Maturation and ripening of avocado Fruit

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SUMMARY

The development of the avocado fruit from anthesis to the final disintegration can be roughly divided into several stages: Growth, maturation, ripening and senescence. In this study we were interested mainly in the maturation and ripening of Avocado fruits.

We studied the growth of the different tissues of the avocado fruit. The growth curve of the whole avocado fruit is sigmoidal. The fresh weight of the seed coats rises rapidly during the first months after fruit set. As the fruit matures the seed coats begin to dry out and lose weight, and in mature fruits the seed coats are completely dry. The growth pattern of the embryo is similar to that of the whole fruit.

The growth pattern of the fruit and of the different fruit parts was similar in the five cultivars we studied, but the onset and rates of growth and development were specific for each cultivar. One of the characteristics of avocado fruits is the oil which accumulates in the pericarp during fruit development. It has been shown in several studies that the oil content of avocado fruits increases rapidly, at a relatively constant rate between September and May (60). We found that between June and August the oil content of avocado fruits rises very slowly. At the end of this period, a time which is different for each cultivar, a rapid accumulation of oil begins, and from this point onward, oil accumulates at a relatively constant rate. The fruit of each cultivar seems to reach a point in its development where a certain "trigger" causes it to begin accumulating oil rapidly. Understanding the way in which this "trigger" works may enable us to enhance or delay accumulation of oil in the fruit, and this may be of a far-reaching theoretical and practical importance.

The period which elapses from harvest to softening becomes shorter as the fruit matures. We found that a fruit of a certain cultivar, which set on a certain time, differed in oil content and in the number of days to softening, compared with a fruit on the same tree which had set a few weeks earlier. There was also a difference in size, oil content and number of days from harvest to softening, between fruits of the same cultivar picked from different orchards. The rate of oil accumulation was also different in different cultivars and in the same cultivar grown in different orchards.

Uneven ripening is one of the problems existing in some avocado cultivars, especially in 'Ettinger' early in the season. (September and early October). Part of the fruit, usually the stem-end softens, but the stylar-end softens a few days later, by which time the ripe stem-end is attacked by fungi and rots. Such a fruit is not considera to be horticulturally mature and should not be harvested.

We studied the calcium and potassium content of the stem-end and the stylar-end of avocado fruits during their growth and development in order to determine whether there

was a correlation between uneven ripening and the calcium or potassium content in the pericarp. We found that the stylar-end has a much lower content of calcium than the stem-end, but a slightly higher content of potassium. There was no correlation between calcium content at the two fruit ends, and uneven ripening of the fruit, even though it is known that calcium may affect production of ethylene, a hormone which is considered to trigger and regulate fruit ripening.

'Pinkerton' is a new avocado cultivar introduced into Israel from California. This cultivar which is grown in the Jordan Valley was found to reach horticultural maturity in mid November, at which time the oil content of the fruit is 9%, its taste was good, and the fruit ripened evenly. A large percentage of fruit harvested at the beginning of January did not ripen evenly,i.e. the stem-end softened 2-5 days later than the stylar-end. In our opinion, if this problem is not solved, it may limit the season during which 'Pinkerton' fruits can be harvested and exported, to a short period of time, between mid November and the end of December. Treating the fruit with ethylene in order to achieve even ripening, enhanced the softening of both ends of the fruit, but that of the stylar-end more than the stem-end. As a result, the difference in ripening between the two ends was greater, and the problem of uneven ripening became worse.

The avocado which is a climacteric fruit, produces high levels of ethylene during ripening. In young 'Ettinger' fruits there are three ethylene peaks during ripening: the first is produced by the seed coats, a few days after harvest, the second, a few days later, is a small peak produced by the pericarp at the stem-end, and several days later there is a third peak, the highst of the three, which is produced by the pericarp at the stylar-end of the fruit. The three peaks were recognized both by measuring the ethylene production of the whole fruit, and of the pericarp at the stem-end and at the stylar-end. In mature 'Ettinger' fruits there were only two peaks. The seed coats in the mature fruit were completely dry and did not produce ethylene. The two peaks produced by the pericarp at the stem-end and the stylar-end, were very close to each other, and appeared only a few days after harvest. In all cases each part of the pericarp softened a day or two after the climacteric peak had been attained.

The peak of ethylene production differed quantitatively but not qualitatively between the dorsal and the ventral sides of the fruit. In most cases ethylene, at peak production, was higher at the ventral side of the fruit than at the dorsal side, but both sides reached peak ethylene production and softened at the same time.

Ethylene production was higher in the inner parts of the fruit mesocarp (near the seed cavity) than at the outer mesocarp (near the fruit peel).This was also true for EFE activity. Our work showed that in the pericarp of cv. 'Fuerte', ethylene is first produced by the inner mesocarp at the stylar end of the fruit, then by the outer parts of the mesocarp, and last by the stem end of the mesocarp. The mesocarp at the stylar end reaches the climacteric peak first followed by the mesocarp of the stem-end. In 'Ettinger' fruits ethylene production is different. First the mesocarp at the stem-end produces ethylene and reaches the climacteric peak and only later does the inner mesocarp at the stylar end reach peak production, followed by the outer mesocarp.

The reason for uneven ripening of the fruit was found to be due to the lack of the enzyme ACC synthase, which is not synthesized or not active in the part of the fruit that does not produce ethylene.

Treating young immature or just matured avocado fruits with 100 ppm ethylene,

beginning right after harvest for a short duration (24 hours), did not enhance the ripening of the fruit in comparison with control fruits stored in air, fruits stored in ethylene for 48 h right after harvest, or fruits stored in ethylene for 24 h begining 24 h after harvest. In some cases the short ethylene treatment even caused a slight delay in ripening in comparison with untreated fruit. This was true for fruits on the verge of maturity but not for mature fruits.

Our hypothesis for this phenomenon is that exogenous ethylene activates the enzyme N-malonyltransferase. As a result the ACC produced in the pericarp is conjugated to MACC instead of producing ethylene so that ethylene production and ripening are delayed. Our work suggests that the enzyme is effective in conjugating ACC only when the quantity of ACC in the tissue is not very high. Prolonged ethylene treatments cause the synthesis of a high quantity of ACC which can not all be conjugated by the N-malonyltransferase. The ACC that was not conjugated produces ethylene via the EFE and causes the autocatalysis of ethylene production and subsequent ripening of the fruit. In our opinion, the reason that ethylene treatment which begins 24 hours after harvest is effective in enhancing ethylene production and softening is because the ethylene producing-systems in the pericarp are partially activated and the fruit is more sensitive to ethylene. Similarly, even short ethylene treatments given to very mature fruit cause an enhancement of ripening.