Summary

The temperature has a considerable effect on the rate of extraction of crude oils from vegetable oil seeds with solvents. Quantitative data have been presented relating extraction rate and temperature for soybeans, cottonseed, and flaxseed extracted with several solvents. These data were obtained by the Percolation Method, modified where necessary.

Since no satisfactory theoretical basis for correlation could be established, the results were correlated empirically. For all practical purposes the time in minutes required to reduce the oil seed to 1.0% residual oil content on a dry basis varied inversely with the square of the extraction temperature in degrees Fahrenheit.

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Oil Production From African Oil Palms in Honduras

E. O. REIF, United Fruit Company, Tropical Research Department, Tela Railroad Company, La Lima, Honduras, C. A.

THE search for new crops for Latin America and the world shortage of edible oils led to an investigation, commencing in 1942, of the possibilities of producing palm oil in Honduras. Large areas of land were available where both soil and climatic conditions were considered satisfactory for development of this important crop.

A collection of African oil palm varieties comprising the following selections was available in the Plant Introduction Garden of the United Fruit Company at Lancetilla, Honduras:

Variety	Origin
Reinking No. 7-C-1	Java
Reinking No. 8-C-1	Java
Reinking No. 32-B-3	Java
Reinking No. 19	Federated Malay States
Reinking No. 33	Federated Malay States
Reinking No. 51	Federated Malay States
Fairchild No. 1192	Africa (Diwakkawakka)
Sumatra	Sumatra (U. S. Rubber Co.)

This planting of selected strains from the East Indies, Malay States, and West Africa was made in 1926. In 1942 the stand included 60 palms of Java variety, 137 from Malaya, 43 from Africa, and 200 of Sumatra varieties. Fruit from these palms was observed and compared over a period of two years in order to select the highest variety for propagation.

Processing methods and yields per acre were studied over a period of five years in a pilot plant at La Lima, Honduras, utilizing fruit from a 23-acre farm, established in the years 1936 to 1938 by a local planter with mixed seed.

Varietal Studies

Mature fruit was harvested monthly from individual palms in the Lancetilla collection and their weights were recorded. Due to age and crowded condition of this planting, yield figures are not necessarily indicative of production under more favorable circumstances, but the difference between varieties was quite evident (Table I). The number of fruit bunches harvested annually per palm varied from four to seven. The largest bunch harvested was of the Java variety and weighed 124 lb.

TABLE I

Number and Weight of Fruit Bunches From Mature Palms

Variety	Harvested	Average weight per bunch in lb.
Java	104	45.8
Sumatra	218	45.4
Malay	102	38.8
Africa*	5	24.6

* One bunch only.

Over a period of two years one bunch of mature fruit of each variety was analyzed monthly for yield of palm and kernel oil. The Java variety was the highest producer of both palm and kernel oil per bunch and also gave the highest average field weight per bunch (Table II).

TABLE II

Yield Data of Representative Bunches of Three Palm Varieties (In Pounds)

	Java		Sumatra		Malay	
	Range	Average	Range	Average	Range	Average
Gross weight per bunch	37-96	59	34-87	53	30-93	47
Net weight fruit	28-62	42	28-57	32	21-54	31
Palm oil	5.2-17.7	8.3	3.6-14.9	7.2	2.4-10.5	6.1
Kernel oil	1.0- 3.8	1.9	1.0- 2.8	1.4	.5- 2.6	1.2

These varieties of oil palms were also classified as to the percentage of oil contained in the pericarp and kernel; by the weight of fruit, pericarp, and kernel; and by the thickness of pericarp and shell. Samples from identical fruit used in the yield studies were

TABLE III

Analysis of Varieties of Honduras Palm Fruit in Comparison With "Deli" Type Fruit From East Indies

Composition	Variety			
	Java	Sumatra	Malay	"Deli"*
Oil in pericarp, %	37.3-57.0	36.7-52.9	21.3-50.7	41-42
Oil in kernel, %	38.8-52.7	38.7-52.4	28.6-51.9	40-50
Thickness of pericarp, mm	2.6-5	2.4-5	3.0- 4.5	2- 5
Thickness of shell, mm	2.2-4	2.2-4	2.6- 3.5	2- 5
Weight of 1 fruit, g	10.6-15.5	9.8-15.3	9.5-14	11-14.5
Weight of 1 kernel, g	0.8- 2.1	0.8- 2.1	0.8- 1.2	Variable
Shell to whole fruit, %	32.7-42.6	32.8-43.8	26.4-49.3	30-40
Pericarp to whole fruit, %	49.6-62.9	48.4-62.1	39.8-62.6	43-73
Kernel to whole fruit, %	7.8-12.5	7.0-12.6	5.2-12.0	Variable

* From "Varieties of Oil Palm," by Cocil Yampolsky, A.V.R.O.S., Medan, N. I.

employed in these analyses with a view to rating them for seasonal or other variations. Results of this work (Table III) indicate that the Java and Sumatra varieties in the Lancetilla collection can be placed in the superior "Deli" type, known in the East as *Elaeis guineensis* form "dura," Baccari. All palms of this type were propagated by the Dutch from a few superior selected plants and the preponderance of the same or closely related types in the large plantings in the East Indies indicate their inherent stability. The Sumatra variety can be classified as average "Deli" type palm while the Java type seems to be a superior strain of "Deli."

Varieties with only a single kernel in the nut are considered more desirable in regard to mechanical cracking. In this respect the Java variety is considerably better than any other (Table IV).

TABLE IV

Percentage of Nuts With Single and Multiple Kernels (Average of 24 Bunches)

Number of kernels	Variety		
	Java	Sumatra	Malay
1	96	66	79
2	4	33	20
3	....	1	1

Free Fatty Acids in Palm Oil

An oil-splitting enzyme is present in the pericarp of the palm fruit which becomes active when the exocarp is broken and causes decomposition of the palm oil into free fatty acids and glycerol. This oil-splitting enzyme can be destroyed by heating the fruit (1). It is customary in the factory processing of palm fruit to sterilize the bunches at a steam pressure of 30 p.s.i. for from 45-60 minutes. This heat treatment of the fruit not only destroys the enzyme but also facilitates the subsequent stripping of the fruit from the stalk. No information was available regarding the period which may be allowed to elapse between harvesting and sterilization of palm fruit, which determines the amount of free fatty acids in the oil. For this reason the fruit was brought to the laboratory from six to 36 hours after harvesting and sterilized in an autoclave for 15 minutes at a steam pressure of 30 p.s.i. The oil was then extracted with solvents 20 to 94 hours after sterilization, and the free fatty acids were determined by the A.O.C.S. method. Some of the bunches were intentionally bruised at the time of harvesting, and other samples for investigation were selected from sound fruit. Less than 1.5% of free fatty acid was found in the oil of sound fruit which was sterilized from six to 23 hours after harvesting. Oil from bruised fruit had a higher percentage of free fatty acid, with one sample exceptionally high (14.74% at 23 hours). Fruit brought to the laboratory from the pilot plant yielded an oil of surprisingly low free fatty acid content, although the interval between harvest and sterilization was 24 hours (Table V).

TABLE V

Effect of Holding Fruit After Harvest on Free Fatty Acids in Pericarp

Hours between harvest and sterilization	Free fatty acids as palmitic, %				
	Sound fruit[1]	Sound fruit[2]	Bruised fruit[2]	Sound fruit[3]	Bruised fruit[3]
6	0.31-0.35	0.47-0.72	3.29- 5.09	1.44	.....
12	.....	0.12-0.73	1.10- 6.56	2.00	.....
23	.....	0.27-1.48	2.58-14.74	.....	.....
24	.....	.....	.....	2.94	3.65
36	7.43	.....	.....	.....	.....
46	.....	0.82-0.90	2.20- 4.19	.....	.....

[1] Small fruits not completely mature from palms 51 months old. Transportation: Truck for three miles.
[2] Mature fruits from old palms at Lancetilla. Transportation: Railroad motorcar for 60 miles.
[3] Fruits from Birichiche Plantation. Transportation: Railroad for 40 miles.
NOTE: Kernel oil made from seeds of sterilized fruits had a free fatty acid content of between 0.85 to 1.1% as lauric acid.

Palm oil suitable for the tin plating industry should not have more than 7.5% free fatty acid. For human consumption an oil containing up to 5% free fatty acid can easily be refined. A higher percentage of free fatty acid would cause excessive loss of oil and higher refining costs.

This investigation proves that commercially harvested mature fruit can be sterilized up to 24 hours after harvest without deterioration of the quality of the oil; that bruising of fruit should be avoided as much as possible; and only completely mature fruit should be harvested if sterilization is to be delayed.

Plantation Yield

From 1944 to 1948 the entire crop of palm fruit from a private plantation was processed in a pilot plant at La Lima. The yield of palm oil per acre was lower than expected. Solvent extraction of the fruit in the laboratory proved that the hydraulic press which was used in the pilot plant operated at an efficiency of only 71.2%. Moreover a botanical investigation of the plantation revealed that a large percentage of the palms were of the low-yielding African types and there were comparatively few of the improved Far Eastern strains. The highest annual yield of palm oil per acre was 2,364 pounds and the lowest 1,338 pounds. The lower yield of oil per acre during the last three years of the investigation was due to a prolonged drought together with reduced yields of younger palms as more acreage came into production (Table VI).

TABLE VI

Plantation Yield of Pericarp Oil Per Acre Per Year[1]

Number of bunches	10,074	11,172	10,115	9,949	9,923
Net weight of fruit, lb	209,055	263,534	237,519	221,425	197,165
Weight of fruit per bunch, lb	20.75	23.58	20.75	22.20	19.86
Total yield of palm oil, lb	35,139	42,556	32,993	32,703	30,794
Yield of palm oil per bunch, lb	3.5	3.8	3.3	3.3	3.1
Palm oil to fruit, %	16.8	16.1	13.9	14.7	15.6
Acres in production	16	18	18	23	23
Palm oil per acre, lb	2,196	2,364	1,833	1,421	1,338
Bunches per acre	629	620	562	432	431
Fruit per acre, lb	13,065	14,640	13,195	9,627	8,572

[1] The plantation was planted in the years 1936 to 1938.

African oil palms produce fruit throughout the year, but there is a peak season from July to October when an average of 68.3% of the fruit matures.

Composition of Palm Fruit

In order to determine the amount of fuel available for generating steam from the waste after processing of palm oil and palm kernels, six experimental pilot plant extractions, each of exactly one ton of fruit, were undertaken and weights recorded. Six tons of fruit bunches yielded 8,712 pounds of loose fruit which on processing yielded 2,400 pounds of crude pericarp oil, 1,854 pounds of pericarp waste, and 4,068 pounds of nuts containing 834 pounds of kernels and 3,225 pounds of shells. From the known b.t.u. value of the pericarp and shell waste it was calculated that five times as many boiler horse power are available from the waste fuel as is required for the necessary processing steam.

Summary

The behavior of African oil palms in Honduras was studied with the view of establishing it as an economic crop in Central America. The highest yielding variety for this region was determined to be the Java variety. The influence of post-harvest handling of fruit on the formation of free fatty acids in palm oil was investigated. Actual plantation yields were obtained by processing plantation-produced fruit.

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The Infrared Spectra of Saturated Fatty Acids With Even Number of Carbon Atoms From Caproic, C_6 (Hexanoic), to Stearic, C_{18} (Octadecanoic), and of Their Methyl and Ethyl Esters[1]

ROBERT T. O'CONNOR, ELSIE T. FIELD, and W. SIDNEY SINGLETON,
Southern Regional Research Laboratory,[2] New Orleans, Louisiana

BEFORE many successful applications of infrared spectroscopy to fatty acid and vegetable oil chemistry can be made, extensive spectral data on a large number of pure reference compounds will be required. Heretofore the scant spectral data available on fatty acids, esters, and triglycerides have consisted either of measurements made over a very limited range of the infrared spectrum or have been obtained with compounds of undescribed purity.

Markley (12), reviewing the application of infrared spectrophotometry to fatty acid chemistry, refers to work of Barnes *et al.* (2), of McCutcheon *et al.* (13), and of Gamble and Barnett (7). Barnes and his co-workers (2) include, in a library of reference curves, infrared spectral data on several fatty acids and vegetable oils, measured however only over the region 5 to 13 microns. Some of their compounds were, admittedly, not of highest purity. McCutcheon *et al.* (13), investigating cis and trans isomers, measured only the region of the C=C absorption band at about 6 microns. This vibration band, arising from C=C stretching vibration, is very weak and is masked by the intense C=O band at 5.8 microns. Gamble and Barnett (7) measured a few fatty acid esters and drying oils over the region 1 to 15 microns, but most of their curves include only the region 5 to 15 microns. These authors made some vibration band correlations with molecular structure. None of these studies reports any quantitative data.

To this brief list of studies of the infrared spectral properties of fatty acids should be added the work on deuterium-substituted fatty acids in the vapor phase by Herman and Hofstadter (8) and the more recent work of Rao and Daubert (15), of Honn, Bezman, and Daubert (10), and of Lemon and Cross (11). These latter papers, in particular, indicate the possibilities of utilizing infrared spectral properties for analytical purposes.

After the work to be described in this communication was well under way, Shreve, Heether, Knight, and Swern presented infrared absorption data on a number of long chain saturated and mono-unsaturated fatty acids, methyl esters, and alcohols (19). Their data constitute the most complete study of the infrared spectral properties of fatty acids and esters which has yet been described. As a result of their observations, they have proposed an analytical method, based on infrared spectrophotometry, for the quantitative determination of trans isomers of mono-unsaturated acids and esters in the presence of the cis isomers and of saturated compounds (20). Comparisons of the method with the Twitchell lead salt-alcohol method for the determination of trans acids and esters have also been described (21).

To achieve a satisfactory degree of accuracy in quantitative analysis, measurements of infrared spectra will, very probably, have to be made on solutions of the material to be analyzed by the so-called differential analysis method (17). This method is the procedure universally employed for quantitative measurements in the ultraviolet region. With the infrared spectrophotometer adjusted to correspond to 100% and the beam passing through the solvent cell, the slit width and the gain are adjusted until a null reading is obtained on the output meter. Then the cell containing the absorbing specimen is shifted into the beam and the potentiometer is adjusted until a null reading is again obtained. The percentage transmission and/or optical density at the wavelength in question is read directly from the scale.

[1] Presented before the 1950 Fall Meeting of the American Oil Chemists' Society, San Francisco, California.

[2] One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture.