BEN (MORINGA) SEED OIL

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BEN oil is obtained from the seeds of the tree Moringa oleifera belonging to the Moringacease family which contains only two other species. This tree which is indigenous to Arabia, India and Syria, was introduced many years ago into many tropical and semi-tropical regions including Central and South America and the West Indies. Early records state that in 1784 the tree was established in the vicinity of Kingston, Jamaica, by Hinton East. Also, it may be mentioned that this species is widely distributed in the Philippines. In India and elsewhere, it has long been known as the horse-radish tree on account of the flavor of the roots and is sometimes used as a substitute for horse-radish. The soft white wood of the tree when freshly cut has the same characteristic odor and taste. As this investigation deals with seed from Haiti, it should be noted that the tree or its oil is much interest is being shown there in the production of this oil.

The tree is a rapid grower even in poor soil and is said to be little affected by drought. It grows to a height of about 30 feet. The leaves are alternate, 25 to 50 centimeters long, and two or three pinnate, with an odd leaflet. There are 3 to 9 leaflets on the ultimate pinnules. The showy flower clusters occur as auxillary solitary panicles. The petals of these hermaphrodite irregular flowers are white with a yellow tinge, touched with crimson on the outside near the base, as is the case with the white calyx. The three-angled or cornered nine-ribbed slender pods range in length from 15 to 30 centimeters. These contain about 20 seeds which are three angled and winged on the angles. The wings have a ruffle-like appearance. The seeds weigh from about 0.3 to about 0.5 grams.

The oil was first studied many years ago, but about 1847 A. Völcker (cf. A. Strecker, Liebigs Annalen der Chemie *64*, 342 (1847), isolated a high melting acid which he named behenic. He also obtained a very small quantity of an acid with a higher melting point, which evidently was lignoceric acid and which was found to be a constituent of ben oil during the investigation to be described. The other acid constituents of the oil found by former investigators were oleic, palmitic and stearic acids. Some of the more important characteristics of the oil previously reported are as follows:

Iodine number 67.7 to 72.2
Saponification value 186 to 187.7
Refractive index at 25° 1.4668
Acid value 0.9 to 2.3 per cent.
Unsaponifiable matter 0.9 per cent.

For those not acquainted with the oil, mention may be made that in India and in some other countries, it is used for cooking, as a cosmetic, and for the extraction of perfume from flowers. Years ago in Jamaica the oil was used as a lubricant, particularly for watches. The press cake or meal, owing to its strong disagreeable bitter taste, is only usable as a fertilizer material.

For this investigation 34 pounds of seeds were received from Geoges Heraux, Chief Agronomist, National Agricultural Service of Republic of Haiti. The seeds averaged about 0.3 gram in weight. They consisted of 73.8 per cent of kernels and 26.2 per cent of shells. The kernels contained 5.1 per cent of moisture and 37.7 per cent of oil.

(A small sample of seed previously received from Nicaragua was examined. The seeds consisted of 70.7 per cent of kernel and 29.3 per cent of shells. The kernels contained 5.4 per cent of moisture and 49.2 per cent of oil. The oil gave an iodine number (Hanus) of 66.2 and a saponification value of 186.7, and contained 22.6 per cent of saturated acids.)

The oil was expressed from the seed (half of which had been decorticated) by means of the expeller. A brilliant yellow oil was obtained which has a characteristic slight pleasant taste. The more important chemical and physical characteristics of the oil are given in Table I.

Table I — Chemical and Physical Characteristics

Refractive index at 25°C.	1.4631
Iodine number (Hanus)	68.02
Saponification value	186.4
Acid value	0.74
Unsaponifiable matter, %	1.50
Saturated acids, %	22.38
Unsaturated acids, %	71.82

Unsaturated Acids

The percentages of oleic and linoleic acids were calculated using the iodine number and the quantity of unsaturated acids present in the oil. The calculated proportions of each of the unsaturated acids are given in Table II.

Table II — Unsaturated Acids

Acids	Per Cent	Per Cent in Oil
Oleic	94.75	68.05
Linoleic	5.25	3.77
	100.00	71.82

Saturated Acids

The saturated acids separated from the saponified oil by the lead-salt ether method were esterified with anhydrous ethyl alcohol in the presence of dry hydrogen chloride [J. Amer. Soc., *42*, 1200 (1920)] The ethyl esters which amounted to 57 grams, after being freed from solvent and moisture, were fractionally distilled at one millimeter pressure. Five fractions were obtained and the compostion of each one was determined by the methods which have been previously described. (J. Amer. Chem. Soc., *46*, 775 (1924)).

The acids were recovered from portions of each of the ester fractions of the entire very small undistilled ester residue (0.400 g.) by saponifying them with alcoholic potash and decomposing the soaps with hydrochloric acid. The acids were completely separated from potassium chloride and any free hydrochloric acid by remelting them with hot distilled water in the usual manner. In each case, the acids were then subjected to fractional crystallization from ethyl alcohol, and the identity of each of the acids so obtained was determined in the usual manner.

After finding that there was a notable quantity of myristic acid in the first ester fraction, it became desirable to examine the unsatu-

rated acid fraction in order to determine the quantity of this acid it contained, owing to the solubility of lead myrstate in cold ether. Fifty-nine grams of the ethyl esters of the unsaturated acid fraction were prepared and distilled under one millimeter pressure. As was expected, all of the myristic acid was found in the first fraction collected. In this connection, it should be mentioned that no measurable quantities of other saturated acids of higher molecular weight were found in these distilled ester fractions.

The final results which were calculated from the various analytical data obtained are given in Table III.

Table III — Saturated Acids

Acids	Per Cent	Per Cent In Oil
Myristic	6.85	1.53
Palmitic	16.03	3.59
Stearic	48.42	10.84
Behenic	28.10	6.29
Lignoceric	0.60	0.13
	100.00	23.38

It may be of some interest to mention that the behenic acid finally obtained by repeated recrystallization from ethyl alcohol melted at 79.5° C. Also, in so far as could be determined, all of the lignoceric acid which was found, was in the small residue of undistilled ethyl esters.

The composition of the oil in terms of glycerides is given in Table IV.

Table IV — Glycerides of

Acids	Per Cent in Oil
Myristic	1.6
Palmitic	3.8
Stearic	11.3
Behenic	6.5
Lignoceric	0.14
Oleic	71.1
Linoleic	3.9

SUMMARY

A brief description of the tree Moringa oleifera, flowers and fruits has been given. The oil expressed from seed produced in Haiti, the subject of this investigation, gave the following characteristics:

Refractive index at 25° C. 1.4671
Iodine number (Hanus) 68
Saponification value 186.4
Acid value 0.74
Unsaponifiable matter 1.5 per cent.

The results indicated that the oil contained 68.9% oleic acid, 3.8% of linoleic acid, 1.5% myristic acid, 3.6 % palmitic acid, 10.8% stearic acid, 6.3% behenic acid, and 0.13% lignoceric acid.

An Hypothesis Concerning The Role of The Enzymes in the Relative Value of Cottonseed

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THOSE of you who analyzed cottonseed grown in the Mississippi Valley during the season of 1937-38, as well as those of you who came into contact with the refining of the oil produced in that section of the Cotton Belt, will not have to be told that the crop of cottonseed produced in that section that season was probably without precedent not only because of the intensity of deterioration that had taken place but also because of the extensive territory in which deterioration appeared in the seed. In Mississippi, for instance, 46 percent of the shipments during October had excesses of free fatty acids; during November, 76 percent; during December, 85 percent; January, 91 percent; and during February, 94 percent of the shipments contained excesses of f. f. a. The maximum and average f. f. a. contents during these months were 21.5 percent and 3.29 percent respectively, in October; 17.5 percent and 4.42 percent in November; 20.5 percent and 5.29 percent in December; 35.0 percent and 8.30 percent in January; and in February, 2449 shipments with a maximum of 38.0 percent and an average f. f. a. content of 12.40 percent, were received at the oil mills.

While we have no facilities for a direct study of the question of the generation of f. f. a., it occurred to me that something might be discovered by an analysis of the seed analysis records.

For the purpose of studying the question of the generation of f. f. a. I first examined the analyses of Mississippi Delta seed that were graded during December 1936. Among these there were 386 analyses in which the moisture content ranged from 12.2 to 19.7 and averaged 13.08; but in all of the 386 analyses not a single report showed more than 1.8 percent f. f. a.

Then thinking that possibly the f. f. a. might be related to the degree of maturity or development of the seed as indicated by the oil content, I took some 23,671 grade reports for Mississippi-grown seed which were analyzed during October, November, and December, 1937, and January and February, 1938, and broke them down into groups of the various oil contents; but found that whether the seed had matured only 14 percent of oil or 22 percent, the reversed enzymic activity seemed to be equally as active, for just as high f. f. a. was found whether the seed contained little or much oil. The tabulations for January and February would