cent. The percentage change in the result is twenty-four per cent, and it is in the reverse direction of what we would expect.

DR. NEWTON: May I ask if the temperature of the sample itself was measured in those two cases?

DR. FEYER: Yes, I measured the temperature with thermometers placed right in the glass oil tube. I did it a sufficient number of times to be convinced that that had no particular effect. I used rather thin wall, close-fitting copper sheaths. So, we will expect air flow, if varied beyond a certain limit, to have some effect.

MR. KILGORE: We have followed this same work and Mr. Freyer did also, only we ran probably thirty or forty samples like this. When we first began collecting this data that I have just given, I found in the case of the low flow rate, the curves tended to lie high all the time, and I thought there was actually a difference, that the low rate gave a higher value. But after running about one hundred of them, we found that they all stayed within about a five per cent limit.

I have in my room a table showing a spread between the lower and highest rates. In all cases, the low rate tends to run high. In other words, the low rate will give a shorter keeping time than a high rate, but it is within about five per cent. When we began collecting data for this paper, we thought that we had discovered something in that the low rate apparently does not remove the peroxide as fast as the high one does, or something of that sort. But when we worked over a large number of samples, instead of using one or two, we found that all came within this five per cent average range. Therefore, in doing work of this kind, by this method, it seems to me that at least duplicates should be run, and that the total number of samples should be very sizable in order to make a generalization. Although you might get a smooth curve in one run, if you do it over half a dozen times, you will find that a nice smooth curve is not a true picture.

BAGILUMBANG OR SOFT LUMBANG (ALEURITES TRISPERMA) OIL*

By G. S. JAMIESON and R. S. McKINNEY

CONTRIBUTION FROM THE OIL, FAT AND WAX LABORATORY, BUREAU OF CHEMISTRY AND SOILS, U. S. DEPARTMENT OF AGRICULTURE

THE bagilumbang, also known as the banucalag, soft lumbang and by other native names in the Philippines, where it is indigenous, is related to the lumbang or candle nut tree, Aleurites moluccana, the Chinese tung trees A. fordii and A. montana, and the Japanese A. cordata. It is being cultivated in Malaya and the Philippines on a small scale, and a few scattered trees are to be found in southern Florida. It can be propagated from both seeds and cuttings and is a rapid grower. At maturity the tree in favorable localities reaches a height of about 45 feet. Like the lumbang tree and in contrast to the tung trees, it appears to thrive in calcareous soils. The somewhat rounded, angled fruit, which is from 5 to 7 centimeters in diameter, usually has three cells, each of which contains a single seed or nut. The oval, smooth seeds, which are about 3 cm. long and nearly as broad, have hard, thin brittle shells, 0.25 to 0.5 mm. thick. The fleshy, white, oily kernel is enclosed in a thin white paper-like membrane. Unlike the candle nuts, the kernel with this membrane shrinks slightly from the seed coat or shell as the seed dries after maturity is reached, thus making it easy to separate the kernels from the shells. The kernels have a pleasant nutty flavor, but leave a burning sensation in the mouth and within a few hours cause an extremely violent purging. This is also a characteristic of the kernels of other species of Aleurites. Although the oil is not prepared on a commercial scale, the Philippine natives in localities where the tree grows have used it for many years to paint their boats.

The present investigation is concerned with fruits and seeds collected and sent to us by H. S. Wolfe, Horticulturist in charge of the Florida Semi-Tropical Experiment Station, from a tree growing in the vicinity of Homestead. The fruits ranged in weight from 23 to 39 grams, and the seeds or nuts consisted of 63.3 per cent of kernels and 36.7 per cent of shells. The kernels, which ranged in weight from 4 to 5.3 grams, contained 59.94 per cent of oil and 3.95 per cent of moisture. Richmond and del Rosario (Phil. J. Sci. 2, p. 439, 1907), who examined the seeds, reported that they consisted of 64.3 per cent of kernels and 35.7 per cent of shells. Those grown in Malaya (G. D. V. Georgia, Malayan Agric. J. 14, p. 290, 1926) had 56.4 per cent of kernels and 43.6 per cent of shells. The kernels contained 50.9 per cent of oil.

On account of the small quantity of kernels available, the oil was extracted with ether. During the removal of the last part of the solvent an atmosphere of carbon dioxide was maintained to protect the oil from oxidation. The oil was a pale yellow limpid liquid. A portion of the oil was mixed with an equal volume of a 10 per cent chloroform solution of antimony trichloride, according to M. T. Francois (Comp. rend. 198, p. 1046, 1934). In about two hours the solution had solidified. Tung oil similarly treated solified in one-half hour, although Francois stated that it should gel immediately. Oiticica oil was also found to require two hours for solidification. On the other hand, linseed, perilla and lumbang oils treated with the antimony trichloride solution remained liquid even after standing for 24 hours. The test clearly indicated that bagilumbang oil is not similar in composition to lumbang oil, as claimed several times in the literature.

When this oil was heated to 280°, 300° and 310° no gelation took place. R. G. Aguilar (loc cit) could not solidify the oil by heating it.

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Another portion was exposed to direct sunlight for two days, but the only change observed was that it had thickened slightly. Then it was placed in the refrigerator for 18 hours, but no glycerides separated. To 25 grams of the oil about .1 gram of precipitated sulphur was added, and after the mixture was heated to 50° C. it was set out in the sunlight for about three hours. After being in the refrigerator for one-half hour the oil was solid and remained so to a large extent even at room temperature. An equal volume of acetone was added, and the mixture was warmed until it was entirely in solution. Then it was placed in the refrigerator for several hours. The glyceride crystals which formed were filtered by suction, washed with small portions of chilled acetone, and recrystallized from the same solvent.

The crystalline glycerides which separated were filtered by suction and washed with small quantities of cold acetone. Their melting point was about 65° C. The acids were prepared from the glycerides in the usual manner, and after several recrystallizations from ethyl alcohol an acid was isolated which melted sharply at 71° C., indicating that it was beta elaeostearic acid.

A film of the oil on a glass slide solidified to a non-tacky condition, after standing in the laboratory for about 36 hours. The hardened film was rough and opaque and had the appearance of a tung oil film.

A film of lumbang oil on glass after standing for 5 days was still liquid. On the seventh day it was somewhat solid but tacky to the touch. The film from that time slowly became harder and less tacky, but remained smooth and clear.

In 1919, H. A. Gardner (Pt. Mfgr's Assoc. Circular No. 75) called attention to its similarity to tung oil and stated that the properties of the oil made it most desirable for use in paints and varnishes. The oil from Philippine seed which he examined when spread on glass dried in 34 hours and when made into varnish, it produced a waterproof film.

Upon making several determinations of the iodine number of the oil by the Hanus method, it was found that the results varied both with the time allowed for the reaction and the quantity of sample taken (c.f. H. A. Gardner loc. cit.). The same situation has been found with *oiticica* oil. When 0.1113 gram of oil was allowed to react for one hour with the Hanus solution, an iodine number of 155.1 was obtained, but a two-hour reaction with 0.1239 gram of oil gave an iodine value of only 142.4. A repetition of this experiment with 0.051 gram of oil gave an iodine number of 243. Rosario and Richmond (loc. cit.) using the Hanus method, reported an iodine number of 158.5; H. Gardner (loc. cit.), with the Hübl procedure, reported iodine numbers from 161 to 164.2, but George (loc. cit.) gave the value 111.4 for the Malayan oil. R. H. Aguilar (Phil. J. Sci. 12, p. 235, 1917) reported an iodine number of 145.2 as determined by the Wijs method.

It should be observed that none of the iodine numbers determined either by the Hanus or Wijs methods are comparable with the theoretical or true iodine number of the oil. The Wijs reagent reacts only with two of the three double bonds of elaeostearic acid. On the other hand as will be shown, the Hanus method gives low as well as high results. For example, an attempt was made to calculate the unsaturated acids in the oil using the highest iodine number (243) and the thiocyanogen value. The result indicated an impossible quantity of elaeostearic acid and no oleic acid. It showed that this abnormally high iodine number was due to a large amount of halogen substitution in the unsaturated acid molecule. It became obvious that in order to calculate the quantity of the elaeostearic acid present in the oil as well as its true iodine number, it would first be necessary to determine the percentage of oleic acid.

For this purpose we used the well-known method of A. Lapworth and E. N. Mottran (J. Chem. Soc. 127, p. 1628, 1925), which is based on the oxidation of the unsaturated acids in a cold alkaline solution with potassium permanganate under carefully controlled conditions. This treatment converts oleic acid into dihydroxystearic acid. In this case and in others where oils containing elaeostearic or similar acids were subjected to this method, it was found desirable to prepare the potassium salts instead of the sodium salts of the acids as recommended, owing to the insolubility of the latter in cold aqueous solutions. Furthermore, it was found necessary to use considerably larger quantities of permanganate than suggested; otherwise oxidation was incomplete.

The quantity of dihydroxystearic acid finally separated indicated that the oil contained 12.3 per cent of oleic acid or as glyceride 12.9 per cent. From the several oxidation experiments made, no evidence of the presence of linoleic acid in the oil was obtained, but some isolinusic acid ($C_{18}H_{36}O_8$) melting at 173-5° C. was obtained, showing the presence of an acid having three double bonds.

A bromination experiment with the oil made in the usual manner gave no ether insoluble hexabromides (as does lumbang oil), indicating the absence of linolenic acid. It was obvious that the source of the isolinusic acid was elaeostearic acid.

Using the theoretical thiocyanogen values for oleic and elaeostearic acid glycerides together with the quantity of oleic acid glyceride found in the oil, the percentage of elaeostearic acid glyceride can be calculated from the following formula:

$87.26x + 86.04y = 100$ SCN value of oil in which x = per cent of elaeostearic glyceride and y = the per cent of oleic acid glyceride. Substituting the value for y and solving the equation gives x equal to 67.1 per cent. From the percentages of these glycerides, the calculated or true iodine number of the oil was found to be 187.

As the lead-salt ether method is not applicable for the determination of saturated acids with oils containing elaeostearic or similar acids, the well-known Bertram oxidation procedure was used. The oil contained 16.53 per cent of saturated acids (or 17.30 per cent of their glycerides).

The characteristics and the approximate percentages of the fatty acids in bagilumbang oil are given in the following table:

CHARACTERISTICS AND FATTY ACIDS

Refractive index at 25	1.4971
Acid value	0.87
Iodine number (true)	187.0
Thiocyanogen value (Kaufmann)	69.9
Saponification value	196.0
Unsaponifiable matter, percent	0.50
Iodine number of unsapon	107.5
Saturated acids, percent	16.5
Unsaturated acids, percent	77.0
Saturated acids as glycerides, percent	17.3
Oleic acid as glycerides, percent	12.9
Elaeostearic acid as glycerides, percent	67.1
Total glycerides, percent	97.3

An analysis of the oil was made with the object of checking the total quantity of glycerides (97.3 per cent) found in this investigation (cf. p. 400, "Vegetable Fats and Oils," the Chemical Catalog Co., 1932). This analysis gave 96.5 per cent of glycerides, after the deduction of the unsaponifiable matter (0.50 per cent). To this figure, 1.2 per cent of glycerides must be added (which accounts for the free fatty acids obtained during the analysis), making a total of 97.7 per cent of glycerides, which is in good agreement with the figure 97.3. The analysis also indicated that the non-oil constituents of the oil amounted to 1.9 per cent. Adding this figure along with that for the unsaponifiable matter gives a total of 99.7 per cent.

Bagilumbang oil, obtained from the seeds of Aleurites trisperma, has marked drying powers, due to the presence of a large quantity of glycerides of elaeostearic acid, as shown for the first time by the present investigation. The tree can grow fruit in calcareous soils, and the kernels can be separated readily from the shell. In view of these facts, the attention of horticulturists will doubtless be given to ascertaining whether or not it would be feasible to undertake commercial planting of this tree in southern Florida, as well as in semi-tropical and tropical localities not adapted to the cultivation of the tung tree, Aleurites fordii.

OILS
THEIR PRODUCTION AND CONSUMPTION*

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When we are absorbed in the duties of our daily lives, whether it be dealing with fats and oils in general, or refining, hydrogenation or soap-making in particular, it is so easy to lose the proper perspective. We are likely to over- or under-estimate the value of our work and the importance of the industry we serve. A study and comparison of figures pertaining to our industry provides us with a fair valuation. Facts and figures are always interesting, the more so as data pertaining to the past can give us an indication of what we may expect in the future.

All our figures have been taken from reports of the Government, trade journals, and other reliable sources and have all been checked against each other.

This total production is distributed for 1927 (1) as follows:

U. S. A.	Germany	England	France	Italy	Russia	Rest	
35%	14%	11%	11%	4%	4%	21%	
55 lbs.	42 lbs.	45 lbs.	51 lbs.	19 lbs.	5.3 lbs.		per capita

The total production has not changed very much between the years 1927 and 1934. The production of vegetable oils decreased 7%; this decrease of production was almost made up by a 25% increase of production of animal fats. The tonnage of lard, 600,000 tons and originating entirely in our country, remained the same, but comprised in 1934 only 46%of the total, as both marine oils and tallow increased considerably.

The percentages of the most important constituents of the vegetable oils remained practically the same with the exception of olive oil whose production in 1934 was slightly larger than soybean oil.

WORLD'S PRODUCTION OF FATS AND OILS IN 1927 (1) AND 1934 (2)

Animal:							
1927							1,300,000 tons
1934							1,625,000 tons
Most important constituents:							
	Lard		Marine oils				Tallow
1927	60%		25%				15%
1934	46%		31%				23%
Vegetable:							
1927							8.300,000 tons
1934							7,850,000 tons
Most important constituents:							
	Cottonseed	Peanut	Linseed	Coconut	Soybean	Olive	Palm
1927	20%	20%	16%	14%	13%	11%	6%
1934	20%	20%	15.6%	14.5%	11.6%	12%	6.3%
Total production:							
1927							9,600,000 tons
1934							9,475,000 tons

As to the distribution of the total oil and fat production over the different countries, it is significant that in 1934 our country produced only 26% of the total with a production per capita and year of 40 lbs.

Considering the growing of oil seeds and the crushing of the oils, the following facts (2) are interesting:

Seed	Principal grower	Of total
Cottonseed	U. S. A.	46%
Peanuts	India	68%
Flaxseed	Argentina	52%
Copra	Dutch E. Indies	34%
Soybeans	Manchukuo	79%
Olives	Spain	52%
Sesamum	India	94%
Sunflower	Russia	100%
Rapeseed	India	90%
Palm kernels	Br. W. Africa	65%

Oil	Principal crusher	Of total
Cottonseed	U. S. A.	79%
Peanut	France	44%
Linseed	U. S. A.	29%
Coconut	Philippine Islands	18%
Soya	Germany	38%
Olive	Spain	41%
Sesame	Italy	40%
Sunflower	Russia	97%
Rapeseed	England	25%
Palm kernel	Germany	60%

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*A paper presented at the 26th annual meeting of the American Oil Chemists' Society at Memphis, Tenn., May 23-24, 1935.