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EVALUATION OF SOME PHYSICAL METHODS FOR DETERMINING AVOCADO MATURITY

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A non-destructive procedure for determining maturity of avocados has been a long sought but elusive goal. Among the methods considered as possible replacements for the current destructive oil method has been the use of optical and electrical characteristics of the fruit. Bean, et al (1) reported on experiments in which changes in electrical characteristics of avocados during ripening were measured. Bean (2) also discussed possible application of these and various other physical measurements to non-destructive maturity testing.

The investigation of electrical and optical properties as measures of maturity have been continued. Capacitance and resistance were measured at various stages of maturity throughout a season to determine if changes could be detected in these values. The light transmission and delayed light emission characteristics were also included in the investigation.

LIGHT TRANSMISSION

Optical properties of fruits and vegetables have been used for sorting based on changes in the reflectance or transmission characteristics of the material. Although no striking visible changes occur in the color of the flesh or skin of avocados, an investigation was conducted to determine if any transmission changes could be detected by sensitive instrumentation. Modification of existing equipment would have been necessitated if whole fruit were to be used in the transmission measurements. It was deemed advisable to run the first series of tests with fruit slices and if positive results were achieved, the equipment changes could be made for subsequent non-destructive tests. The fruit slices also provided a means for more reliable and informative data than would have the whole fruit.

Fuerte avocados were used throughout the investigation with the first fruit picked for light transmission, light emission, and capacitance measurements at a very immature stage on October 8, 1964. Samples were picked and tested at two-week intervals through February 11, 1965.

Slices, approximately ¼ inch thick, were cut from the fruit. One slice was taken from the large end after the end section had been removed. This provided one slice without the skin or any of the green pigment near the skin. A second slice was taken from the side of the fruit and included the skin. A third slice without skin was taken from the side; however, this was discontinued when it was found to show no significant difference from the end sample. Transmission measurements were made with a sensitive spectrophotometer over the range of 450 to 950 mu. Typical response curves for this series of tests are shown in Figure 1.

Oil and impedance measurements were made on other samples beginning on September 24 and ending on March 11. Although the oil content of the fruit increased from 4.67% on October 8 to 17.4% on February 11, no significant changes occurred in the transmission characteristics Pronounced variations were observed but no correlation between these and increased maturity could be established.

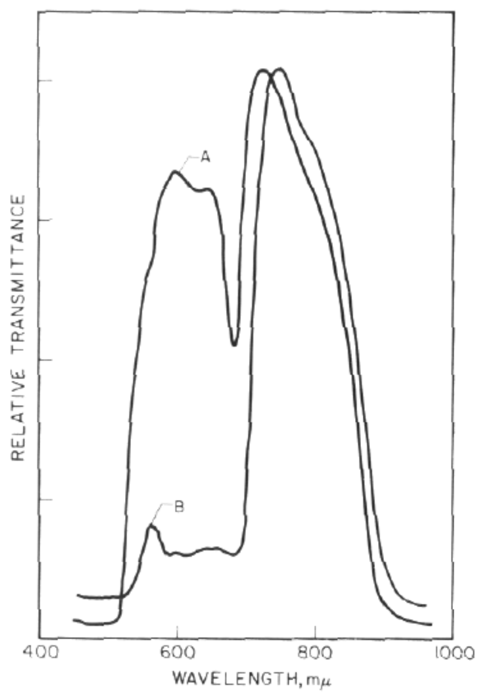


FIGURE 1. Typical Transmittance curves for avocado slices. Curve A is for a slice without skin. Curve B is for a slice with the skin intact.

DELAYED LIGHT EMISSION

A technique described by Jacobs, et al (3) using delayed light emission was investigated as a possible measure of maturity. Fruit has been shown to radiate light following exposure to visible light. The rate of decay of the emission subsequent to exposure is a function of certain properties of the fruit. One of the most obvious of these is the chlorophyl content. Fruit was successively exposed to monochromatic light at 550, 680, 700, 720, and 750 mu and to an incandescent lamp. Following each exposure the emitted light intensity was measured and recorded for a period of two minutes during which time the fruit was held in a dark chamber. Typical decay curves are shown in Figure 2.

No significant change in decay rate was disclosed by these tests. Corking of the lenticels did have a profound influence on the level of the emitted light. However, since this corking is not an acceptable measure of maturity (Hatton & Campbell 4), the effect on the delayed light emission does not provide a suitable measure of maturity.

CAPACITANCE MEASUREMENTS

The electrical capacitance of a capacitor is established by the dielectric constant of the material forming the device. The numerical value of the dielectric constant of common materials ranges from 1 for a vacuum to about 80 for water, with oils ranging from 2 to 5 dielectric constant of substances can be measured by introducing the substance as a dielectric in a capacitor. When fruit is considered as the dielectric, the problem is complicated by the irregular shape of the fruit. The capacitor is thereby formed by a combination of air and fruit as the dielectric. The fringe field effect also becomes a factor to be considered. Fortunately, relative values are sufficient and the exact dielectric constant is not required, making this method feasible for determining changes in the dielectric properties of the fruit.

It can be established that for fruit of given weight, a change m the ratio of two components such as oil and water would result in a change in measured capacitance. The obvious disadvantage to this method is that the fruit weight will not be the same. In this investigation, the measured capacitance was divided by the weight to obtain a value of capacitance per unit weight in an attempt to compensate for the weight variation.

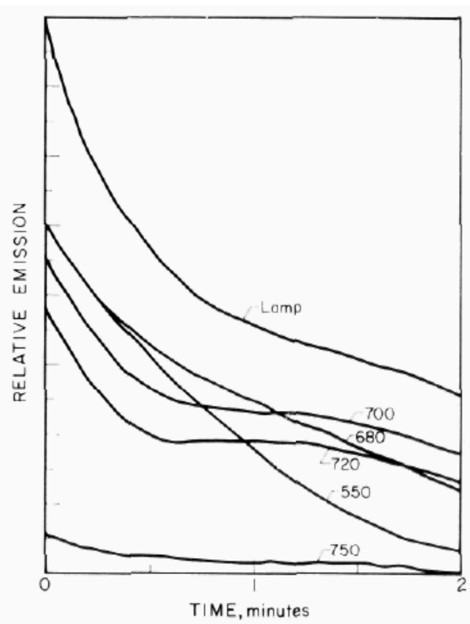


FIGURE 2. Delayed light emission from a Fuerte avocado following exposure to selected light sources. Measurements were made following the exposure of the fruit to monochromatic light at each of the indicated wavelengths (mu) and an incandescent lamp.

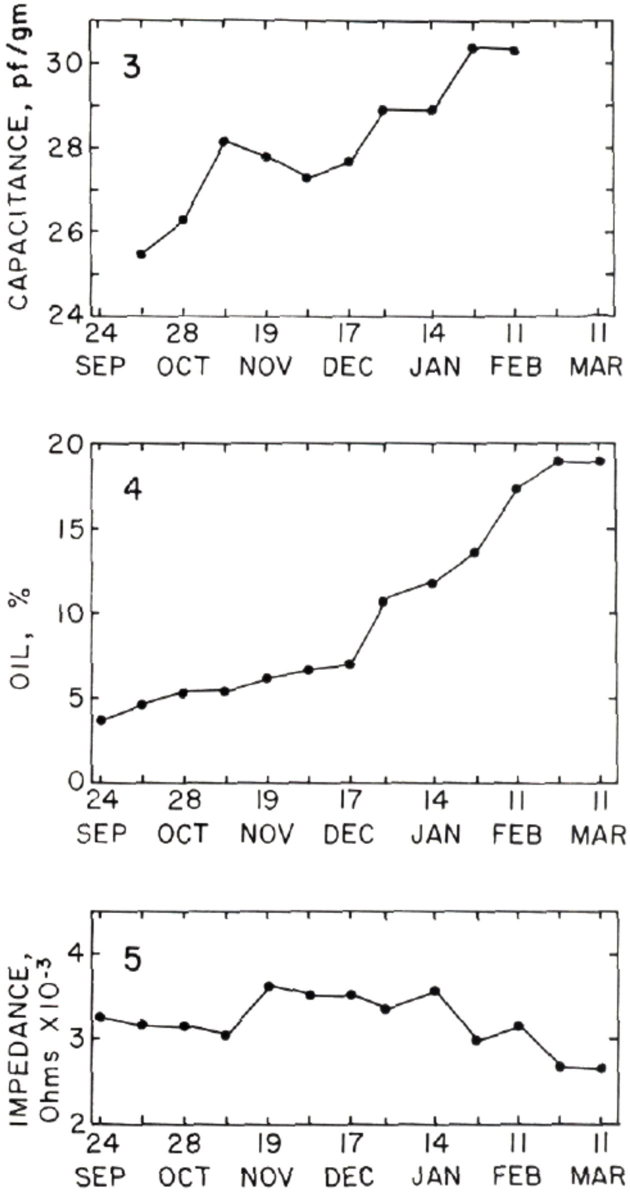
The capacitance measurements were made with two parallel plates separated by 3½ inches. These were enclosed in a metal box which acted as a shield to maintain a constant fringe field effect. The fruit was inserted between the plates utilizing an access door. The fruit was supported in a position centered between the plates by a plastic shaft. The reading was shown to be rather sensitive to the position of the fruit relative to the plates even though it was never allowed to contact the plates. Therefore, the fruit was carefully oriented for all tests in an effort to eliminate this variable. The distribution of the fruit between the plates as a function of fruit size was one variable for which compensation could not easily be provided.

Preliminary tests also included the use of slices of a constant size placed between small, parallel-plate electrodes. This test provided for the elimination of all the problem variables anticipated. However, the capacitance reading was very sensitive to slight variations in pressure even though the electrodes were well insulated. No satisfactory solution was apparent and this method was deleted from subsequent tests. All capacitance measurements were made with a capacitance bridge at a frequency of 1 mc.

The results of the capacitance tests illustrated in Figure 3 show an increase in the measured capacitance per unit weight, as the fruit became more mature. The oil content of the similar sample is illustrated in Figure 4. Impedance* measurements were also conducted on the fruit used for determining oil content. These data are presented in Figure 5.

**The impedance in this case was primarily the AC resistance of the sample as opposed to the pure capacitive reactance, measured in the test for capacitance.*

The impedance was shown to decrease as the capacitance increased and vice versa. These fluctuations occurred while the oil content evidenced a continual increase. The relationship between changes in measured impedance and capacitance were observed in earlier investigations where all tests were conducted using the same fruit. These earlier studies utilized electrodes inserted in the fruit and different instrumentation. This provides a rather firm case for the relative changes described above. One conclusion that could be drawn from these data is that the water content of the fruit varies significantly. This could account for the increase in capacitance accompanied by a decrease in resistance. Water could vary in the fruit due to the accumulation of oil, and it could also vary as a result of fluctuations in soil moisture and weather conditions. The effect of water content on impedance and capacitance is probably confounded with changes in cell permeability in view of the findings of Bean, et al (1) that electrical properties change during fruit ripening, and Sacher (5) has shown that ripening is accompanied by increased permeability. Additional studies where the moisture content would be measured as well as the electrical properties determined would be required to elucidate these interrelationships.



FIGURES 3-5. Changes in Fuerte avocados during development and maturation. Fig. 3. Capacitance in picofarads per gram. Fig. 4. Oil as percent of fresh weight. Fig. 5. Impedance in ohms x 10^{-3}.

SUMMARY

Light transmission, delayed light emission, and electrical capacitance were investigated as possible measures of avocado maturity. Light transmission in the visible ranges and delayed light emission did not show promise as potential maturity measures.

Electrical capacitance and resistance showed significant changes as the fruit matured. However, the trends were not as consistent as changes in oil content nor was it clear

whether variations resulting from factors not related to maturity induced unacceptable fluctuations in the measured values.

LITERATURE CITED

1. Bean, Ross C, John P. Rasor, and Gerald G. Porter. 1960. Changes in electrical characteristics of avocados during ripening. California Avocado Soc. Yearbook. 44:75-78.
2. Bean, Ross C. 1962. Avocado maturity studies: A discussion of possible applications of various physical measurements to non-destructive testing. Calif. Avocado Soc. Yearbook. 46:94-99.
3. Jacob, F. C., R. J. Romani, and C. M. Sprock. 1963. Fruit sorting by delayed light emission. Paper prepared for 7963 winter meeting of the American Society of Agricultural Engineers, Chicago, Illinois.
4. Hatton, T. T. and C. W. Campbell. 1959. Evaluation of indices for Florida avocado maturity. Proc. Fla. Hort. Soc. 72:349-353.
5. Sacher, J. A. 1962. Relations between changes in membrane permeability and the climacteric in banana and avocado. Nature 195:577-578.