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# Biochemical Studies of the Fuerte Avocado Fruit—A Preliminary Report

**David Appleman and Lafayette Noda**
*University of California, Los Angeles*

## Introduction

This is a preliminary report on biochemical studies of the avocado fruit started in the fall of 1940, the purpose of which was to determine the progressive physical and chemical changes that take place in the fruit during growth and storage. At the same time, and to some degree with the same materials, Dr. P. M. Scott of the Botany Department undertook an investigation on the morphology and anatomy of the fruit, and Dr. J. B. Biale of the Division of Horticulture, a study of fruit respiration rates under various conditions of storage. It is hoped that these coordinated studies will yield information which will be helpful in providing a better understanding of the physiology of the avocado fruit, and that this in turn may lead to a better basis for determining the state of maturity of the fruit.

## Material and Methods

The present study was limited to the Fuerte variety. It is probable that later studies will include other commercial varieties.

The fruit was obtained from 4 large trees reserved for this study in an orchard in the Escondido district of San Diego County. Samples of at least 18 fruits were picked at two-week intervals and delivered to our laboratory. The samples were divided into two lots of 9 fruits each; one was worked up immediately, the other left in the laboratory a few days to soften. It was worked up when the fruit reached the edible stage. The following determinations were made on each sample.

1. Specific gravity was determined by weighing the material in air and in water. These determinations were made on each whole fruit. The fruit was then cut in half and the specific gravity determined, separately on the seed and the pericarp.

2. Moisture and oil content were determined on small representative samples taken with a cork borer. These were dried to constant weight in a vacuum oven at 50° C. The oil was completely extracted from the dry material with ether, the ether evaporated off and the oil weighed.

In order to obtain oil for chemical studies a large composite sample (approximately half of the total fruit) was grated on an ordinary food grater and spread in thin layers on enamel pans and placed in an air circulating oven at 40° C. for 6 hours. This removed the bulk of the water. The incompletely dried pulp was then placed in a 50° C. vacuum

oven through which preheated carbon dioxide was slowly passed. After about 6 hours the avocado pulp was removed and the oil expressed in a hydraulic press, with pressures up to 400 kg./cm$^2$ (5700 lbs./sq. in.). The oil was filtered through a sintered glass filter in order to remove particles of tissue. The yield varied from 70% in the first hard samples to 90% in the last soft samples. All determinations listed below were made on the oil so obtained.

a. Iodine number (Hanus method)

b. Thiocyanogen number

c. Saponiflcation number

d. Hydroxyl number (1)

e. Refractive index

**Discussion of Results**

At the outset it should be emphasized that avocado fruits are highly variable. Even though the fruits are uniform in size and appearance they may still be in different stages of physiological development. This is undoubtedly due to the fact that the fruit sets over an extended period of time. Several workers (2), (3) have reported data based on samples ranging from 1 to 6 fruits. It is our belief that although the samples consisted of a minimum of 9 fruits the sampling error was still considerable. The data here reported should be considered therefore, indicative of the trends shown by the smooth curves in the figures.

Since the results obtained with fruit that had been set aside to soften indicated the same trends as with the hard fruit the data will not be reported in detail. The specific gravity of the whole fruits and of the pericarp of softened avocados were respectively .01-.02 and .015-.03 units higher than that of the hard fruits. The oil content of softened fruit was 1-8% higher than hard fruit picked at the same time. The refractive index and iodine number of the oil from hard and softened fruits picked at the same time were about the same.

In respect to specific gravity of the whole fruit our data are in agreement with the findings of Church and Chace.(3) Our observations indicate that the large variability in specific gravity of the whole fruit is due to (1) the variability in proportion of seed to pericarp—the seed varies between 9% and 27% of the weight of the whole fruit, (2) seeds that fit loosely in the cavity, and (3) variation in density of the component parts of the fruit.

Stahl (2), working with several varieties in Florida, including Fuerte, found that the specific gravity of the whole fruit decreases regularly as the fruit matures, and he suggested that this may be used as a criterion of maturity. While we find a general downward trend in the specific gravity of Fuerte fruit, (See fig. 1) the variability between individual fruits of any single sample is so great that the use of specific gravity of the whole fruit as a measure of maturity has doubtful value.

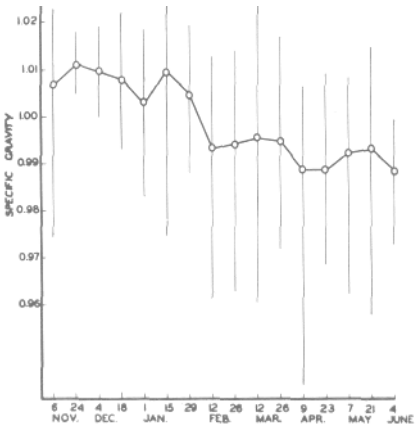


FIG. 1

Changes in the specific gravity of the whole fruit of the Fuerte avocado. The vertical lines indicate the range of variability in a sample of nine fruits.

The specific gravity of the pericarp (fig. 2) shows a more consistent trend, also the variability of individual fruit within each sample is much less than in the whole fruit. This fact affords some promise as a possible aid in determining fruit maturity.

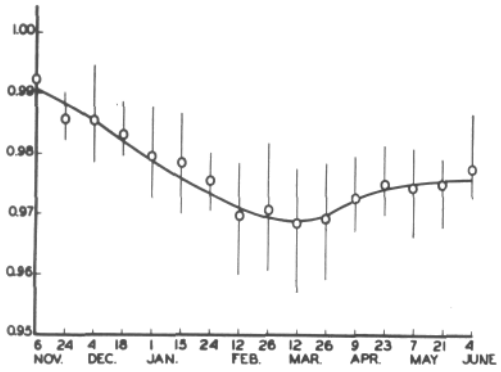


FIG. 2

Changes in the specific gravity of the pericarp of the Fuerte avocado. The vertical lines indicate the range of variability in sample of nine fruits.

The specific gravity of the seed is so variable as to be valueless, and hence is not reported.

The relationship between fresh weight of fruit and grams of oil per fruit is shown in figure 3. It is evident that as the weight of the fruit increases the total oil increases. The percentage oil (fig. 4), either on fresh or dry basis, increased regularly until early in March, then it either remained constant or increased slowly. The per cent moisture (fig. 4), in the fruit likewise decreased regularly until March and then remained constant.

Of the various constants determined on the oil only the iodine number* and the refractive index will be discussed here. The other values are of a more theoretical nature and will be published elsewhere.

- Iodine number is a measure of drying property of oil. It is defined as grams of

iodine absorbed by 100 grams of oil.

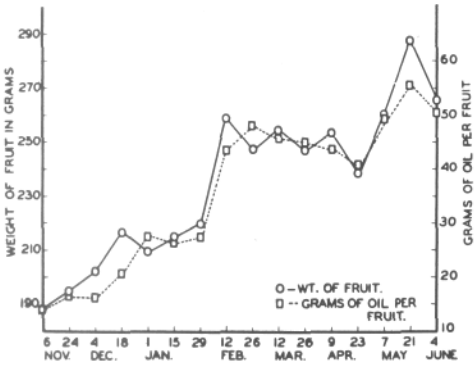


FIG. 3

Changes in weight of fruit and in oil content of the Fuerte avocado.

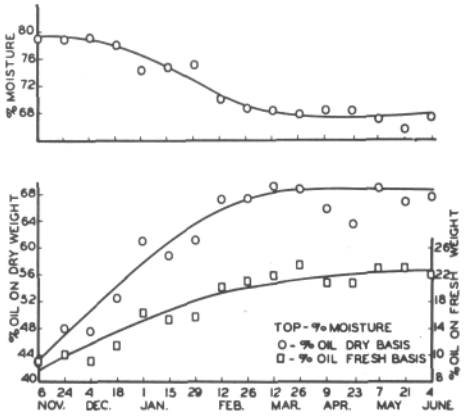


FIG. 4

Changes in moisture and in oil content of the Fuerte avocado fruit.

The iodine number (fig. 5), started at about 103 and decreased continuously, reaching a minimum of 94 early in March. Then it rose again to about 96. The index of refraction of the oil (fig. 6), remained re-markedly constant throughout the season (November to June). It should be noted in passing that this observed constancy of refractive index of the oil of the avocado at various stages of maturity lends support to the accuracy of the refractometric method of Lesley and Christie (4) for determining the per cent oil in avocado flesh.

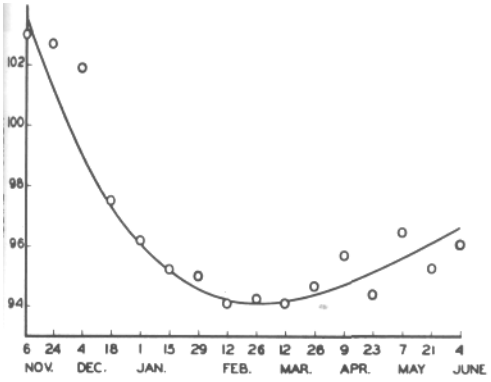


FIG. 5

Changes in iodine number of Fuerte avocado oil.

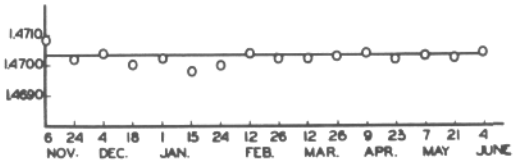


FIG. 6

Refractive index of Fuerte avocado oil at 20° C.

The index of refraction is not a simple function of the iodine number but is a function of both the degree of unsaturation and the length of chain of the fatty acids in the oils. Since the determination of the index of refraction by means of an Abbe refractometer is reliable, and so is the iodine number determination, it is probable that there are factors which compensate for the expected change of refractive index with the change in iodine number. These we hope to investigate more fully in the future

**Summary**

In summary it may be stated that in general the Fuerte avocado in the Escondido region reaches full physiological development between the middle of February and the middle of March. At that stage the fruit has reached its maximum oil content and minimum water content. The changes in trend of some of the properties of the oil and probably of other constituents occur at this time. The consistent trend in the specific gravity of the pericarp, as well as the constancy of the index of refraction of the oil, may be useful as an indication of the state of development of the fruit.

Some preliminary work has been done on the changes in the carbohydrates of the avocado fruit which we expect to follow-up during the coming season.

1. E. S. West, C. L. Hoaglaiid and G. L. Curtis. J. Biol. Chem. 104, 627-634 (1934).
2. A. L. Stahl, Fla. Agr. Exp. Station Bull. 269. (May, 1933).
3. C. G. Church and E. M. Chace, U.S.D.A. Bull. 1073 (1922).
4. B. E. Lesley and A. W. Christie, J. Ind. Ad. Eng. Chem. (anal. Ed.1 1: 24 (1929).

We wish to thank Calavo Growers of California, for supplying us with the fruits, which were picked at their expense by one of their experienced field men.