

## Physiological Gradient in Avocado Fruit

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Studies on fruit maturity of avocado and related topics of subsequent storage and handling procedures have resulted in a substantial literature concerning the morphological and biochemical sequences which occur in the fruit structure. The unique high oil content of the fruit has stimulated extensive investigations into the nature of the constituents which are involved in the development of this oil, and the biochemical sequences which are associated with the dramatic climacteric respiration curve and softening process (2).

The extensive research on oil formation and accumulation in the developing fruit generally has considered only the entire fruit as a basis for sampling. Likewise the majority of investigations on the biochemical pathways to explain the physiological behavior of the fruit has utilized mostly composite samples taken from the fruit as a whole without particular reference to specific positions of tissues within the fruit.

Determination of fruit maturity in avocado has been related for the most part to increase in oil content of the fruit. Legal standards for fruit maturity have been described on the basis of tissue samples from several fruits. More recently, critical evaluations of fruit maturity have been based on fruit size and dry weight of pericarp tissue (6, 13). This has called attention to the relationship of dry weight and oil content as a reasonable criterion for time of harvest and legal maturity.

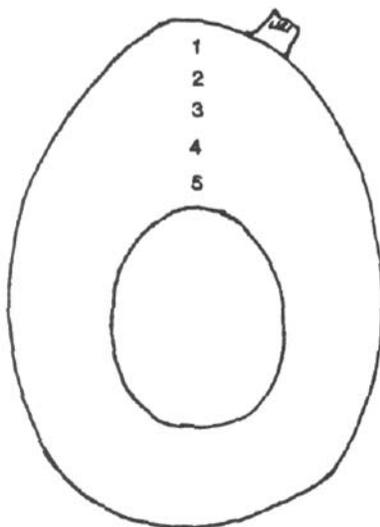
A series of problems concerned with fruit development such as failure of uniform softening in various tissues, the appearance of stony layers in otherwise soft tissue, and tissue discoloration in storage have provoked more detailed investigations on specific tissues. The present study inquires into possible physiological gradients within the fruit which may be related to these problems.

### Methods

The method utilized in this investigation consisted of sampling individual avocado fruit of various sizes by use of a cork-borer to obtain cylinders of tissue from specific points in the fruit. These cylinders 8 mm in diameter were then cut transversely into shorter cylinders usually 0.5 to 1.0 cm in length. The fresh and dry weight of each small cylinder was obtained with a Mettler balance. The tissue cylinders were dried in a microwave oven for 20 minutes at which point the dry weight was determined and the percentage of oil was calculated.

## Observations

While some variations exist in dry weight between comparable samples of fruit of apparently the same stage of development (Fig. 1), a general and essentially reliable trend of data warrants its utilization to explain some aspects of fruit behavior.



Fresh Weight		172 gr.	179	184	167	185	161
Dry Weight Percent	1	28.7%	28.9	28.4	29.1	32.5	29.5
At Given Sample Point	2	30.2%	30.1	29.5	28.0	32.1	29.0
	3	28.3%	28.5	24.9	25.3	29.9	28.0
	4	25.4%	24.8	22.0	23.2	26.8	25.1
	5	22.1%	20.7	18.5	19.6	20.8	20.0

Figure 1. Dry weight percentage of tissue samples taken at specific points along axis of six Hass fruits (March 5, 1985).

A static view of the typical distribution of dry weight (oil content) at specific points of a Hass fruit collected on February 1 is given in Figure 2. The points of sampling are depicted in the diagram of a longitudinal plane section of the fruit. Samples taken at right angles or behind and in front of the longitudinal section are shown along the side of the diagram. A marked gradient is noted in oil content between the tissue near the stem insertion (31.6 percent) and the seed (16.8 percent). The points of highest oil content

are scattered in the pericarp near the rounded end of the seed. Another general observation is the comparative higher concentration of oil in the mid-pericarp area surrounding the seed. There is less oil just beneath the skin, a higher concentration in the middle fleshy portion, and continuing inward, a comparatively lower accumulation of oil along any given section. This internal-external gradient differs at the stem end where a single direct gradient from high to low concentration is noted.

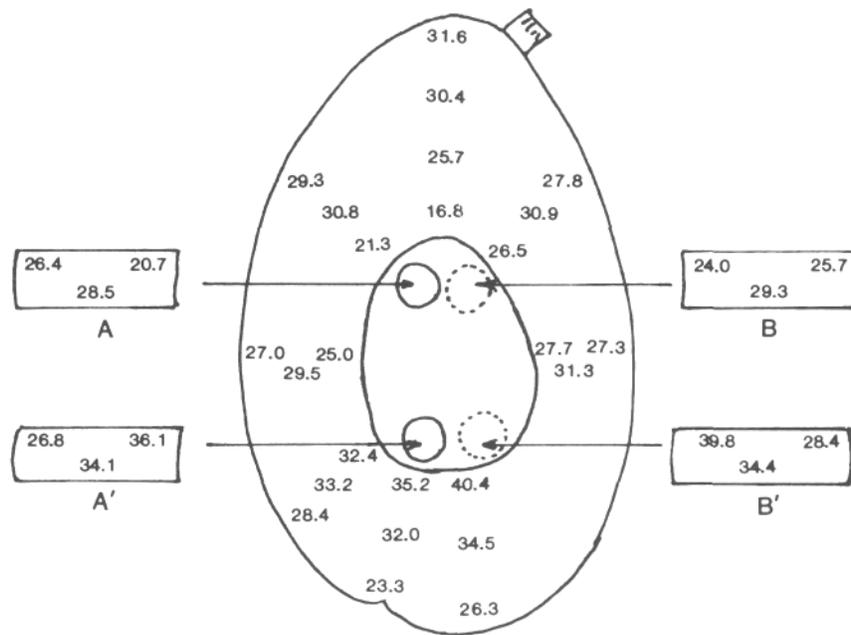


Figure 2. Dry weight percentage of tissue at specific points of a Hass fruit as viewed in longitudinal section. Samples at side were taken at right angles to plane section (A-A beneath plane, B-B' above plane).

The fleshy tissue immediately around the seed shows a greater amount of oil at the apical (rounded) end and lowest oil content near the pointed end (Fig. 3). The peripheral tissue just beneath the skin appears to be rather uniform in character with a slightly higher oil content near the stem insertion and comparatively lower amounts near the apex of the fruit. The intermediate tissue between the skin and the seed is generally and uniformly higher in oil throughout the fruit.

It is apparent that there is not a uniform distribution of dry weight in the several parts and tissues of the avocado fruit at any stage of development. One notes the high dry weight percentage or oil content near the stem insertion (Fig. 4). Following the tissue from this point directly toward the pointed end of the seed there is a distinctive and gradual reduction in oil along this axis. The lowest figure for dry weight of the entire fruit is in the tissue surrounding the pointed end of the seed. This gradient from stem to seed is general and consistent in fruits with a short neck such as Hass. The gradient is frequently more pronounced in slightly necked specimens of Pinkerton and dramatically

demonstrated in the unusually long necked fruit from a seedling tree (1-491) in which a differential oil content of 15.7 percent exists between the point of stem insertion and the seed.

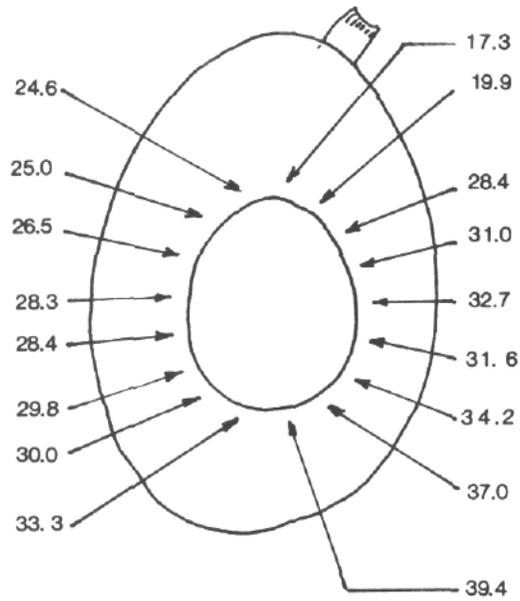


Figure 3. Dry weight percentage of tissues at specific points near seed and in periphery of pericarp of Hass fruit (April 15, 1985).

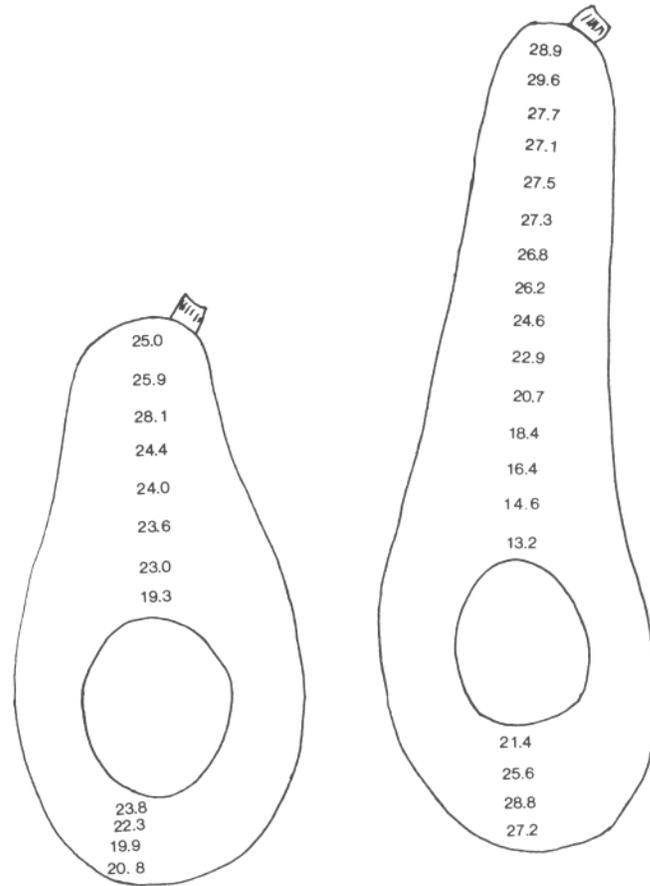


Figure 4..Dry weight percentage of tissue at specific points in fruits of Pinkerton and seedling (I-491) (December 12, 1984).

## Discussion

Physiological gradients within fleshy fruits have been reported for several fleshy fruit species. Marked differences in sugar content and acidity exist between the upper half, or stem end, and the lower, or stilar, half of the citrus fruit (1, 5). The lower end of the orange fruit, the stilar end as it hangs on the tree, has more sugar and more acid than the stem end. The stem end of some oranges is more susceptible to crystallization and abnormal drying compared with the apical half. Similarly there is a gradient of vitamin C content with a greater concentration in the stem half of orange and grapefruit compared with the stilar halves. There is a comparable gradient of vitamin C showing a higher concentration around the central axis and a lesser amount in the juice located just beneath the peel of orange (14).

Similar marked differences are noted in sugar content in different portions of cantaloupe, casaba, honeydew, Persian melons (13), and watermelon (7). The tomato exhibits a decrease in calcium near the distal or stilar end of the fruit which is associated with some forms of necrosis (16).

Without doubt, there are many differences in structure and metabolic activity which eventually will be demonstrated within the avocado fruit. Specific points of normal and abnormal physiological activity possibly can be related to problems of development and fruit maturation during its growth on the tree and in its post-harvest responses. Physiological gradients which indicate differential development or accumulation of specific elements or organic molecules can suggest accumulations or deficiencies of substances which might explain the responses of the fruit at various periods in its development.

The significance of the variation in dry weight or oil content can be related to observations on some problems of irregular fruit softening in avocado. The failure of fruit tissue to soften uniformly has been reported from Israel (8), California, and South Africa (9, 10, 11). The calcium relationships within the fruit tissue have been associated with the abnormal premature softening of the apical end of some avocado varieties (3, 15). Especially among Mexican types, there is a physiological weakness or a deficiency within the tissue at the stylar end of the fruit. The data in the present study support the idea of the highest accumulation of oil in this tissue near the apical end. Thus, if high oil content is associated with fruit softening and maturation, then one will expect fruit ripening to be initiated in the apical end. Empirical observations in several varieties indicate this maturation and breakdown of the apical end while the stem end is still firm. In contrast, there are some seasons in which the stem end of long necked varieties, such as Pinkerton, will soften prior to maturation of the other tissues. This could be related to the comparatively high oil content of the tissue around the stem insertion. A similar premature stem-end softening is sometimes noted in the variety Ettinger in Israel.

A problem which has been reported on several occasions for the Fuerte fruit has been uneven softening of the pericarp at various points, especially in the basal or stem half of the fruit (11). The hard, lumpy tissue is noted to be lighter in color compared with the normal soft tissue. Such "lumpy-tissue" frequently surrounds the pointed end of the seed. It is in this area that lower oil concentration is detected. If one assumes that oil content is a factor in tissue maturation, then the gradient in oil in the several parts of the avocado fruit could be related to the problems of uneven softening of the tissues.

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