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DETERMINATION OF SURFACE AREA AND VOLUME OF AVOCADO FRUITS

Louis C. Erickson and Yoshio Kikuta

Louis C. Erickson is Plant Physiologist and Yoshio Kikuta is Research Assistant and Graduate Student in the Department of Biochemistry, Citrus Research Center and Agricultural Experiment Station, University of California, Riverside.

In studying the cuticle wax of avocados, it is important to determine the surface area of the fruit in order to compare the amount of wax produced at various stages of development, under various environmental conditions, and by various varieties. Because there is no easy way to determine the surface area of the fruit experimentally, it was necessary to calculate the area from fruit measurements. The reliability of the area calculation had to be evaluated indirectly by calculating fruit volume and comparing the latter with experimental determinations of volume obtained by water displacement. The water displacement was carried out simply by catching and weighing the water which drained from a 4-inch overflow tube on the side of a container in which the fruit was immersed.

Calculations of the surface area and of the volume of avocados were based on the assumption that the fruit corresponded closely to the composite of the following geometrical forms (Figure 1): (1) a hemisphere at the stylar end, (2) a portion of a cylinder next to the stylar hemisphere, (3) a frustum of a cone, and (4) a smaller hemisphere at the stem end of the fruit.

The formulas used were as follows:

Curved surface area

hemisphere $= \frac{\pi d^2}{2}$

cylinder $= \pi dh$

frustum of a cone $= \pi (r_1 + r_2 \sqrt{h^2 + (r_1 - r_2)^2}$

Volume

hemisphere $= \frac{\pi d^3}{12}$

cylinder $= \pi r^2 h$

frustum of a cone $= \pi \frac{h}{3} (r_1^2 + r_1 r_2 + r_2^2)$

The formula for the surface area of an avocado becomes:

$$\pi \left[\frac{d_1^2 + d_2^2}{2} + dh_1 + (r_1 + r_2) \sqrt{h_2^2 + (r_1 - r_2)^2} \right]$$

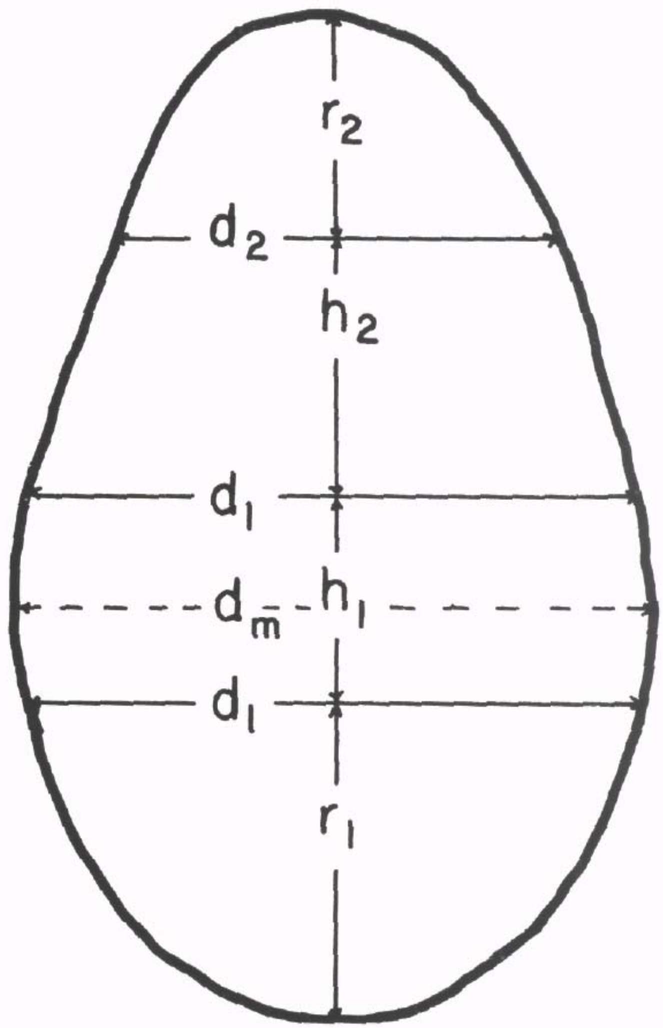

FIGURE 1. Outline of Hass avocado showing locations of various measurements used in the calculations.

The formula for the volume of an avocado becomes:

$$\pi\left[\frac{d_1^3 + d_2^3}{12} + r^2h_1 + \frac{h_2}{3}(r_1^2 + r_1r_2 + r_2^2)\right]$$

Where d = diameter of the cylinder, obtained by averaging

d_1 and d_m

d_1 = diameter of the fruit at a distance of $\frac{1}{2}d_1$ or r_1 from the large end.

d_2 = diameter of the fruit at a distance of $\frac{1}{2}d_2$ or r_2 from the small end.

d_m = mean maximum diameter of the fruit.

r = $\frac{1}{2}$d

h_1 = length of cylinder portion.

h_2 = length of frustum.

In Table 1 it may be seen that the mean calculated volume of Hass avocados differs from the experimental volume by approximately one per cent. Inasmuch as volume is based on three dimensions and surface area on only two, it follows that the error in calculated surface area should be less than that for volume.

TABLE 1. Surface Area and Volume of Mature Hass Avocados

Fruit	Measured volume, cc. Trial 1	Trial 2	Average	Calculated surface area, sq. cm.	Calculated volume, cc	Calculated as per cent of measured volume
1	219	223	221	190	219	99.1
2	251	256	254	203	257	101.2
3	200	206	203	183	217	106.9
4	158	171	165	155	166	100.9
5	199	208	204	181	214	104.9
6	183	186	185	162	180	97.3
7	152	145	149	140	144	96.6
8	236	239	238	194	237	99.6
9	228	231	230	194	237	103.0
10	190	188	189	166	187	98.9
					Mean	100.8

While a more precise analysis of shape might be derived for individual avocados, the generalized formula presented is flexible enough to fit most fruit. The length of the frustum and the relative diameters at its two ends are the features which take into account the length and thickness of the neck of the fruit. Asymmetry or curvature of the fruit introduces a variable error which has not been considered.