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Physiological gradients in fleshy pericarp of avocado

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SYNOPSIS
Investigations on the developmental aspects of the fleshy avocado fruit have indicated a marked physiological gradient between specific points within the pericarp wall. Dry weight percentage of pericarp tissue near the stem insertion (30-35 per cent) compared with that near the proximal end of the seed (15 per cent) reflect in part a marked contrast in oil content of these tissues. Similar gradients along other axes and between various tissues can be demonstrated. Failure to attain adequate oil content appears to be related to uneven softening of tissue and irregular maturation of the entire fruit. Some aspects of the developmental sequence of these physiological gradients at specific points may be related to the problems of fruit maturity and tissue breakdown.

INTRODUCTION

Investigations on fruit development in avocado generally have implied the pericarp to be uniform in structure and physiological behaviour. This is suggested by composite samples which are reported with little or no indication of specific points where unusual physiological activity could prevail. The assumption that the fruit is of uniform structure and hence represents a singular tissue behaviour pattern, does not explain some of the observations of tissue breakdown and abnormal development (8,9,10). The assumption that tissue dry weight can be utilised to indicate oil content of specific tissues, provides a means to investigate various tissues of the fleshy avocado pericarp and relate these to tissue points where aberrant and normal physiological conditions tend to develop.

The investigations presented in this report verify those earlier observations and extend the study toward the less mature fruits. The marked physiological gradients of dry weight (oil content) were previously described in a few selected varieties such as Hass, Pinkerton and an undescribed seedling cultivar from a breeding project. The present study includes some additional observation of oil distribution in mature fruits in some younger fruit stages of the cultivar Hass.

MATERIALS AND METHODS

Samples were taken of avocado fruits at various stages of development grown in Orange County, California. Dry weight determinations were made on tissue samples from specific points in the fleshy pericarp. Tissue cylinders (8 mm in diameter) obtained with a cork borer, were cut to various lengths, 5 to 10 mm. The samples were dried in a microwave oven for 25-30 minutes. Fresh and dry weights were determined on a Mettler balance. The results expressed as percentage dry weight are assumed to indicate oil

content. The magnitude and trends of differences between the several points in the pericarp tissue are emphasised in this study.

OBSERVATIONS

Analyses of oil content at specific points in the Hass fruit (April 1985) are depicted in Figure 1 A. A vertical section made through the stem end of a mature fruit was sampled in the median plane at specific points. Each sample measured approximately 8 mm diameter and 5 mm in thickness. The tissue dry weight percentages are expressed at the appropriate points between the stem and the seed. It is noted that the trends are consistent with other observations, namely a distinctive gradient between the point of stem insertion (high oil - 36,7 per cent) and the proximal end of the seed (low oil - 22,3 per cent). Nearly all other sample points along the vertical axis indicate a similar gradient. Likewise, the peripheral points are higher in oil than interior points.

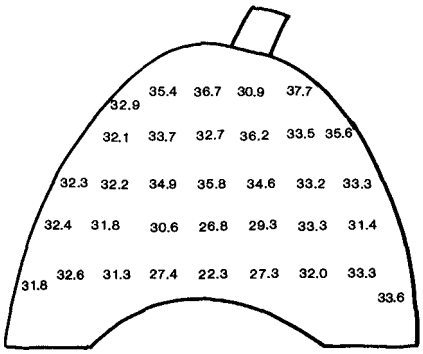

Fig 1 Distribution of oil (tissue dry weight percentage) at specific points on median vertical plane between stem and seed cavity of mature Hass fruit (176,5 g April 1985). Each segment approximately 5 x 5 x 5 mm.

A typical observation of differential oil content in another Hass fruit is shown in Figure 2A. The tissue sample in a vertical median section shows high oil at the stem end (28,2 per cent) and low oil near the seed cavity (16,1 per cent). Again the extreme end of the fruit is low in oil (23 per cent) whereas the interior tissue near the seed is 32,3 per cent, These observations are consistent with previous results. Radial gradients near the mid position of the seed again indicate high oil near the seed and just under the skin, with less oil in the mid pericarp area. These data support the suggestion that a physiological gradient is probably established while the fruit is rather small. This gradient continues to develop and differentiate as fruit maturity and fruit size increases.

It should be noted that increase in fruit size in avocado differs from most other fruits in that cell division provides the major contribution to the increase in bulk of the pericarp, as the maximum cell size remains constant. Most other fruits increase their bulk size by cell enlargement after the basic tissues are laid down upon the cessation of cell division, about three weeks following pollination. Cell division in avocado fruit is continuous throughout its development while the fruit remains attached to the tree.

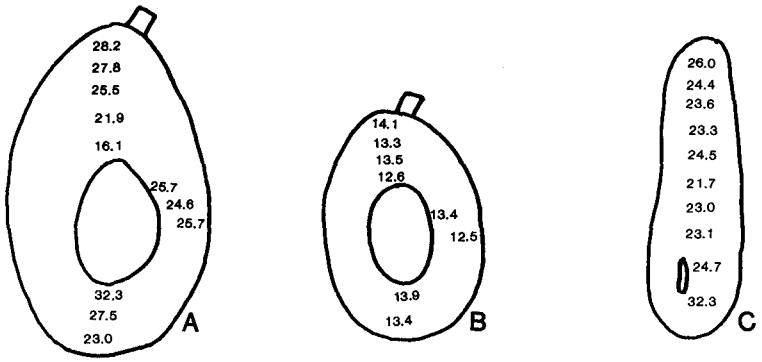

Fig 2 Distribution of oil (tissue dry weight percentage) along vertical median axis of Hass avocado.
A — nearly mature fruit (281,5 g, Dec, 1984),
B — young fruit (81,5 g, Aug, 1984),
C — seedless fruit (56,0 g, Dec, 1984).

The oil content of interior pericarp tissue near the distal (rounded) end of the seed is rather high and decreases near the stylar, distal end of the fruit. There is also a radial gradient of oil at nearly all points along the vertical axis. The outer peripheral tissues generally show medium to high oil, while the intermediate tissues are comparatively lower at nearly all points. There is a higher oil-bearing layer immediately surrounding the seed except at the proximal end, as demonstrated previously (10). While variation in the pattern of oil distribution can be found, the general distribution is highly consistent and suggestive of a physiological significance which can explain several situations of fruit breakdown and abnormal fruit development (7,8,9,10). Irregular softening, hard spots and premature breakdown at the point of stem insertion may appear in fruits from some growing areas in some seasons and occasionally in most varieties.

The irregular softening of fruit tissue or the failure to soften is sometimes of major economic importance. This uneven ripening is not restricted to any given cultivar. The failure of pericarp tissue to soften uniformly is noted on occasion in such a variety as Fuerte. Direct observation of tissue sections indicates the normal soft tissue is filled with oil whereas the hard, 'low oil' tissue frequently located near the proximal end of the seed, has very little oil in the individual cells.

When the tissue oil content is high, particularly near the seed, there is generally a rapid, early maturity. Sometimes this specific tissue is completely softened while the stem end tissues of the given fruit are still firm. The empirical observation of the physiological gradient of tissue dry weight (oil content) can account for many of these aberrant fruit and in some cases explain in part the natural sequential developments which eventually result in a completely softened fruit.

The value of tissue dry weight technique as an indicator of oil content in avocado fruit (4,5) has been demonstrated as a reliable, simple, fast and cheap method for use in

several cultivars including Ettinger, Fuerte, Hass, Nabal and Reed. The sample for these determinations is not specified but *probably* implies that slices of, or perhaps the entire fleshy pericarp, was utilised.

The report of cellulases in relation to the cell wall of Hass avocado (1) again does not specify the location of sample collection in the fleshy pericarp. Likewise in another study of oil accumulation in avocado fruit, the sampling technique does not consider differential accumulation of oil in specific tissues (6).

A gradient of IAA and some other hormonal molecules are reported in avocado fruit (3). These specific molecules are directly related to the seed and testa as these structures affect growth and maturation of the pericarp as a whole.

The above reports show that avocado fruit studies generally are nonspecific regarding differential development and location of specific biochemical reaction sites within the fleshy pericarp. The present investigation calls attention to the wide range of physiological conditions (which probably prevail in the pericarp) that must be considered to adequately explain some of the observed phenomena of fruit growth and physiology.

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