 1988.

Response of Mature Avocado Fruit to Postharvest Ethylene Treatment Applied Immediately after Harvest

Giora Zauberman, Yoram Fuchs, Uri Yanko, and Miriam Akerman
Department of Fruit and Vegetable Storage, Institute for Technology and Storage of Agricultural Products, Agricultural Research Organization, The Volcani Center P.O.B. 6, Bet Dagan 50250, Israel

Additional index words, climacteric, *Persea americana,* softening

Abstract. **Ripening of mature avocado fruit was accelerated by 18- and 24-hr ethylene treatments which were applied beginning 1 hr after harvest. Exposure to ethylene for 12 hr or less, starting 1 hr after harvest, did not accelerate the respiration rate, ethylene evolution, or fruit softening. Ethylene treatment for 6 hr starting at 1, 6, 12, or 18 hr after harvest did not accelerate the onset of the ripening process. It is suggested that ethylene does not just "trigger" the ripening of avocado fruit but rather is involved in a relatively long (18 to 24 hr) process which requires its continuous presence.**

It has been well established that ethylene treatment of detached mature avocado fruit enhances its ripening (1, 5-9, 14). The climacteric patterns of avocado fruit harvested at various stages of development are similar, but the pre-climacteric period decreases as the fruit becomes more mature (16). Also, it has been shown that the length of the ethylene treatment required for the acceleration of ripening is shorter with late season than with early season mature avocado fruit (5). In 1970, Gazit and Blumenfeld (9) suggested that avocado fruit do not ripen on the tree because of an inhibitor in the fruit, and that after harvest this inhibitor must disappear before the fruit will respond to ethylene. Therefore, they stated that "Avocado fruit may remain insensitive to ethylene during the first day after picking". They based their statements on hand-tested softening measurements only. Since then, many authors have cited their paper to support the existence of a ripening inhibitor, as yet unknown, in avocado fruit. In 1973, it was reported (14), based on respiration measurements supported by hand tested softening, that mature 'Fuerte' avocado fruit respond to ethylene applied for 24 hr immediately after harvest. More recently, Lee and Young (10) have shown that the application of ethylene at 20°, 24°, 27°, and 30°C accelerated the climacteric respiratory rise of 'Fuerte' avocado fruit when applied on the day of harvest. The purpose of the present study was to determine the shortest period of exposure to ethylene needed during the

---

Received for publication 2 Apr. 1987. Contribution from the Agricultural Research Organization, The Volcani Center, Bet Dagan, Israel, no. 1293- E, 1984 series. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

first 24 hr after harvest to accelerate ripening of mature avocado fruit.

Mid-season (12% oil content) 'Fuerte' avocado *(Persea americana* Mill.) fruit was brought to the laboratory within 1 hr of harvest. Some fruit were exposed immediately to an atmosphere of 100 µl-liter"[1] of ethylene in air in a ripening chamber (36 m^3) at 20°C for 6, 12, 18, or 24 hr. Other fruit were similarly exposed for 6 hr, but the exposure period started at 6, 12, or 18 hr after harvest. There were 30 fruit in each treatment. All the fruit were kept at 20° before, during, and after the treatments. Fruit that was kept at 20° without any ethylene treatment served as control.

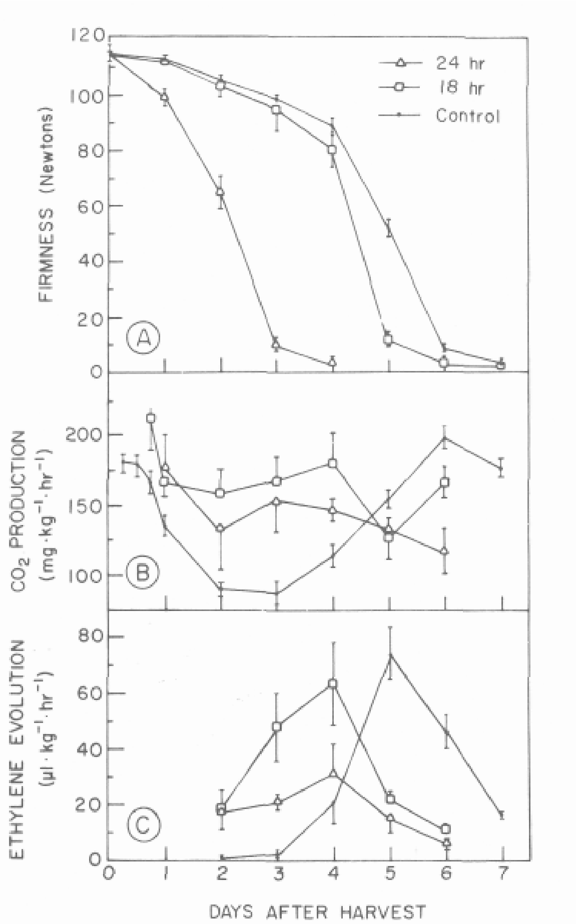

Fig. 1. Firmness (**A**), respiration rate (**B**), and ethylene evolution (**C**) of avocado fruit treated, at 20°C, with ethylene for various periods during the first day after harvest: ethylene for 24 hr, starting 1 hr after harvest (-△-); ethylene for 18 hr starting 1 hr after harvest (-□-); untreated fruit (-●-). Vertical lines represent the standard errors.

The respiration rate and ethylene production of five individual fruit of each treatment were determined. Respiration was measured at the end of the ethylene exposure and then daily for 6 or 7 days; ethylene measurements were started on the second day of the experiment in order to avoid measuring the exogenously applied ethylene, which might have been absorbed during the treatment and released shortly after it ended. Each fruit was enclosed for 1 hr in a 2-liter glass-jar. The headspace was sampled through a rubber septum and then the jars were left open until the next day. Carbon dioxide and ethylene were determined by gas chromatography, using thermal conductivity detector (TCD) for CO_2, and flame ionization detector (FID) for ethylene. The lowest concentration of ethylene that could be detected was 0.02 µl-liter-[1] in a 1-ml sample. Firmness (Newtons required to penetrate the fruit) was determined with a mechanized Chatillon pressure tester using a conical tip 6.5 mm in diameter (15). Six such determinations (three fruit, two determinations per fruit) were made daily until the fruit was soft. Fruit tested for firmness were discarded at the end of the determination.

The 18- and 24-hr exposures to ethylene, starting 1 hr after harvest, were the only ones to accelerate avocado ripening in this study. Results with fruit in all other treatments were similar to the nontreated fruit and therefore are not shown in Fig. 1. Exposure for 18 and 24 hr to exogenous ethylene accelerated the onset of ethylene production by the fruit (Fig. 1C), with the peak of ethylene production preceding by 1 day that of all other treatments. The 24-hr ethylene treatment reduced markedly the amount of ethylene produced by the fruit. These results, showing inhibition of ethylene production by exogenous ethylene treatment, confirm previous observations with avocado (15) and with other fruit (2, 11, 13, 17).

The respiratory climacteric of untreated fruit (Fig. 1B) and of those that were exposed to ethylene for less than 18 hr (data are not shown in the figure) lagged 2 days behind the 18- and 24-hr ethylene-treated fruit (Fig. 1B). This response confirms a previous report on the response of 'Fuerte' avocado to a 24-hr ethylene treatment applied immediately after harvest (14). In another report (5), it was demonstrated that even 6 hr of ethylene treatment applied 24 hr after harvest enhanced the onset of the respiratory peak with late season 'Hass' fruit, but not with early season fruit.

The 18- and 24-hr ethylene treatment accelerated softening markedly, whereas exposure to ethylene for <18 hr did not accelerate softening (data not presented). Overall, these data conform with those of a previous report (14), but not with the report by Gazit and Blumenfeld (9). Also, these data do not support the suggestion of the existence of ripening inhibitor in avocado fruit that is supposed to interfere with ethylene action after harvest.

It has been suggested that the capacity of avocado fruit to respond to ethylene either immediately after harvest (14) or later (5) depends on the length of the exposure period and the state of maturity of the fruit. Of course, the concentration of the gas (1) and the temperature of the fruit (8) have to be adequate. The requirement for a continuous presence of ethylene for induction of an ethylene effect has been reported for other effects, such as phytoalexin induction (4), phenylalanine ammonia lyase activity (3), and ethylene-induced ethylene production in citrus leaf discs (12). It is still not known how ethylene acts in the fruit tissues nor what prevents the fruit from ripening on the tree, but the results of this study and the previous studies (10, 14) indicated that ethylene can act effectively in accelerating the ripening process when applied on the day of harvest. Also, since in this study only the relatively long exposure periods (18 to 24 hr) were effective, it seems that ethylene does not just "trigger" the ripening of avocado fruit but rather is involved in a relatively long process which requires its continuous presence.

Literature Cited

1. Biale, J.B. 1960. The postharvest biochemistry of tropical and subtropical fruits. Adv. Food Res. 10:293-354.
2. Burg, S.P. and E.A. Burg. 1965. Ethylene action and the ripening of fruits. Science 148:1190-1196.
3. Chalutz, E. 1983. Ethylene-induced phenylalanine ammonia-lyase activity in carrot roots. Plant Physiol. 51:1033-1036.
4. Chalutz, E., J.E. DeVay, and E.G. Maxie. 1969. Ethylene induced isocoumarin formation in carrot root tissue. Plant Physiol. 44:235-241.
5. Eaks, I.L. 1966. The Effect of ethylene upon ripening and respiration rate of avocado fruit. Calif. Avocado Soc. Yrbk. 50:128-133.
6. Eaks, I.L. 1978. Ripening, respiration and ethylene production of Hass avocado fruit at 20° to 40°C. J. Amer. Soc. Hort. Sci. 103:576-578.
7. Eaks, I.L. 1980. Respiratory rate, ethylene production and ripening response of

avocado fruit to ethylene or propylene following harvest at different maturities. J. Amer. Soc. Hort. Sci. 105:744-747.

8. Erickson, L.C. and T. Yamashita. 1964. Effect of temperature on the ripening of Hass avocado. Calif. Avocado. Soc. Yrbk. 48:92-94.

9. Gazit, S. and A. Blumenfeld. 1970. Response of mature avocado fruits to ethylene treatments before and after harvest. J. Amer. Soc. Hort. Sci. 95:229-231.

10. Lee, S.K. and R.E. Young. 1984. Temperature sensitivity of avocado fruit in relation to C_2H_4 treatment. J. Amer. Soc. Hort. 109:689-692.

11. Riov, J. and S.F. Yang. 1982. Autoinhibition of ethylene production in citrus peel discs: Suppression of 1-aminocyclopropane-l-carboxylic acid synthesis. Plant Physiol. 69:687-690.

12. Riov, J. and S.F. Yang. 1982. Effects of exogenous ethylene on ethylene production in citrus leaf tissue. Plant Physiol. 70:136-141.

13. Vendrel, M. and W.B. McGlasson. 1971. Inhibition of ethylene production in banana fruit tissue by ethylene treatment. Aust. J. Biol. Sci. 24:885-895.

14. Zauberman, G. and Y. Fuchs. 1973. Effect of ethylene on respiration rate and softening of avocado fruit at various stages of development. Intl. Inst. of Refrig. Commission C2, p. 107-109.

15. Zauberman, G. and Y. Fuchs. 1973. Ripening process in avocado stored in ethylene atmosphere in cold storage. J. Amer. Soc. Hort. Sci. 98:447-480.

16. Zauberman, G. and M. Schiffmann-Nadel. 1972. Respiration of whole fruit and seed of avocado at various stages of development. J. Amer. Soc. Hort. Sci. 97:313-315.

17. Zeroni, M., I. Galil, and S. Ben-Yehoshua. 1976. Autoinhibition of ethylene formation in nonripening stages of the fruit of sycomore fig *(Ficus sycomorus* L.). Plant Physiol. 57:647-650.