The role of ethylene in development maturation and ripening of avocado fruits

Adato, I. (1974) Unpublished PhD Thesis, The Hebrew University of Jerusalem, Israel

The avocado fruit is unique in that it does not attain climacteric and does not soften as long as it is attached to the tree. It reaches the climacteric rise and softens only after it is harvested. We studied endogenous levels of ethylene, and the response of avocado fruits to ethylene applications, before and after harvest. The large seed enabled us to establish the role of the different seed tissues in ethylene production during fruit development and abscission.

The research was divided into several parts:

A. Ethylene production, respiration and abscission, during fruit development;
B. Ethylene production, respiration, and ripening after harvest;
C. Response of attached fruits to ethylene treatments during fruit development;
D. Response of detached fruits to ethylene treatments during fruit development;
E. Response of developing fruits to wounding, girdling and water deficit stress; and
F. The response of mature picked fruits to external supply of growth regulators.

A. Ethylene production, respiration and abscission during fruit development

Our study was started about 2 weeks after set (fruitlets weighing 0.l g) and was carried on until one year after set (mature fruits weighing more than 200 g). Rates of respiration and ethylene production were measured 2 to 3 hours after picking.

Positive correlation was found between the rate of ethylene production and the rate of fruit abscission. The seed in young abscising fruit (smaller than l g) produced 40-l00 times more ethylene than the pericarp and seems, therefore, to be responsible for this abscission.

In July, relatively high ethylene levels were found in the proximal region of pre-drop fruits; ABA levels were 7 times higher in the mesocarp of those fruits than in the mesocarp of fruits that did not drop.

B. Ethylene production, respiration, and ripening after harvest.

In mature harvested fruits, only the climacteric peak of ethylene production was observed. In immature medium age fruits (25-180 g) two peaks of ethylene were distinguished: a preclimacteric peak and a climacteric peak. Medium age fruit, like mature fruit, ripened concomitantly with the climacteric rise. However, in young fruits (smaller than 25 g) only the preclimacteric peak of ethylene production was found, and such fruits did not display any characteristics of ripening. A preclimacteric respiration peak was found to correlate with the preclimacteric ethylene peak. The preclimacteric ethylene is produced mainly by the seed coat. In the mature fruit where the preclimacteric is absent, the seed coat is dry.

Ethylene production in harvested immature fruits, and in over-mature fruits begins in the proximal region of the fruit. In the mature fruits, ethylene production begins in the distal region of the fruit. This pattern of change shows a correlation between fruit drop during the season and the rate of ethylene production at the proximal end of harvested fruits.

C. Response of attached fruits to ethylene treatment during the season

Attached fruits were treated in the orchard with a continuous stream of air containing 10 ppm ethylene. Response was as follows: young and over-mature fruits abscised earlier than mature fruits (3-4 days compared to 7 days). The young fruits abscised before achieving the climacteric rise whereas over-mature fruits abscised near to the peak of ethylene production.

The ABA level in the pericarp of mature fruits increased from the beginning of ethylene treatment until abscission. In young fruits (5 g) a decrease in ABA levels preceded the pre-drop increase of ABA in the mesocarp.

D. Response of detached fruits to ethylene treatment during the season

Continuous ethylene treatment (10 ppm) increased and advanced the pre-climacteric and climacteric respiration peaks of young fruits. In mature fruits, where there is in any case no preclimacteric peak, the climacteric respiration peak was advanced but did not increase in magnitude

Fruits were more responsive to short ethylene treatment started 49 hours after harvest than to similar treatment started l hr after harvest.

E. Response of developing fruits to wounding, girdling and water deficit stress

The stress treatments involved various forms of injury to the pericarp and the seed parts, girdling of fruits and depletion of the water content of picked fruits.

Various types of severe wounds in picked mature fruit caused ethylene production which increased until a climacteric peak was reached after 24 hrs. Softening of the fruit followed the ethylene production. Injury of the seed coat caused higher levels of ethylene production than did the wounding of pericarp. The embryo showed an acceleration of the ethylene production as a response to injury, only between June and August.

Ethylene production after injuring the seed coat and the pericarp was greater when the damage was done six days after harvest than when the damage was done l hr after harvest.

Girdling, accompanied by the removal of all the leaves between the girdling site and the fruit, always caused fruit drop eventually. This drop was preceded by enhanced ethylene production, which was earlier in young fruits than in older ones. Mature pre-drop fruits revealed higher ABA levels after girdling than in controls.

There was a synergism between girdling and injury in their effect on fruit abscission. Injury to the seed of attached young fruits caused an increase in ethylene production followed by abscission. This response was observed as long as the seed coats were viable. Both the increased ethylene production and abscission subsequent to seed injury, ceased if injury occurred after the seed coat had dried. The rate of ripening of harvested fruit was increased if the fruits were depleted of water (e.g. by increasing evaporation). The rate of ripening can be decreased by adding water to the fruit through its pedicel.

F. The response of mature fruits to external supply of growth regulators

Application of ABA (100 ppm) through the stem, to picked fruits caused an earlier fruit abscission with low ethylene production, although the treated fruits reached climacteric at the same time after harvest as control fruits.

Addition of GA to picked fruits with the same method did not alter the rates of fruit abscission of ripening. However the hormone caused a decrease of the ethylene production at abscission.

IAA caused a remarkable advancement of ripening in mature fruits but in spite of the high ethylene levels which existed in the fruit during its climacteric phase, the fruit abscised only eight days later.

Conclusions

The principle role of ethylene in avocado fruit development is in causing abscission of the fruit. A preclimacteric peak of ethylene production is responsible for abscission in immature fruits. The pre climacteric ethylene is produced in the seed coat, and its generation is induced either by a decrease in the supply of assimilates from the leaves, or by injury to the seed coat. Decreased supply of assimilates can occur either during the natural course of development of the fruit, or may be caused artificially by girdling. Injury to the seed coat may occur as a result of natural defects or by mechanical wounding.

Mature avocado fruits do not ripen while on the tree, nor do they drop spontaneously. The level of ethylene production by such mature fruits is low. External application of ethylene to such fruits on the tree causes ripening and abscission.

Increased levels of ethylene, whether produced by the fruit or due to external application, lead to an increase in abscisic acid in the pericarp. No increase in ABA levels could be detected without prior increase in levels of ethylene.