

## THE ROLE OF THE SEED COAT IN AVOCADO FRUIT DEVELOPMENT (GROWTH AND MATURATION)\*

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The development of avocado fruit (Fuerte in particular) was observed over a number of years as part of a research project investigating the role played by endogenous plant growth regulators in the development of the fruit. Rates of growth of the various fruit tissues were measured and changes in auxin, gibberellin, cytokinin and inhibitor levels were established. Some results of this study have already been published (1, 3). In this report we should like to communicate interesting findings which suggest the role of the seed coat in growth processes, maturation and abscission of avocado fruits.

The avocado seed coat consists of two layers which are difficult to separate. These develop from the two integuments which envelope the embryo sac in the young ovule. In the immature fruit, the seed coat is light in colour and succulent, it shrivels and darkens as the fruit nears maturity. In the mature fruit the seed coat is a dead tissue; it is dark brown and very thin.

The presence of a thin brown seed coat is considered to be an indication of fruit maturity (4).

The seed coat envelopes the endosperm and the embryo. The branched vascular system of the fruit ends in the seed coat; it is the only route of exchange between the developing embryo, the rest of the fruit, and the tree. The distribution of the vascular system can easily be followed if the fruit is infused with 0.1% eosin bluish stain through its pedicel. The general pattern observed conforms with that described by Cummings and Schroeder (2). We found however that vascular bundles from all parts of the fruit converge forming one large bundle which enters the seed coat, and only very few bundles end blindly at the distal end of the fruit. The stain showed up the existence of a very branched vascular system in the seed coat that had no direct connection with the vascular system of the embryo. Staining at different times during fruit development showed that staining solution was taken up by the seed coat even at a time when it is partially shriveled. This shows that even at this late stage the connection between seed and fruit is not completely severed.

**The Rate of Growth of the Seed Coat: its relation to fruit growth and maturation.**

The seed coat is very conspicuous in one month-old fruitlets, being the largest of the seed components. It forms 50% of the seed approximately 5% of total fruit weight. The embryo at this stage is tiny in size, rod shaped and is embedded in the yellow gelatinous endosperm. As the fruit grows the seed coat also grows (see Fig 1) but at a slower rate than the embryo. In Israel the seed coat of Fuerte reaches its maximum weight (ca. 4-5 g.) during August. At this stage it accounts for approximately 20% of seed weight and 2.3% of total weight. Shriveling of the seed coat starts in September.

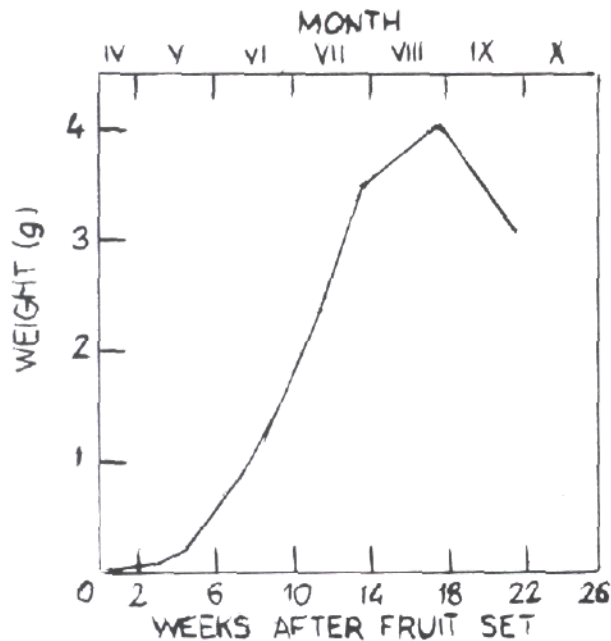


Figure 1—Growth of Fuerte seed coat.

Shriveling of the seed coat seems to be strongly connected with growth processes and fruit maturation. Shriveling starts at the same time as the embryo ceases growing. A marked slow down in the rate fruit growth ensues, as well as the rapid accumulation of oil. A month later (October), the fruit reaches "horticultural maturity." The connection between seed coat shriveling and maturation processes does not only exist at normal maturation time but may also be observed earlier.

Routine oil analysis carried out early in the picking season revealed Ettinger and Fuerte fruits with a high oil content of 12-15% in contrast to the normal 7-9%. These fruits can be recognized by their external appearance. They are smaller than normal fruits, their lower part (region containing the seed) is narrow and their neck is relatively wide. The seed coat in these fruits is always dark and shriveled; the enclosed embryo is much smaller than usual and it is often dead and black. Something apparently caused very early shriveling of the seed coat and early triggering of all maturation processes.

## Plant growth regulators in the seed coat

The seed coat is very rich in growth promoting substances. High concentrations of two auxins, two gibberellins and three cytokinins were found in this tissue. The regulators were assayed in biological bioassays using the wheat elongation test for auxins, the barley endosperm test for gibberellins and the soybean callus test for cytokinins. Compared with other plant tissues, the levels of growth substances activity found in avocado seed coat were very high. This was especially so in the case of gibberellins and cytokinins. Cytokinin and auxin activity found in the seed coat was much greater than in the pericarp. In the case of gibberellin, levels of activity were very high in the seed coat and very low in the two adjacent tissues: the embryo on one side and the pericarp on the other.

We found that as the fruit matures, activity of all growth promoters diminished. A positive correlation was found between fruit growth rate and the level of growth promoting activity in the seed coat. It is especially strong in the case of gibberellins and cytokinins (Fig. 2).

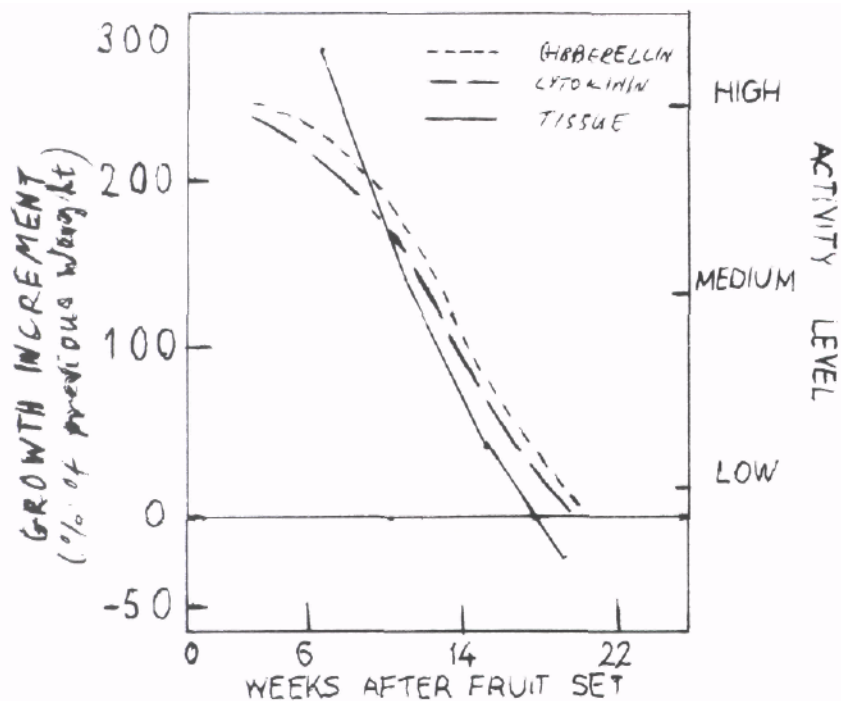


Figure 2—Changes in gibberellin and cytokinin activities plotted against rate of growth of seed coat. Hormon levels are given as relative activity per g.

## Observations on avocado fruit drop and the state of the seed coat.

The "July drop" is a wave of Fuerte and Ettinger fruit drop which starts in July and is distinct from the wave of drop occurring after fruit set. The fruit which drops at this stage is 50-100 g in weight and it abscises with a piece of its fruit stalk. The fruit about to drop can be recognized by its dull colour and occasionally by the cracks at its proximal end.

A black or damaged seed coat is generally found when these fruits are opened. On occasion the embryo was also found to be damaged but generally it seemed intact. If the fruit is pierced at this stage and the seed coat is damaged, fruit abscission always ensues. If only the pericarp is damaged the fruit does not drop. At a later stage of reports concerning the high growth regulator content of seed coat will not result in fruit drop.

## DISCUSSION

Since the seed coat acts as intermediary between the embryo, the pericarp, and the whole tree, it is not surprising that a properly functioning seed coat is essential for normal fruit development. In addition we have found the seed coat to be a very rich source of growth regulators. Seeds of other fruit species are also known to be very rich in growth promoters. In most studies the different tissues of the seed were not analyzed separately, probably because of their small size, and the difficulties in separating them. Little attention was therefore paid to the special role played by the seed coat, even though a number of reports concerning the high growth regulator content of seed coat have been published (5).

The manner in which the seed influences fruit growth is not fully understood, although it is known that for the normal development of many fruit species, the attainment of normal size and the inhibition of abscission the presence of seeds is essential.

In the case of avocados, seedless fruit may be found side by side with seeded ones. The former are always smaller and narrower than the latter. In cases where the influence of the seed ceased early during development due to premature shriveling of the seed coat, the fruit has a different shape from that developing normally. One explanation offered for the role of the seed is that it acts as a "sink" for nutrients. All explanations attribute a major role in the growth regulators synthesized in the seed. Their effect may be a direct one of supply to other tissues, or an indirect one whereby nutrients are mobilized in the direction of the high concentrations of growth regulators. The pericarp benefits from enhanced supplies of nutrients since it forms part of the route taken by this plentiful supply.

In avocado, we found that the tissues' richest growth regulators were the endosperm and the seed coat. The endosperm disappears three months after fruit set leaving the seed coat as the main source of growth substances. The importance of its normal functioning is therefore clear. The seed coat does not develop in the absence of a normal embryo. It may, therefore, be assumed that the embryo is in some way responsible for the normal functioning of the seed coat.

The embryo seems to exert its influence on fruit growth and development both physiologically and morphologically via the seed coat.

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