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AVOCADO MATURITY STUDIES

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In recent years, the large increase in avocado production and the rapid growth of the industry have stimulated search for means and methods of determining fruit maturity and the best time of harvesting. All fruits reach a stage on the tree where maturity is manifest from their physical appearance but usually when this stage is reached in the avocado, the fruit has passed the optimum condition for long distance shipment and must be utilized at once. It is necessary to harvest avocados when firm and in an inedible condition and then store until soft and edible. When it is desirable to harvest fruits before they have tree-ripened, the problem of determining the best time of harvesting is not an easy one and knowledge of their changes in composition during maturation assumes special importance.

In order to establish practices in harvesting or to devise methods of testing the maturity of the avocado, it is necessary to know the composition of the fruit throughout its life cycle and the changes taking place in the various characteristics in the process of maturity. Aside from the investigations by Church and Chase on "Some Changes in the Composition of California Avocados During Growth," little work has been done in this regard, With the exception of the analyses on a few mature West Indian seedling avocados made by Tilt and Winfield; there has been no study made of the composition of Florida avocados. Hence, a detailed study of the quality and the changes in the physical and chemical characteristics of most of the important Florida avocado varieties was made throughout the life cycle of the fruit.

The investigation was carried out over a period of three fruiting seasons and the important varieties from three distinct areas in which avocados are grown in Florida were analyzed at three-week intervals from the time of setting to tree maturity. The fruit was obtained from marked trees of the Brooks Properties, Inc., Homestead; the Ivey

Properties, Inc., Lake Placid; and P. O. Campbell, Estero. Pressure tests were made on both skin and pulp of the fruit with the pressure testers used in corn and peach maturity tests.

The weight and specific gravity of the whole fruit was first determined. The seed, skin and pulp were weighed and the percentage of each determined. The following constituents of the pulp were determined: Moisture, fat, ash, protein, and sugar (free-reducing hydrolyzable and total).

The results of the investigations of the three seasons were very consistent. With the exception of slight changes due to climatic effects on the various constituents of the fruit, the changes in composition of the same varieties sampled from three different areas and throughout three growing seasons were almost identical.

The method of testing maturity in peaches with the so-called pressure tester which has been used and proven very efficient by the New Jersey Experiment Station was tried out on all of the avocado varieties used in the investigation. Unlike the results of this pressure test on the flesh and skin of the peach in which the pressure necessary to force the plunger (various sizes) into the fruit was directly proportional to the degree of ripeness, very unsatisfactory results were obtained when applied to the avocado.

The total weight of the fruit increases in all varieties as the fruit matures, the weight of the seed, skin and pulp increasing with maturity. When these various parts of the fruit are figured on the percentage basis, the per cent, seed increases, the per cent, skin decreases, while the per cent, edible pulp remains somewhat the same throughout the life cycle. There seems to be no satisfactory line of demarcation which indicates maturity in regard to weights and percentage of the various parts as these changes with climatic and environmental conditions, quality of the fruit on the tree and other factors, thus causing differences from season to season and also differences within the same season.

The results of the analyses of all three seasons show the moisture content to decrease in all varieties. The amount of moisture varies inversely with the amount of fat, which fact will be discussed later. The highest moisture content of the fruit is obtained during the spring and summer months, during the early growth phase of the fruit, while the lowest is during the fall and winter months. This is true of all the varieties, thus leaving the earlier maturing West Indian varieties with much higher moisture content when mature than the later maturing hybrid and Guatemalan varieties. The per cent, moisture of the pulp itself cannot be used as a maturity measure, as it varies with climatic conditions, but it must be taken into consideration when other constituents are used as a basis for judging maturity. Thus, the other constituents, when considered on the wet basis, could not be used as true maturity measures since their values would vary with variation in moisture content. However, they can be used as a maturity indication when the content values have been reduced to the water-free basis and the change (increase or decrease) is large enough to be significant.

The amount of protein is small in comparison with other constituents (from a fraction of 1 per cent, to 2 per cent.) for all the varieties of avocados. The protein content increases with maturity but the amount present is too small and too variable to be used as a measure of maturity. The protein content of avocados, however, is high in comparison with that contained in other fresh fruits.

The percentage of ash or mineral matter in avocados is relatively small as compared to the other constituents of the fruit, but it is interesting to note that it is higher than that recorded for other fresh fruits, most varieties containing twice as much mineral matter as that contained in other fruits. The change of this constituent during the process of maturation is too small and too variable to be used for standardizing purposes.

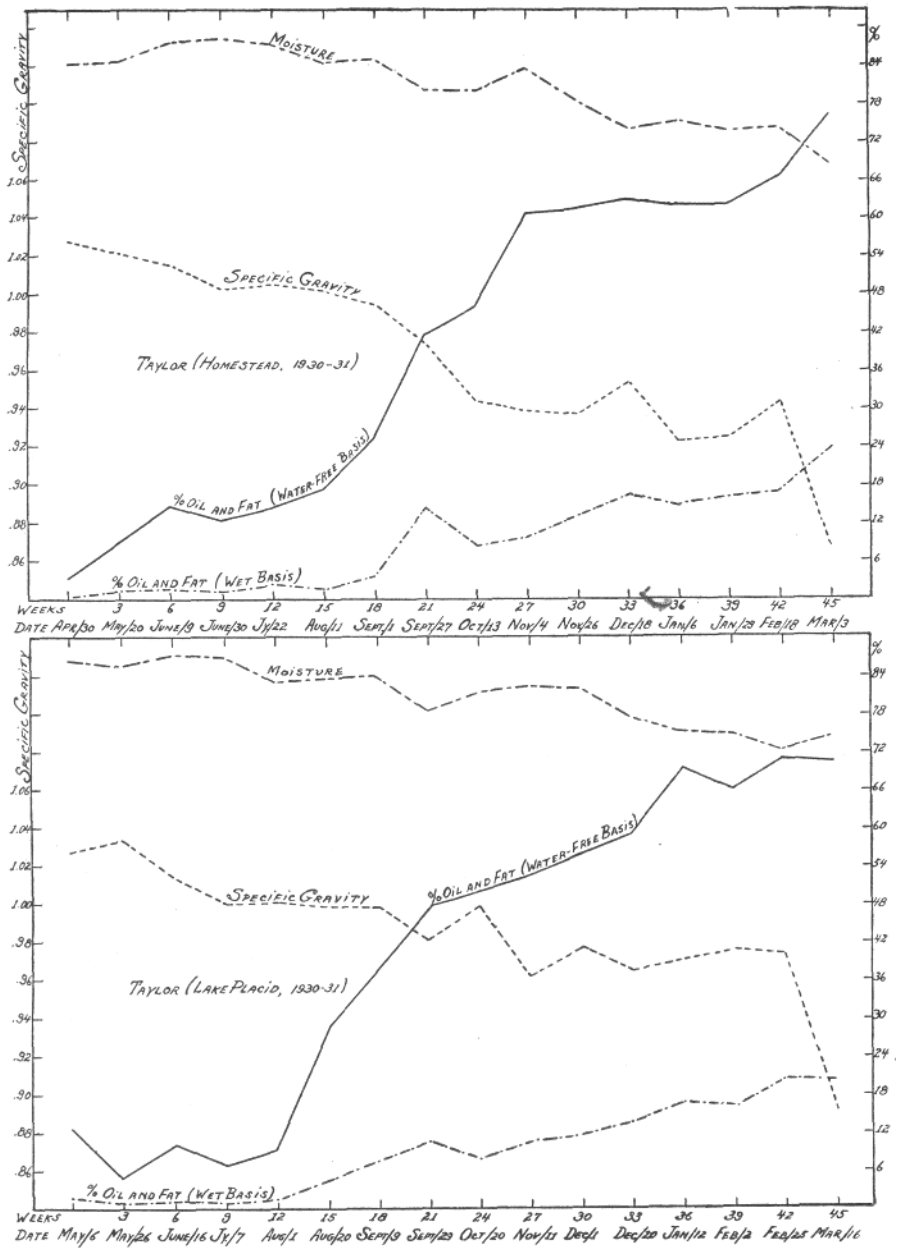

FIGURE 1. Graphical presentation of various characteristics of the Taylor avocado from Homestead and Lake Placid throughout the season of 1930-31.

The results of the investigation indicate small amounts of total sugars present, the amount decreasing as the fruit matures. Nearly all of the total sugar was found in the form of free-reducing sugars. Only a very small amount of hydrolyzable sugars were found at any time during the life cycle of the fruit. It is interesting to note that the sugar content of the Florida avocados is low as compared to those grown in drier climates, a fact which is of much interest to the medical profession in that the avocado, with such low sugar content and, at the same time, high food value is an ideal food for diabetics.

The fat and oil of the avocado is its chief constituent, other than water, and when it has reached its maximum there is no doubt that the fruit is mature. The question arises; however, as to how long before the point is reached that the fruit can be harvested with satisfactory results, as far as eating qualities are concerned. During all three seasons and in all of the varieties tested, the fruits showed a consistent and more or less uniform increase in fat up to a certain point, after which the increase was much less. From a study of the data compiled it would seem that the point where the consistent increase in fat ceases is about the point where satisfactory maturity is found.

The fat content seems to be the best indication of maturity of the avocado of any of the numerous characteristics determined. Its content can be very readily correlated with the maturity of the fruit. If the fat content of the avocado is known it is fairly easy to tell the state of maturity of the fruit after having several complete sets of analyses indicating the trend of the fat content, through the life cycle of the variety and grown in seasons of varying climatic conditions.

In using the fat content as a measure of maturity, it should be emphasized here that those figures not reduced to the moisture-free basis cannot be used as the moisture content is variable, being affected by climatic conditions. Thus, only the fat content reduced to the moisture-free basis can be used as a true measure of maturity. At this point, it may be interesting to note that when the fat content of Florida avocados is calculated to water-free basis, the fat content is equal to that of the fruit of the same variety grown in drier climates and calculated to water-free basis. Also, when the moisture content of the Florida avocados is comparable to that of fruit of the same variety grown in other sections of the country, the fat content is comparable, expressed either on the green or water-free basis.

If there were an easy and rapid method of determining fat, there would be no better means of determining maturity of the fruit. The present method of ether extraction is too expensive and requires far too much time to be of much value in the avocado industry. There have been attempts at determining avocado fats by using other solvents, but none have proven satisfactory, other than to give approximate values. The ether extraction and other solvent methods necessitate the using of the fruit analyzed, thus giving the fat content of single representatives of a group. Avocados vary to such an-extent that there may be a difference of 10 per cent, fat in the fruit picked for shipment. Should the sample tested for maturity by this method just happen to be low, while the majorities are high in fat content, then the whole shipment would be called immature, while the majority may be mature. The reverse may happen and in this manner immature fruit may be called mature.

If the method is to be practicable, it should be determined in a very short time and with little expense. Also, the method should not necessitate taking chance samples which may not be representative of the picked fruit. The ideal method would be one where each individual fruit could be tested without utilizing or injuring the fruit. This may be accomplished by using the specific gravity of the fruit as a measure, since it correlates itself uniformly with the fat content and the maturity of the fruit.

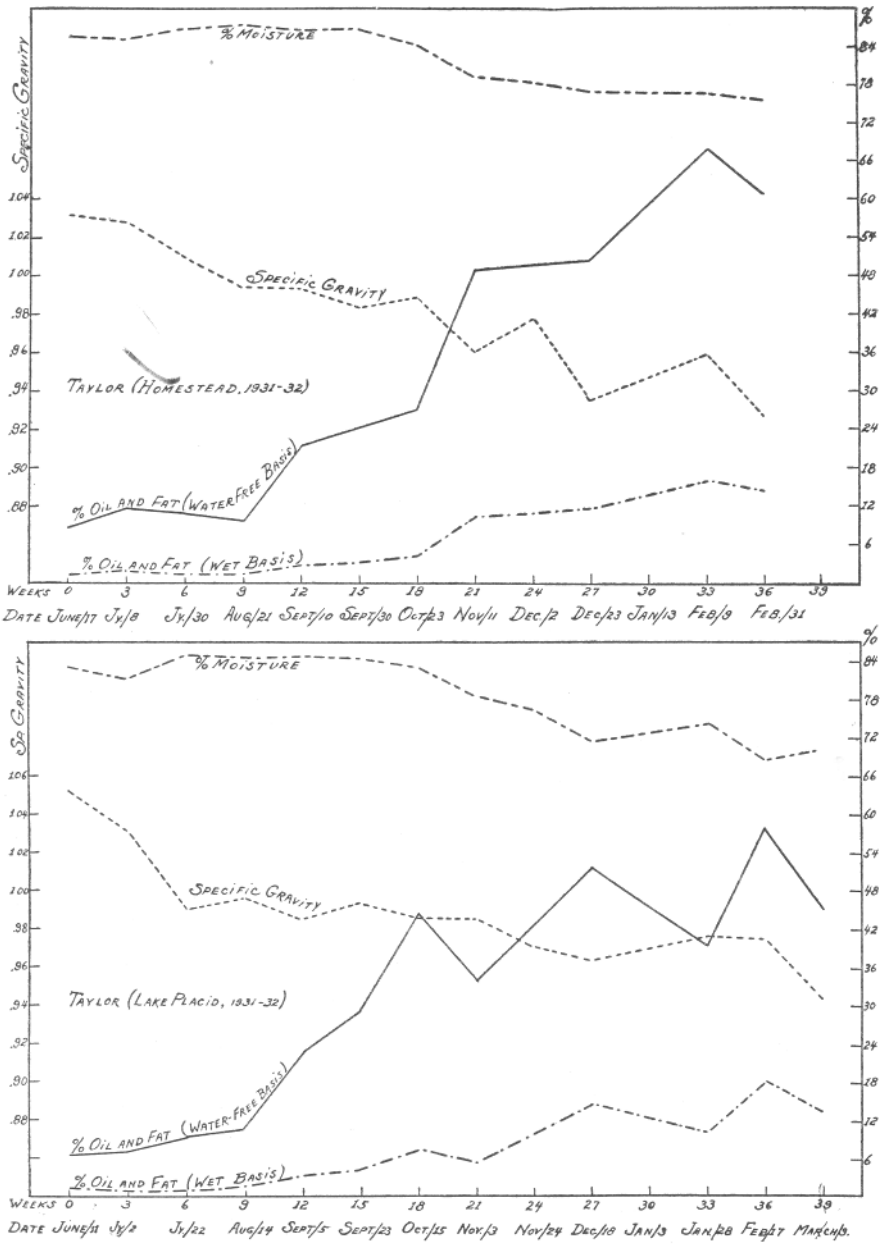

FIGURE 2. Graphical presentation of various characteristics of the Taylor avocado from Homestead and Lake Placid throughout the season of 1931-32.

A very definite correlation was found between the specific gravity, fat content and maturity. Specific gravity decreases with maturity while the fat content increases. In all of the varieties tested, this correlation was found, but it was not in the same proportion in each case. The specific gravity of the whole fruit, however, was not only affected by the increase in fat with maturity but many other factors. The moisture content is another factor which affects the specific gravity, but not to the extent that the fat content affects it. The lower the moisture content, the lower the specific gravity. Also the size of the

seed cavity and seed has a considerable effect on it. The amount of skin or peel present affects the specific gravity, as it varies in fruits of the same variety. In spite of all these variables, the specific gravity shows a uniform decrease with maturity and may prove an easy and practicable method for determination of maturity.

The West Indian varieties analyzed throughout the three seasons were Pollock, Waldin, Trapp and Simmonds. The Guatemalan varieties were Taylor, Linda, Schmidt, Wagner and Eagle Rock. The hybrid varieties analyzed were Collinson, Winslowson and Lula. Other varieties of less commercial importance were also analyzed. The data of these three seasons' analyses were compiled and presented in bulletin form. The values of the characteristics showing the closest correlations with maturity are graphically presented in this bulletin, which can be obtained from the Florida Experiment Station. Only a few of these graphical presentations will be presented here.

Figure 1 contains the graphs of values of the various characteristics of fruit of the Taylor variety from Homestead from April, when the fruit was very immature (5 grams), to March, when tree-ripened fruit was obtained for the season 1930-31, and from May to March from Lake Placid during the same season. Figure 2 is a similar graphical presentation of the values for these characteristics of Taylor fruit sampled from Homestead and Lake Placid from June to March during the 1931-3 season. The graphs of these two figures, representing values for the two avocado areas of Dade and Highlands Counties, are similar and show very little variation with regard to the physical and chemical characteristics throughout the life cycle, thus permitting them to be discussed under one head. Also, the similarity of the graphs representing the two seasons of 1930-31 and 1931-32 is such that they can be discussed under the same head.

The graphs representing moisture content show high moisture content for the immature fruits between 85 and 87 per cent, up to September and then gradually decreases with the maturity of the fruit, reaching 70 per cent or lower in the very mature fruit.

The moisture content of the fruit correlates itself with the rainfall, in that the heaviest rainfall occurred during the late spring and summer months, at which time the highest moisture content of the fruit occurred. Beginning with September, the amount of rainfall decreased and was low for the fall and winter months. The moisture content of the fruit likewise decreased. This correlation of decreasing rainfall with decreasing moisture content of the fruit occurred throughout the three seasons in which the fruit was sampled.

The graphs of Figures 1 and 2, representing per cent, fat (green basis) of the Taylor avocado, began low, showing a low fat content of 1 to 2 per cent, for the immature fruit and remaining at this low percentage until August, when the graphs take a decided upward trend, indicating an increase in fat content. This increase continues throughout the rest of the maturing period in a somewhat uniform manner after this decided increase has ceased and which is shown by the graphs to have occurred during August, September and October. Directly as this decided increase of fat ceased and the increase became uniformly slower, the fruit would ripen normally and could be called mature with regard to taste and composition. In the very mature fruit, the fat content was as high as 24 per cent, (green basis).

The graphs representing fat content, water-free basis, are very similar to those of the green basis, but show the effect of the moisture content upon percentage of other constituents, such as fat. They show the same general trend of increasing amounts of fat as do those representing fat, green basis, but not in the same proportion. While the graphs show the fat content to be 15 to 20 times as much in the mature as the immature fruits when shown on the green basis, they show only 8 to 10 times as much when the fat content is expressed on the water-free basis, thus indicating that the moisture content of the fruit must be taken into consideration when determining the fat content of avocados.

The graph representing specific gravity of the whole fruit is just the reverse of that for fat content, in that it begins high, indicating high specific gravity in the immature fruits (above 1.0). With the decided increase in fat during August, September and October, the specific gravity decreases to below .94 for the mature fruit, decreasing with increasing fat content. The graphs representing the specific gravity of the fruit sampled from the two growing areas and those for the different fruiting seasons are so similar in all respects that they are almost identical, with the exception of fruit and seasonal variations.

If the relationship of specific gravity to fruit maturity continues season after season as it has in the last three seasons of sampling and as it probably will, a very easy and quick test for maturity could be devised, using the specific gravity of the whole fruit as the maturity measure. In the case of the Taylors, it would be very easy to determine immature fruit, in that the very immature fruit with low fat content when placed in water would sink, the specific gravity being above 1.0, the fruit being heavier than an equal volume of water. Later on in the season when the fruit has the appearance of edible fruit, the specific gravity if tested would be above .98. According to the values represented in Figures 1 and 2, any Taylor fruit having a specific gravity of below .98 could be considered mature, for after this time the fruit would ripen normally and have the taste of well-matured fruit. At the time when the specific gravity of the whole fruit has reached .98 or below, the fat content has increased to 10 per cent or better, green basis. There is a uniform increase in fat thereafter and also an improvement in taste in the more mature fruit later in the season. The ability to determine picked fruit which would ripen normally from picked fruit which would not ripen normally would be a very valuable aid to the avocado industry. In the four graphs of specific gravity of Figures 1 and 2, the time when picked fruit ripened normally and could be considered mature was in November. This date may vary with varying climatic conditions. In all of the Taylor varieties tested, it was found that the specific gravity of .98 or lower for the whole fruit was always accompanied by a fat content of 10 per cent, or higher and the fruit would ripen normally and have the characteristic good flavor of mature fruits.

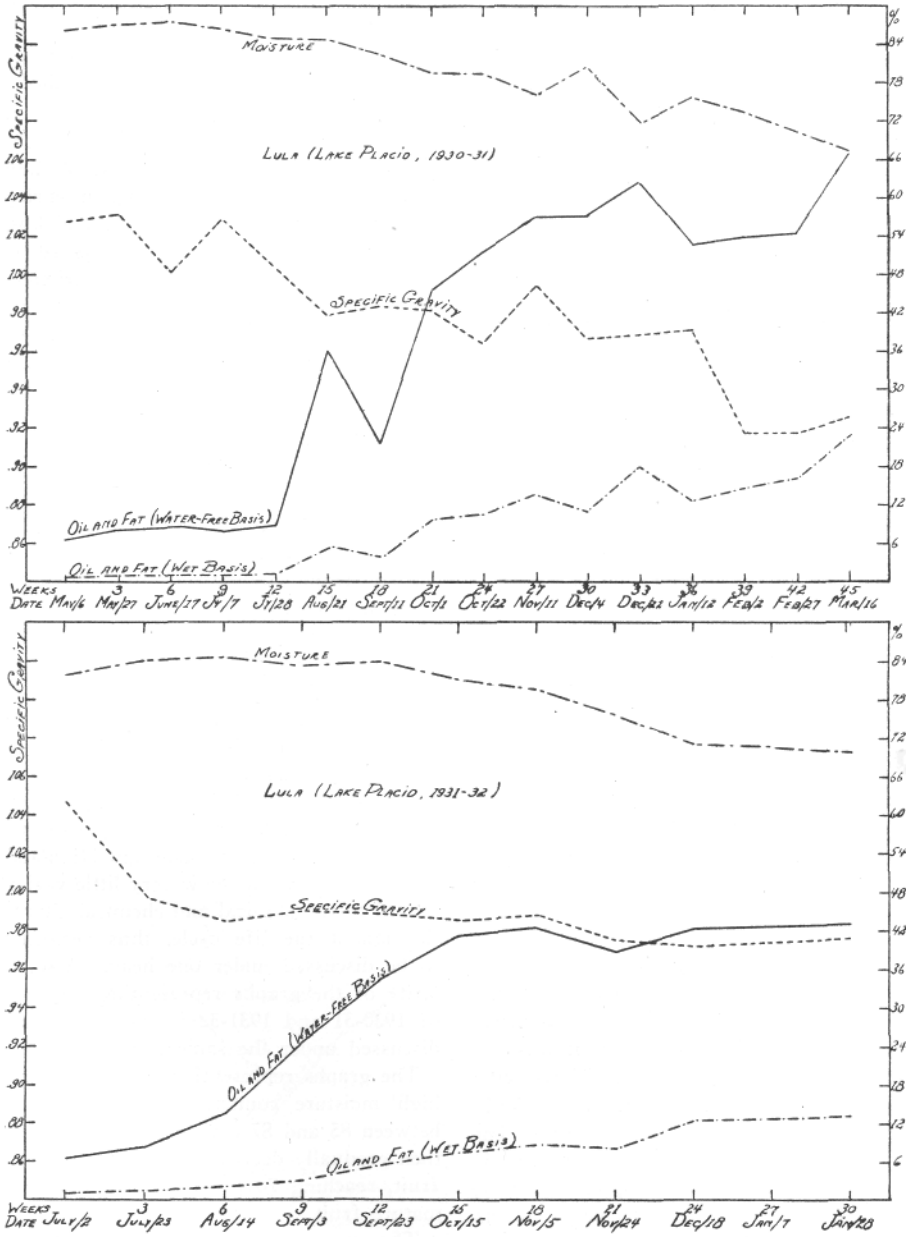

FIGURE 3. Graphical presentation of various characteristics of the Lula avocado from Lake Placid throughout the seasons of 1930-31 and 1931-32.

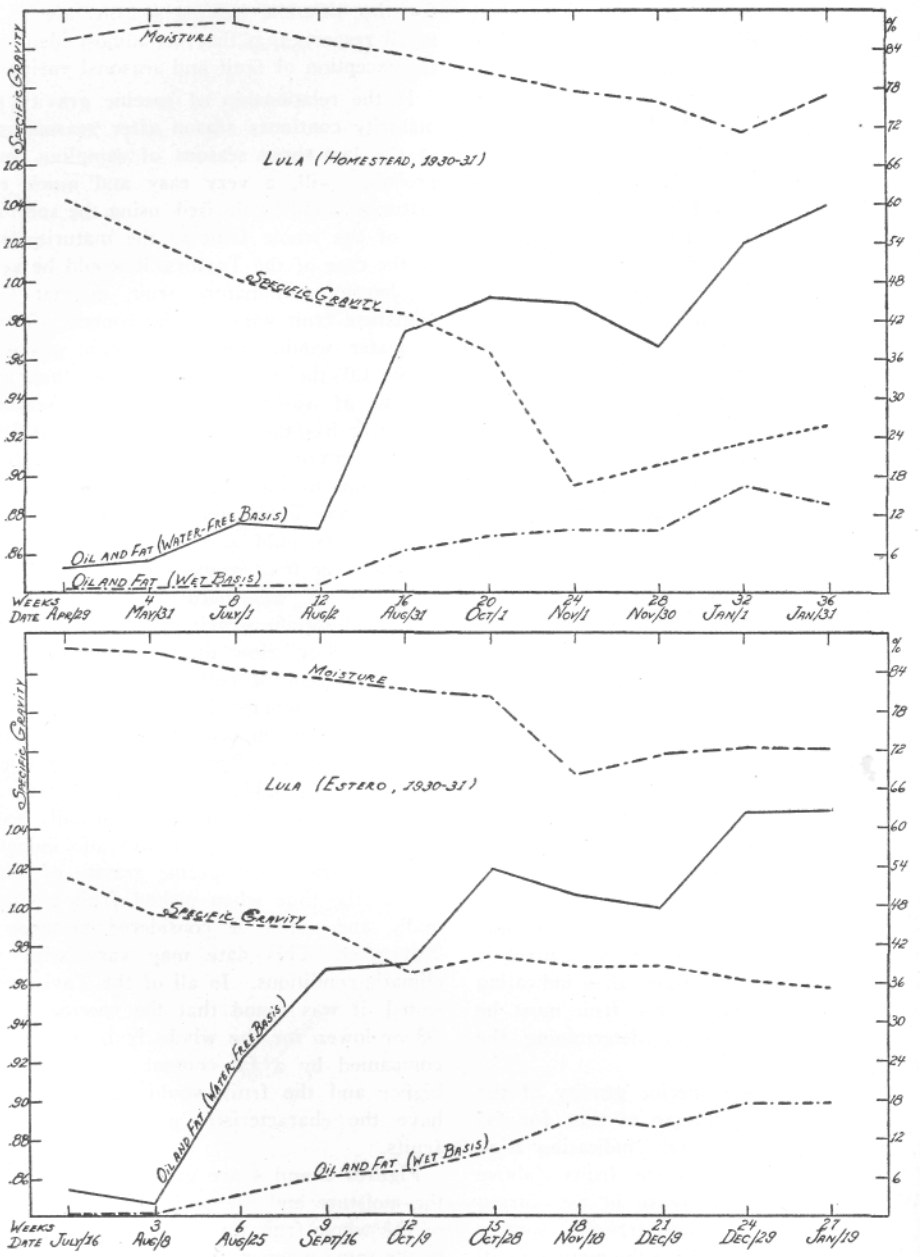

FIGURE 4. Graphical presentation of various characteristics of the Lula avocado from Homestead and Estero throughout the season of 1930-31.

Figures 3 and 4 are graphical presentations of the moisture and fat content and specific gravity of the whole fruit for the Lula avocado presented in the same manner as that of the Taylor variety in Figures 1 and 2. Graphs are shown in Figure 3 for the values for these characteristics for fruit sampled during the 1930-31 season from Dade and Lee Counties and in Figure 4 for 1930-31 and 1931-32 seasons from Highlands County. The graphs take the same general trends as do those of the Taylor variety; those for moisture indicating a decrease with maturity from above 85 per cent, to below 70 per cent., those for fat indicating an increase with fruit maturity from below 1 per cent, to

above 13 per cent., and those for specific gravity showing decrease with maturity, from above 1.1 to below 0.98.

From the values presented in the graphs of Figures 3 and 4, the various steps of fruit maturity can be followed. With regard to specific gravity as a measure of maturity, it can be used here as in the case of the Taylor variety, the very immature fruits, having a specific gravity of above 1.0, would sink if put in water, being heavier than an equal volume of water. According to the graphs, satisfactory maturity permitting normal ripening and fair taste quality is reached when the specific gravity of the whole fruit is below 0.98, which point is reached in October. The fat content at the corresponding time when this specific gravity of the fruit is reached is 8 per cent, or above. As in the case of the Taylors, the Lula improves in taste as it becomes more mature. It was not until November that the fruit was in optimum condition as to composition and taste and should not be harvested until this time unless necessary.

Figure 5 contains the graphs of various characteristics of the fruit of the Simmonds variety from Homestead and Lake Placid from June to October for the season 1931-32. The graphs are similar to those of the Taylor and Lula in that they indicate a decrease in moisture and specific gravity and an increase in fat with maturity. The graphs for moisture content do not show the decided decrease as in the case of the later maturing varieties of the Guatemalan race. The moisture content does not change to any extent until after the heavy summer rainfalls have ceased in September, and then only slightly. The West Indian varieties mature at this time, or shortly after this time, thus having very high moisture content at maturity. With the moisture content high and the life cycle short as compared to the Guatemalan and hybrid varieties, the West Indian varieties show lower fat content through-out the life cycle, especially when figured on the green basis, but show the same general increase with maturity. The graphs for specific gravity show a decrease with maturity, the very immature fruit having a specific gravity of above 1.0 and decreasing with maturity. After the fruit has reached a density of 0.96 or below, normal softening occurred and the ripe fruit had a favorable taste and could have been called mature. The fat content at this time was 3 per cent, or above, wet basis.

Satisfactory maturity occurred in all of the Guatemalan and hybrid varieties or late-maturing varieties when the specific gravity of the fruit became 0.98 or lower, and in the West Indian or early-maturing varieties when the specific gravity became 0.96 or lower, with the exception of the Waldin, in which case the specific gravity was still above 0.98 when fully mature as to taste, normal ripening and composition. The fat content at this time in the Guatemalan and hybrid varieties was two or three times that in the West Indian varieties.

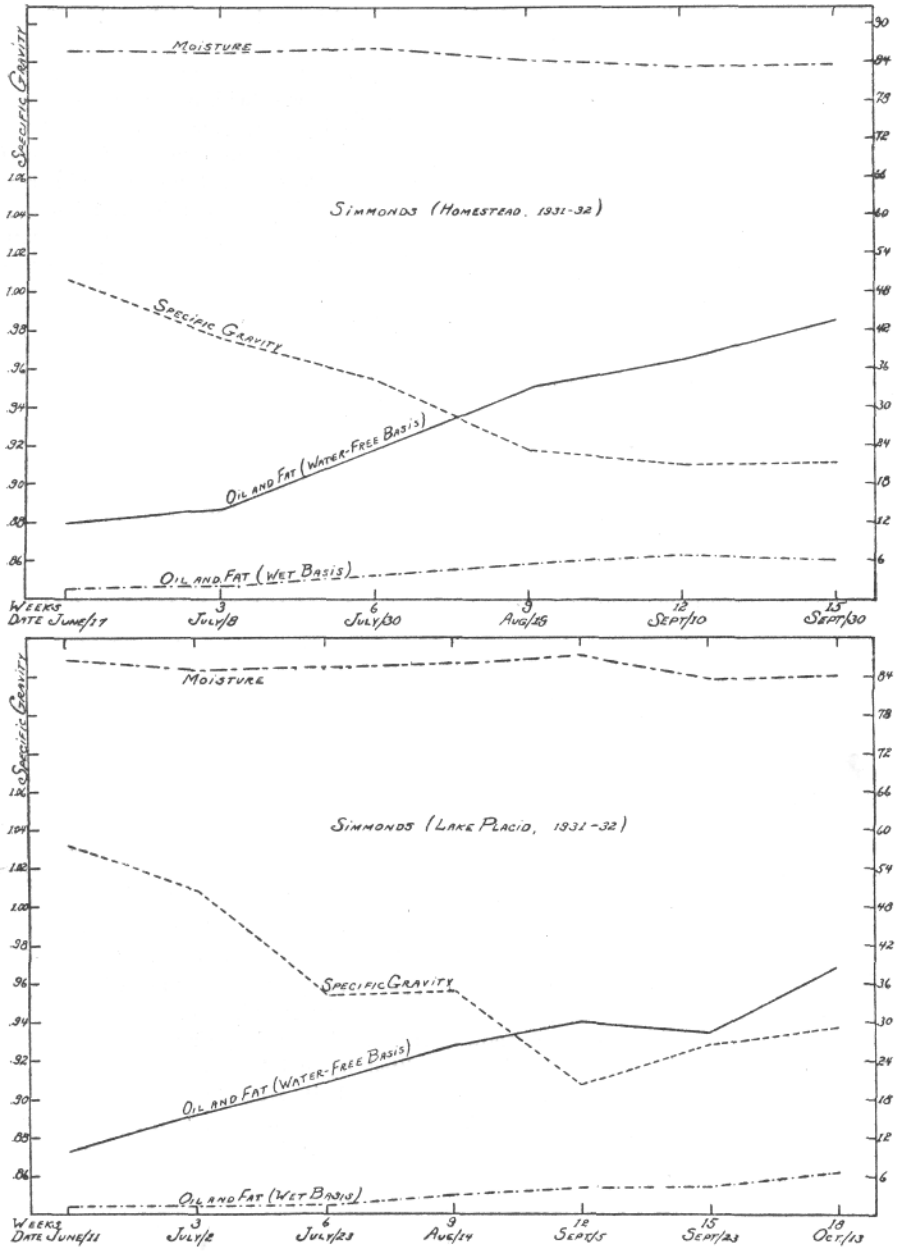

FIGURE 5. Graphical presentation of various characteristics of the Simmonds avocado from Homestead and Lake Placid throughout the season of 1931-32.

A complete compilation of the physical and chemical composition of Florida avocado varieties and the relationship of the changes in these characteristics to maturity are given in the Florida Agricultural Experiment Station Bulletin, "Changes in Composition of Florida Avocados in Relation to Maturity."

Mr. Brooks: These tests are not only to arrive at knowledge of the proper stage of maturity, but also in California they have a fat content law of 8 per cent., so one of our

very best Indian types when completely matured was not allowed to enter California. There are times when our fruit could get into California if they were permitted in, and have a ready market. California intimated if we were able to state when the proper stage was, and some test for it, there would be an inclination on their part to change their law. I was much interested in getting this information together, as Dr. Stahl has done. It's a matter of great importance and interest to the avocado growers. You have all known of the avocado plantings in different parts of the State, that is, from information disseminated by the newspapers, but I am sure there is one part of the State we have heard less about, and that is on the east shore of Lake Okeechobee. Paul Hoenshel has told us all about it.

Another question which is very important to avocado growers will be presented to you by a graduate of the University of Florida, who then went to work for Mr. Krome at Homestead. Later he went to California and took post-graduate work and has had considerable experience there—Mr. Leonard R. Toy. He will talk to you about "New and Promising Varieties of Avocados."