Oil Palm Resources of the American Hemisphere[1]

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1. Introduction

IT has long been known that a large area of tropical America contains vast resources of fats and oils in the form of wild plants and that it is possible to produce even greater quantities through cultivation of indigenous or introduced species of oil-bearing plants. Of these wild plants, castor, babassú, oiticica, carnauba, and a few others are exploited in various degrees, but most of them are untouched except locally by natives and by wild or semi-domesticated animals who live by foraging.

FIG. 1. Large coconut palm plantation on the Caribbean Coast of Venezuela near Morón.

Most of the wild oil-bearing plants of tropical America have been described by botanists and specimens may be found in various herbaria, but few technical surveys have been made to determine the extent and feasibility of exploiting these resources. Even less consideration has been given to the plantation production of indigenous species.

As a result of the loss of supplies of coconut oil and copra from the Philippines and the South Pacific and of palm oil from Africa and the South Pacific during World War II, interest was aroused in sources of similar oils in the American hemisphere which resulted in various technical-economic surveys being made of these resources. Several of these surveys were directed to a considerable extent toward the oil-bearing palms, both wild and cultivated and it is with these plants that the present communication is primarily concerned.

Oil-bearing palms are found throughout the American hemisphere from Mexico to Uruguay and Southern Brazil. In 1936 Dahlgren (1) listed 1,170 species of palms as occurring in this hemisphere and Bomhard (2) estimates the total number to be around 1,250, many of which produce oil-bearing fruits. Bomhard (2) remarks that "It is a strange paradox that the United States has been importing most of its palm oils or kernels from half-way around the globe when coconut palms and African oil palms have been growing in this hemisphere for centuries. The former now number several millions, and the latter total at least one and one-half million trees. Not only these two topflight oil producers but some 25 other palm species that are strictly indigenous to the New World are known at the present time to be worth commercial exploitation. In fact, there is a larger concentration of oil-yielding palms in this hemisphere than anywhere else."

The query raised by Bomhard is not new; the same question arises in the mind of anyone contemplating these vast untapped reservoirs, especially when seen for the first time and particularly when they are seen from the air where they appear to occur in endless profusion. Obviously there must be an answer to this query, and it is not to be found in ignorance of the existence of these resources or in lack of effort to solve the problem of their exploitation.

The information which has been brought to light by several of the recent technical-economic surveys (3-6) of these resources has provided at least a partial answer to the above-mentioned query, as will become evident in the following pages.

It should be remembered in connection with the following discussion that the coconut and African oil palms produce more oil per unit area than any other cultivated oil-bearing plant. The yield of coconuts and of copra and oil per tree or per acre varies with the variety, with the spacing of the trees, cultural practices, and soil and climatic conditions. Good spacing is stated to be 70-80 trees per acre (7) and under good cultural management yields of 60-70 nuts annually should be obtained from mature trees (8), or approximately 5,000 coconuts per acre.

It requires 5 to 10 coconuts to produce a kilogram of copra depending on the variety, size, and maturity of the nuts, and the moisture content of the dried meats. However, approximately six coconuts of good varieties from properly cultivated plantations

Fig. 2. Interior of coconut plantation showing spacing of trees.

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FIG. 3. Coconuts just before harvesting.

will yield one kilogram of sun-dried copra containing about 65% of oil (9). The production of oil therefore is approximately 550 kilograms or about 1,200 pounds per acre.

The annual yield of the African oil palm, while variable, is consistently high in comparison with other oil-producing plants, and it has been increasing steadily. In the Netherland Indies the average yield of palm oil in 1931 was 1,750 kilograms per hectare, in 1936 it was 2,581 kilograms per hectare, while in 1940 it rose to 3,233 kilograms or 2,880 pounds per acre (10). Even in 1925 Eaton (11) reported an annual yield of 2,270 kilograms of palm oil and 550 kilograms of kernel oil per hectare. In Malaya a conservative estimate of the annual yield is 2,000 kilograms of palm oil and 500 kilograms of kernel oil per hectare.

It is apparent from the above-mentioned figures that the combined yield of palm and palm kernel oils from the African oil palm varies between 2,500 and 3,500 kilograms per hectare, or approximately a ton to a ton and a half per acre. Compared with the five-year average (1938-42) yields of oil per acre (12) of peanuts, flaxseed, soybeans, and cottonseed shown in Table I, the oil yields of the coconut and African oil palms appear almost fantastic.

2. Coconut Palm, *Cocos nucifera*

The coconut is one of the world's most important plants not only because it is the principal source of vegetable oil (10) but because it supplies food and beverage, textile fiber and cordage, fuel, timber, and other building materials for a large part of the population of the tropical lowlands throughout the world (7, 13). Although the coconut is well adapted to large areas of tropical and subtropical America, it is grown in the greatest numbers in the Orient and South Pacific.

TABLE I

Average Yield per Acre of Various Oil-Bearing Materials

Source	Oil yield lb./acre
Cottonseed	72[a]
Soybeans	169[a]
Flaxseed	178[a]
Peanuts	216[a]
Coconut	1,200
Palm, pulp	2,000-2,500
Palm, kernel	500

[a] Five-year average (1938-42).

Hansen and Mighell (10) estimate the average annual world production of coconut oil for the five-year period, 1934-38, to be 2,675 thousand metric tons whereas Rossiter *et al.* (8) estimated in 1946 that the entire Western hemisphere production of copra amounted to not more than 80,000 short tons, equivalent to approximately 50,000 tons of oil, of which approximately half was produced in Mexico. The production of copra is probably half or less of the requirements in the copra-producing areas of tropical America and is equivalent to about one-seventh of the American hemisphere requirements of coconut oil which are estimated by Kifer (5) to be 350,000 metric tons annually.

Actually there are no very accurate statistics rela-

FIG. 4. Method of climbing coconut palm to harvest fruit.

tive to the number of coconut trees, coconuts, copra, or oil produced in South and Central America and the West Indies. Although the coconut palm is apparently distributed in large numbers throughout tropical America, the production of copra and coconut oil appears to be relatively disproportionate. For example, estimates of the number of coconut trees in Brazil vary from five to six million (8) with a yield of approximately 140 million coconuts. However, in 1944 only 3,015 metric tons of coconut oil were produced (8), and cottonseed oil still accounts for approximately two-thirds of Brazil's vegetable oil production (5).

FIG. 5. View in copra shed where the tops of the coconuts are removed to drain the water after which they are split in two and the meat removed for drying.

The number of coconut trees in Venezuela were apparently unknown until the recent survey was made by the FAO Mission (6) to that country. On the basis of the survey made by the FAO Mission there are approximately 1.5 million coconut trees producing annually an estimated 93 million coconuts. Large numbers of these trees are in well-cared-for plantations (Figures 1-6). The estimated number of coconuts should provide in excess of 9,000 tons of coconut oil but according to trade estimates production of copra amounts to only about 2,000 tons (6).

The number of coconut palms in Mexico, particularly in plantation cultivation, has increased in recent years. Kifer (5) estimates the number of bearing coconut palms to have been 2.8 millions in 1942, and it is probably greater now. Production of copra which amounted to 18,500 short tons in 1939 increased to about 40,000 short tons by 1945 (8).

FIG. 6. Platform covered with coconut meat being sun-dried to form copra.

FIG. 7. Seedlings of African oil palm in charcoal sand frames, Venezuela.

Several other Latin American countries produce from 2.5 million to 25 million coconuts a year, but, in general, the production of coconut oil from domestic coconuts in any one of these countries is relatively small, 1,000 to 3,000 metric tons at most. The difference in coconut and in copra or oil production is accounted for by the large numbers of coconuts which are consumed as food and beverage, exported, or converted into shredded coconut. Exported and shredded coconuts generally bring higher prices to the producer than copra. By far the larger part of the coconut production is from small native plantings and provides only sufficient fruit for home use and sale in local markets.

FIG. 8. Year-old seedlings of African oil palm in field nursery, Venezuela.

In recent years efforts have been made to encourage increased plantings of coconuts in various tropical American countries without too much success. It is probable that the increased production of copra, amounting to 25,000 per annum since 1939, has resulted primarily from diversion of nuts from edible to industrial use.

3. African Oil Palm, Elaeis guineensis

The so-called oil palm, *Elaeis guineensis*, is indigenous to West Africa where millions of these trees grow along the coastal areas and from which large quantities of fruit are gathered by the natives. So-called palm oil is produced from the fleshy pulp of this fruit and palm kernel oil from the hard inner

FIG. 9. Banana plantation infected with sigatoka disease interplanted with African oil palm (right foreground), Venezuela.

kernel. About 1910 the African oil palm was placed in plantation cultivation in the Netherlands Indies and by 1940 approximately 250,000 acres were devoted to its cultivation, of which 183,100 acres were of bearing age, with an estimated production of 263,500 short tons of palm oil (8).

This palm was placed in plantation cultivation in British Malaya about the time of World War I, and by 1940 acreage devoted to its culture was 78,256, of which about 65,000 acres had reached bearing age. Palm oil production amounted to 64,800 short tons or approximately a ton per acre in addition to 10,800 tons of palm kernels.

More recently, the African oil palm has been introduced in a number of American hemisphere countries where it appears to be well adapted. It has been planted at least experimentally in nearly all of the countries of Central America. The United Fruit Company has had experimental plantings under study for about 20 years and has initiated a planting program on 2,700 hectares of old banana lands near Parrita on the Pacific coast of Costa Rica (14). Plantings have also been made in Honduras near Tela. In Guatemala a plantation of 10,000 palms, 10 years of age, is in production near Escuintla. In other areas along the Pacific coast experimental plantings have been made near San José, La Democracia, and San Antonio Suchitepéquez, where trees have come into production (15).

The African oil palm grows well in the West Indies and is quite abundant in Haiti, where it forms an important native subsistence crop. It is said to have been introduced into Jamaica from Africa before 1688. It was first scientifically described by Jacquin in 1763 from specimens introduced in Martinique. It also grows well in Trinidad and Puerto Rico.

In South America the African oil palm has been introduced into Brazil, Venezuela, Colombia, British Guiana, and Peru. The palm was introduced into Brazil several centuries ago and is found in Bahia and Amazonas. A United States Vegetable Oil Mission (3), studying the fat and oil situation in Brazil, found that in addition to the aforementioned states several other Brazilian states were suitable for production of the African oil palm on a plantation basis. This palm, which is known in Brazil as *dendê*, is widely distributed in the state of Bahia, and it has been estimated that about 1,500,000 of these palms grow in this state, 300,000 of which were growing on Itaparico Island in Bahia. On the basis of yields from Africa and the East Indies, if all the trees were producing, they would yield about 22,700 metric tons of pulp oil and nearly 600 metric tons of kernel oil annually.

The authors visited the plantation of C. A. Bananera Venezolana in Estado Carabobo, Venezuela. About 100,000 palms are being planted on an irrigated banana plantation on which the banana trees have suffered severe damage from sigatoka disease. About 25,000 seedling oil palms have been transplanted and are growing well. The oldest trees (4½ years) are producing fruit (see Figures 7-11).

In Peru the Estación Central de Colonización en Tingo Maria and colonists have planted African oil palms in the vicinity of Tingo Maria and a program of selection and cultivation is being carried on. The varieties known as *Sumatra, Java, Diwakkawakka,* and *Deli* received from Honduras are being tested along with *Macrocarya* from Iquitos, which was planted in 1932. This variety was brought from West Africa, Island of Fernando Po, although it originated in the Belgian Congo. A few plantations of older palms are also found in Peru.

Unfortunately, most of the old and even many of the more recently introduced varieties of African oil palm in the Western hemisphere are quite inferior in yield of fruit, oil content, and ease of processing to the best selected varieties in plantation cultivation in Sumatra, Malaya, and Africa.

4. Expansion of Coconut and Oil Palm Production

Considering the adaptability of the coconut and African oil palm to tropical America, the exceedingly high yields of oils from these palms compared with other oilseed crops, the successful development of plantation systems by Dutch and British interests in the South Pacific, the indispensability of these oils in the American hemisphere fat and oil economy, and the efforts which have been made to encourage the development of plantations, it is difficult to understand why this hemisphere has not become independent of Africa and the Orient with respect to its needs for these oils.

Among the reasons for the lack of expansion in the cultivation of these oil palms on a scale commensurate with the American hemisphere needs may be mentioned the following:

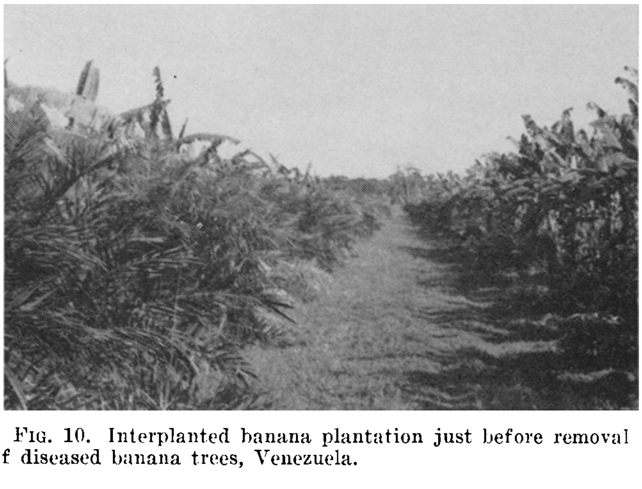

FIG. 10. Interplanted banana plantation just before removal of diseased banana trees, Venezuela.

Large-scale plantation development of coconut and oil palms requires the investment of considerable capital in land, buildings, machinery, and seed stocks, an adequate supply of labor and competent managers, and in many areas, installation of irrigation systems. Little or no return can be expected from this investment for the five to eight years required to bring the plantation into bearing. In most Latin American countries where such plantations would be feasible adequate capital is not available and investments involving considerable risk and a minimum of about six years before any return can be expected are not attractive in the United States.

Although prices of all palm oils are now relatively high and available supplies have been inadequate to meet world demands for some years, it is feared that with the rehabilitation of the industry in the South Pacific surpluses may develop in these oils which would render it very difficult to maintain profitable operation in competition with Pacific sources.

In some Latin American countries, notably Venezuela, an adequate supply of labor and managerial personnel are not available in the area where large plantations could be established; consequently labor would have to be brought to the area, and housing, food, medical, and other services would have to be provided.

However, the greatest obstacle to the development of large scale palm plantations is the problem of suitable land, The requirements of the coconut and African oil palm with respect to rainfall, temperature, and soil fertility, limit cultivation to coastal areas, valleys, and the lower mountain slopes. The African oil palm requires a rainfall of 1,500 mm. or more per year or adequate irrigation, and it does best at altitudes of 300 meters or less. It does not do well on heavy or swampy soils or in very light sandy soils. The coconut, however, is somewhat less critical and can be grown up to about 800 meters.

In many of the smaller and more densely populated Latin American republics suitable land is not available for large-scale plantations either because it is presently devoted to essential food crops (16) or is inaccessible because of lack of transportation. More remote lands would require the development of railroads, highways, or water transportation on a scale and at a cost which could not be borne by the population. However, suitable land is available in the Amazon basin and some of the other larger river valleys in South America, and no doubt many other smaller areas would be revealed by adequate surveys.

The introduction of the African oil palm into banana plantations which have been or are being destroyed by sigatoka disease has already been mentioned, and further expansion may be expected unless some means of controlling this disease are developed, but such expansion cannot lead to adequate production of the required oils. Production on this scale can only be attained by the establishment of new plantations adequately financed and scientifically developed and managed.

5. Wild Palms as Possible Sources of Lauric Acid Oils

Much has been written concerning the immense numbers of wild oil-bearing palms which are to be found in tropical America (2-4, 17-20), and many suggestions have been made concerning their exploitation. The fact that these palms exist in relatively vast numbers has been repeatedly substantiated and many efforts have been made to exploit them. Some exploitation is carried out in almost all countries possessing these palms, but for every successful operation there have been a dozen failures. Everywhere in Latin America where large stands of wild oil-bearing palms abound there can be heard tales of the failure of previous attempts at exploitation as well as many new plans for future developments. Some of these past efforts have been little more than stock promotion schemes and at best have been put forward with no real knowledge of the problems involved or the technical know-how to solve them.

The most successful commercial exploitation has been that of the babassú palm, *Orbignya oleifera.* This palm has been reported to cover large portions of a half dozen states in Brazil (2, 3, 8, 20), or according to Kifer (5) an estimated area of 2,700,000 square miles, and to number from one to 13 billion trees having an annual production of fruit equivalent to that required to supply the present world deficit of vegetable oils.


FIG. 11. African oil palm (4½ years old) with first crop of fruit, Venezuela.

The trees reach a height of 60 feet and when mature may bear two to eight bunches of fruit weighing up to 200 pounds each. The individual fruits resemble small coconuts and are four to six inches long and two to three inches in diameter. The kernels of the fruit are contained in perhaps the hardest shell of any oil-bearing seed. Because of the height of the

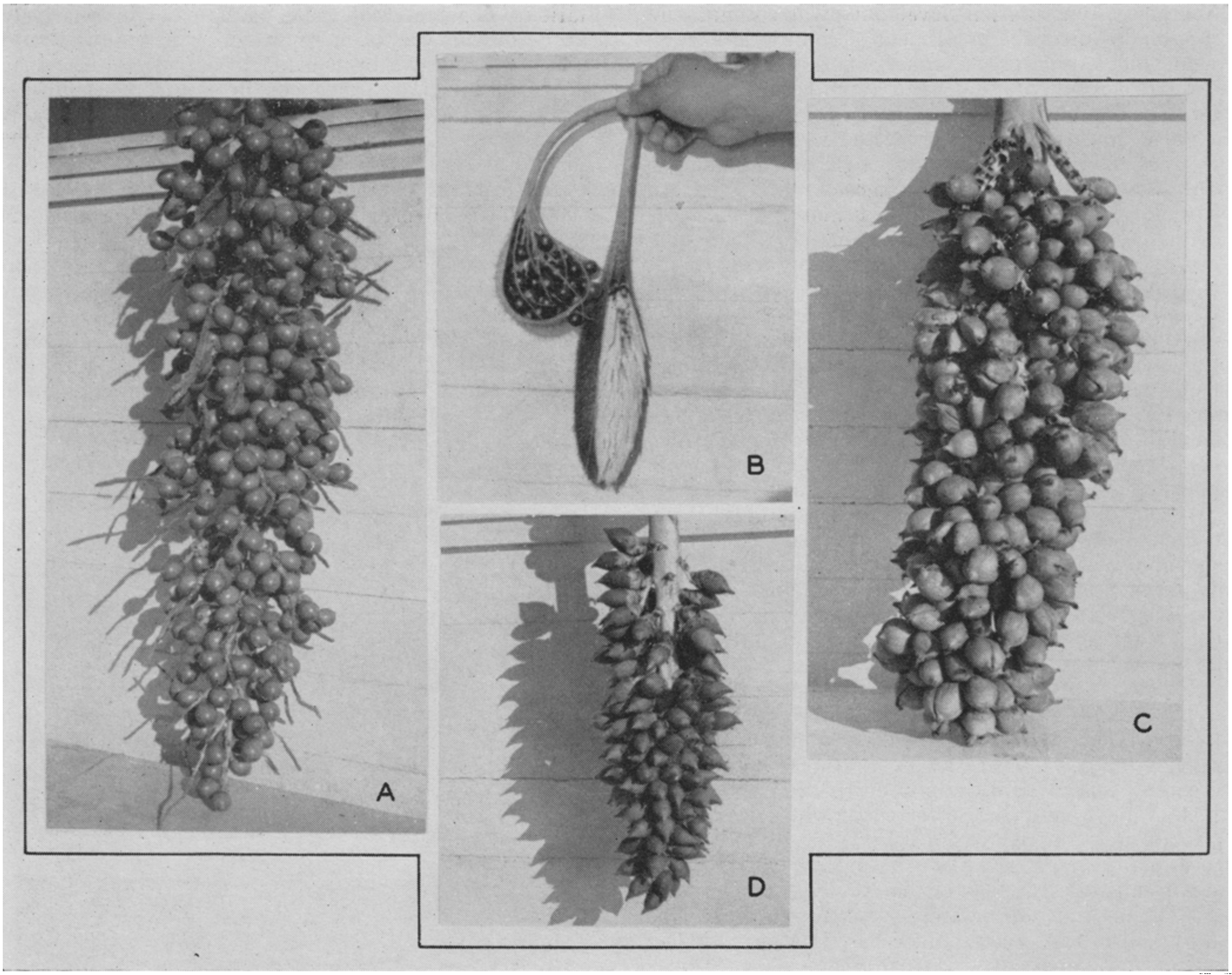

FIG. 12. Fruits of various species of wild palms collected at Puruey, Estado Bolivar, Venezuela. A. ''Macanilla,'' *Astrocarym jauri*; B. ''cubaro,'' *Bactris sp.*, fruit and flowers (not important for oil); C. ''corozo,'' *Scheelea microlepis* (mature); D. ''corozo,'' *Scheelea microlepis* (immature).

trees the only harvesting possible is to pick the fallen nuts from the ground, and only by hand-cracking can the shell be removed from the kernel. Despite many efforts no machine has been devised which is light enough to be transported and operated near the areas of production and yet strong enough to break the shell without severely damaging the kernels. Despite the dependence on hand labor for cracking, the production of babassú kernels reached a peak of 72,000 tons in 1941 (5); by 1944 it had decreased again to 25,000 tons, but in 1947-48 it was reported to be above 66,000 tons. It has been stated (3, 20) that 75,000 persons were engaged in the production of babassú kernels in the State of Maranhão (1941-42), a ratio of labor to output of product which is inconceivable in this machine age.

A number of other wild oil-bearing palms are exploited on a limited scale. These include, according to Kifer (5), 1,000-6,000 metric tons of tucum kernels, and 2,000-4,000 tons of licuri kernels, both from Brazil; 200-600 tons of palma de vino (Scheelea) kernels in Colombia; 3,100 tons of coquito kernels in Ecuador; 250 tons of aceituno kernels in El Salvador; and 4,000-6,000 tons of coquito, coyol, and corozo nuts in Mexico. Small amounts of corozo kernels were being processed in the plant of Köng Hermanos, Guatemala City, when it was visited by the senior author early in 1948.

Except for tucum and murumuru none of this production was exported; however, the entire production is only equivalent to a small fraction of the total babassú production.

Early this year the authors served on a Food and Agriculture Organization Mission for Venezuela to survey, among other purposes, the wild oil-bearing palms of this northernmost country of South America. The principal edible oil palm forests were surveyed with the aid of airplane, jeep, and boat during which the Mission covered 3,500 air miles in a Venezuelan army plane, 1,000 air miles by commercial plane, about 2,000 miles by jeep, and about 250 miles by boat. The aerial survey was made by the method described by Jenkins (4, 21) and used by him for making similar surveys in Mexico, Central America, and the West Indies, supplemented with aerial photography. The aerial surveys were supplemented with detailed ground surveys in selected areas where tree and fruit counts were made and samples were collected for identification and analysis. The details of the survey and results are contained in the Mission's report (6), recently released by the Food and Agriculture Organization of the United Nations, therefore only a few observations will be made here because of their bearing on the general problem of the utilization of wild oil-bearing palms in the American hemisphere.

Venezuela contains approximately 35 million wild oil-bearing palms, the majority of them in extremely remote and almost inaccessible regions. Only about 10% of the total palms could at the present time be considered accessible and within areas served by any type of transportation. Within these areas the density of the palms varies from 5 to 60 trees per hectare (2-25 per acre). Isolated and widely separated corobales were observed which varied in extent from a few acres up to 50 acres with 100-150 coroba palms per acre.

The estimated average potential oil production based on analyses and concentration of fruit in areas ranging from 5,000 to 200,000 acres varied from about 80 lb./acre for corozo kernel oil to 75 lb./acre of coroba kernel oil plus about 200 lb./acre of pulp oil. Over limited areas the average yield might be expected to be twice these averages. These figures should be compared with those for plantation production of 1,000 to 1,200 lb./acre for the coconut, and 2,500 to 3,000 lb./acre for the African oil palm.

The coroba and similar palms can be considered as a potential source of palm (pulp) oil only if the fruit is harvested by picking, and then only in the event that some mechanical means can be devised for separating the pulp from the fruit. If the fruit are allowed to ripen and fall to the ground, the pulp rapidly decomposes and the oil is converted to fatty acids through enzymic hydrolysis.

Despite the vastness of the stands of these oil-bearing palms the potential yield of oil per unit area is relatively low, in fact, lower than most annual oilseed crops. Their economic exploitation therefore depends entirely on the fact that no cost has been involved in their production.

However, the cost of collection in time and labor is relatively high, especially when it is realized that it is necessary to provide and maintain passable trails and transportation through the jungles, to establish and operate labor camps in isolated areas, supply and maintain equipment, provide adequate supervision and management, as well as transport the products to oil milling centers.

The greatest problem, however, is not the collection of the fruit but that of cracking the nuts and separating the kernels in relatively undamaged form. All but a few species of the American hemisphere wild oil-bearing palms produce nuts with shells so hard that no practical machine has been devised to crack them. A great deal of effort has been expended on the solution of this problem; many working models have been built and tried on a large and small scale, but none has been devised which will successfully handle the more common of the palm nuts, babassú, coroba, corozo, and cohune, consequently production of kernels from these palms up to now has been entirely by the slow and laborious method of hand-cracking.

In areas where abundant and cheap labor prevails, and at times when oil prices are relatively high, the exploitation of some of these palms is possible, but in countries like Venezuela, where labor is relatively costly and limited in amount, profitable exploitation is impractical.

6. American Oil Palm, Corozo oleifera

The discussion of the American oil palm, *Corozo oleifera,* has been reserved until the last because it deserves special consideration. This indigenous palm, which is found in Mexico, Costa Rica, Panama, Colombia, and Brazil, is more nearly comparable with

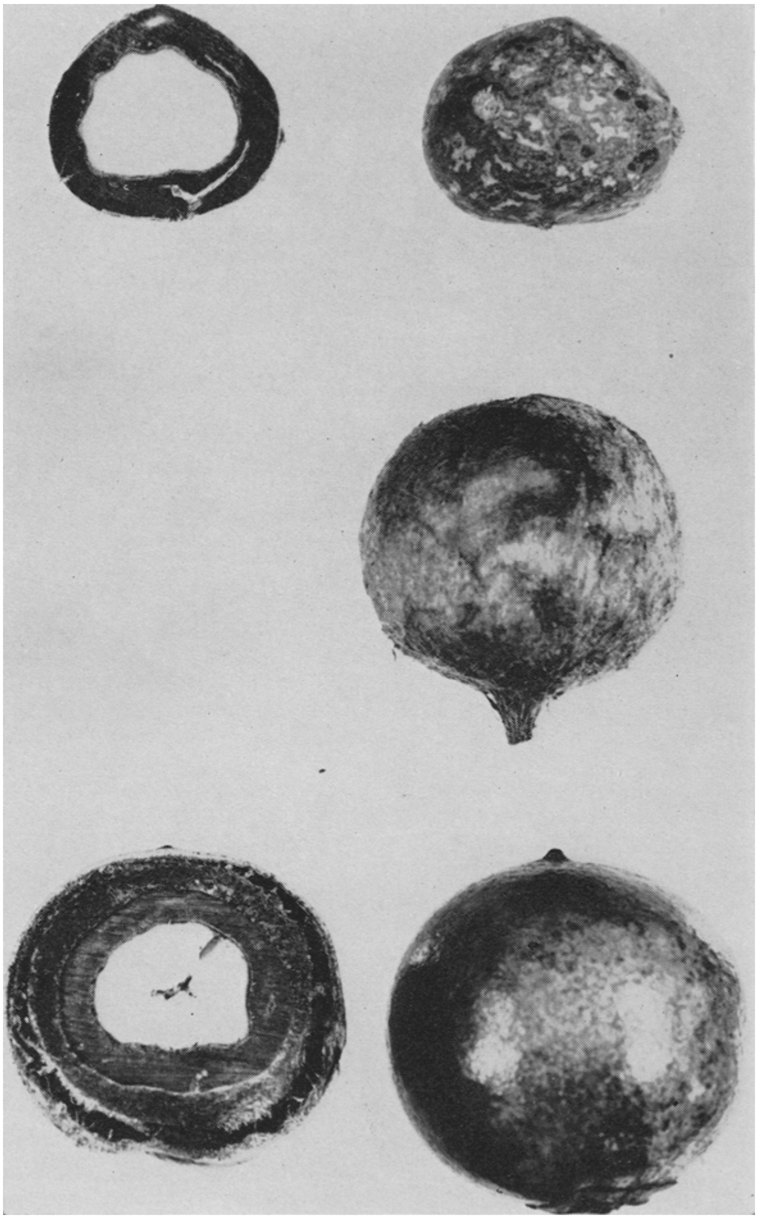

FIG. 13. Individual fruits (natural size) of corozo palm, *Acrocomia eirensis,* collected near Cachipa, Estado Monagas, Venezuela.

the African oil palm than any other American species. Both palm produce pulp and kernel oils, and the American oil palm has the advantage that it does not grow tall, thereby making harvesting simpler and less costly. Both the pulp and kernel oils are similar in composition to those obtained from the African oil palm. Like the African oil palm, the pulp oil of the America species is semi-solid, orange-colored, and has a very high carotene content.

The usual habitat of *Corozo oleifera* is stream valleys, along sea coast and swampy areas. It is occasionally abundant and dense in wet forested areas but is

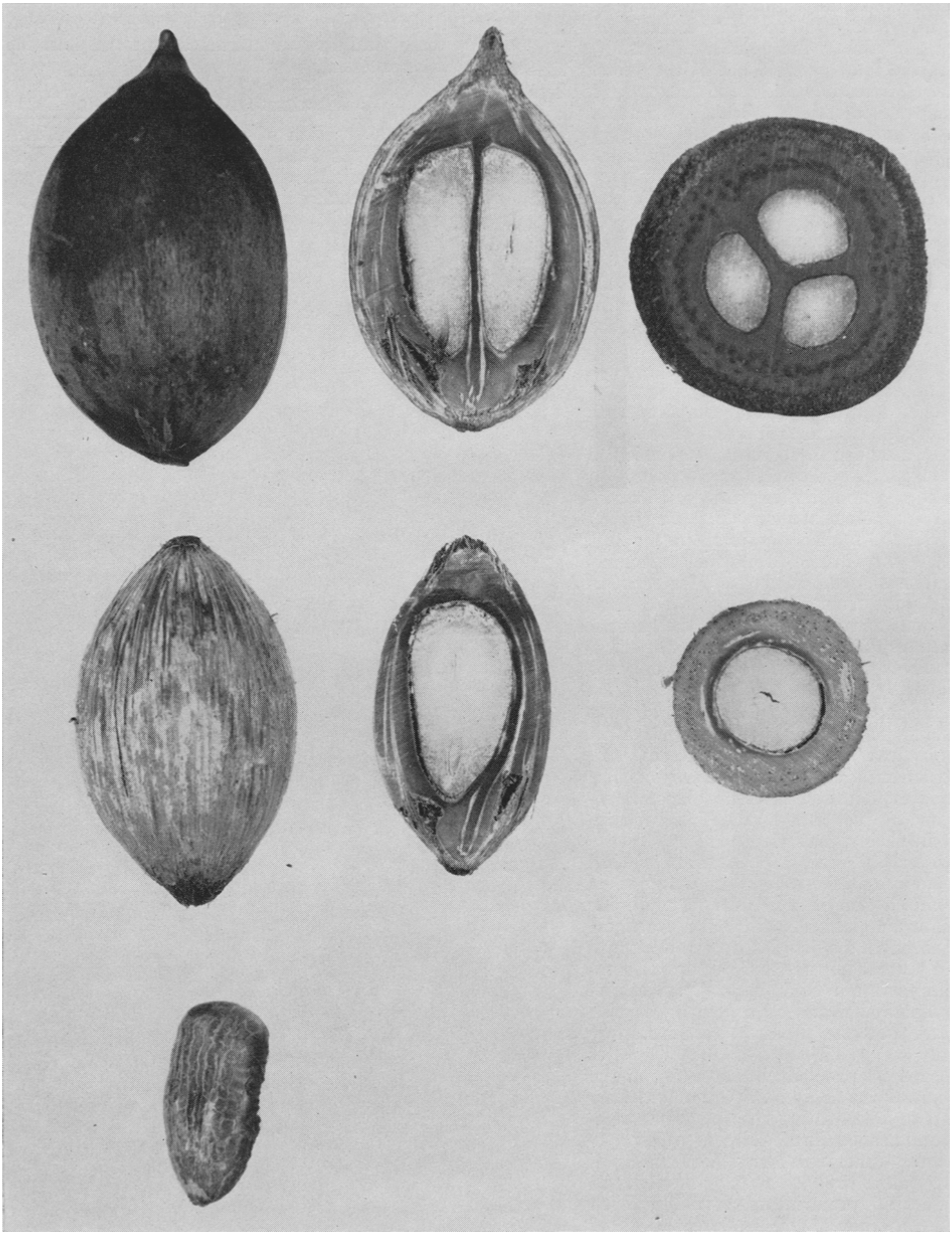

FIG. 14. Individual fruits (natural size) of coroba palm, *Scheelea macrocarpa*, collected near La Fria, Estado Zulia, Venezuela.

found characteristically in shady forests or in open cleared areas near water. However, it withstands seasonal drought without irrigation.

Although sometimes confused with the African oil palm, the American oil palm is very readily recognized. The most outstanding characteristic is its short, thick, frequently prostrate trunk. The palm is not tall, and the heavy clusters of fruit can be reached from the ground. The leaves are pinnate and erect. The fruits are bright orange-colored, from 2.5 cm. to 3 cm. in length, oblong in shape, pointed, and with the surface marked by fine longitudinal striations. The fruit bracts are 5-10 mm. long and remain attached to the fruit. Below the outer husk is a yellowish pulp which contains the so-called palm oil. The hard black inner shell is about 1.5 cm. in length and has 3 pores or openings at the top. The shell varies from 2-5 mm. (0.08-0.20 inches) in thickness. The kernel is small, more or less short-oblong and measures about 6 by 13 mm. (0.25 by 0.50 inches) (see Figure 15).

The American oil palm is known in local areas by the following names: Mexico (Jalisco), coquito de aciete; Costa Rica, coquito, palmiche; Panama, corozo colorado, corocito colorado, corocito negro; Colombia, corozo, noli, ñolí, yolí, corozo manteca, corozo del Sinú, corocito, corozo antá; Nicaragua, hone; Central America, ajou; Brazil, cayaúe, caïaúe, caïahúa, dende do Pará, dendezeiro do Pará.

In Panama, Jenkins surveyed these palms in the Canal Zone and in the Republic of Panama, parts of the provinces of Panama, Coclé, Colon, and Chiriqui. In the Canal Zone it was estimated that 200 metric tons of fruit were produced annually. In parts of the provinces of Panama, Coclé, and Colon, a minimum yield of 200 additional tons was estimated; however, the total annual yield would be much larger for the whole of the provinces. In the Chiriqui region, in areas near the United Fruit Company, the potential production of an area of about 30,000 hectares has been estimated to be approximately 150 metric tons. A preliminary estimate, subject to revision, of the total annual yield of the Republic of Panama and the Canal Zone would be approximately 1,000 metric tons.

The present production in terms of kernels or oil sold is very small, and Jamieson (ref. 9, p. 130) states that, "This oil is not produced on a commercial scale." This palm constitutes a very important part of the diet of the natives, especially in Panama where a large percentage of the fruit is used locally as a source of cooking and edible oil. Several species of wild animals eat the fruit, especially the oily outer cortex. In Nicaragua the pulp is used for poultry and hog feed and the kernel is used as a source of cooking oil. In many parts of Colombia the pulp oil is used as a substitute for butter and the kernel oil for cooking, soap, and as a luminant.

A special study was made of the American oil palm in Panama by Jenkins (6) for purposes of comparison with the African oil palm in this hemisphere. The particular palms were located at Old Panama in the Republic of Panama. They were growing in open pastures exposed to the sun. Each palm bore an average of five bunches of fruit, and four to five bunches of male flowers. The trunks of about 100 palms which were examined were all semi-prostrate, and the bunches were located about one and one-half meters from the ground. The upright portion of the trunks to the base of the leaves averaged about two meters. The leaves were approximately four meters in length. The usually curved, prostrate part of the trunks averaged about four meters in length.

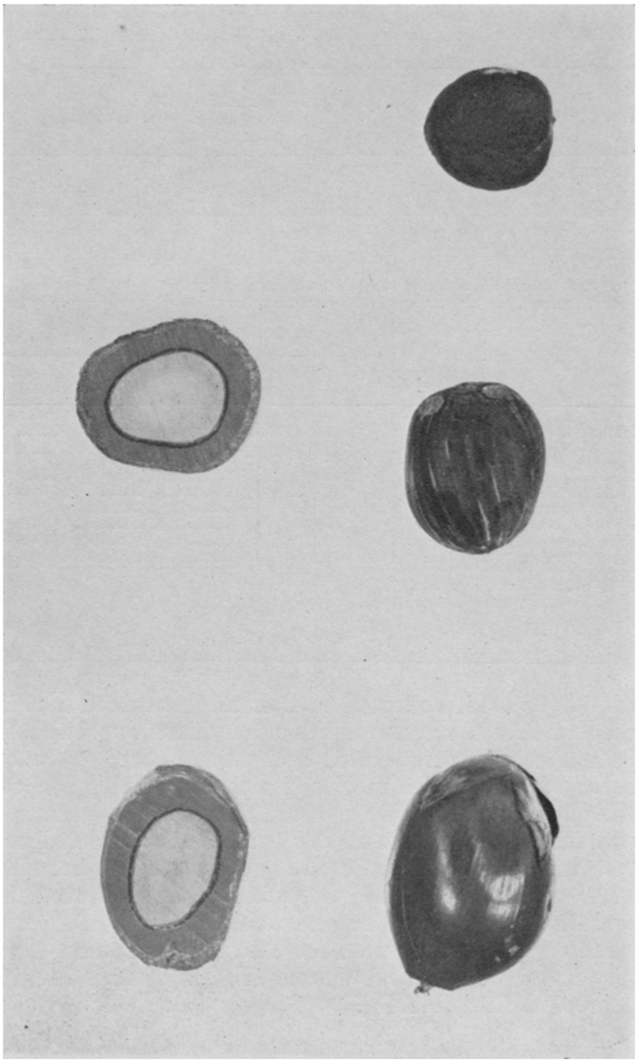

Fig. 15. Individual fruits (natural size) of the American oil palm, *Corozo oleifera*, collected in Old Panama.

Analysis of Fruit and Oils. The fruit of this species matures during the dry season, from January to May or June. It is bright orange-colored when mature. Some of the more exposed fruit matures early and drops to the ground. On February 9, 1948, an average-sized bunch was collected for analysis. It measured 51 cm. by 28 cm. and was elliptical in shape. The weights were as follows: total 8.20 kg., fruit 5.0 kg. or 61.6%, lateral branches 1.82 kg., central stem 1.37 kg. It contained 1,570 full-sized fruit and many small pulpy fruit at the ends of the stem branches which lacked a central nut. The average palm produces 40 kilograms of bunches yielding about 25 kilograms of fruit. The distribution of the component parts of the fruit are given in Table II.

The kernel oil is similar to African palm kernel oil. The oil and moisture content of kernels in the Panama sample were 29.3% and 15.0%, respectively. Other reported analyses indicate an oil content of 34.7-50%. The known characteristics of the kernel oil are presented in Table III. The pulp or pericarp from the

TABLE II

Distribution of Components of the Fruit of the American Oil Palm. *Corozo oleifera*

Component	Panama		South America (22)	Brazil (18)
	Mature	Undeveloped		
Pericarp, %	27.2	85.4	16	26.6
Shell, %	54.5	14.6	62	58.0
Kernel, %	18.1	......	22	16.0

TABLE III

Physical and Chemical Characteristics of American Palm Kernel Oil

Characteristic	Panama		Brazil	South America
	Jenkins (6)	Blackie (23)	Pesce (18)	Anon. (22)
Refractice index, $N_D^{40°}$	1.4513	....	....	....
Iodine value	30.95	15.4	25.5	27.7
Saponification value	225.5	245.7	232.5	234.0
Unsaponifiable, %	0.74	....	....	0.8
Reichert-Meissl value	1.65	....	....	1.4[a]
Polenske value	3.32	....	....	3.0[b]
Free fatty acids, %	0.27	....	0.55	0.6[c]
Melting point, °C	31.5-32.5	....	30.2[d]	26.9[d]

[a] Soluble, volatile acids, %.
[b] Insoluble, volatile acids, %.
[c] Acid value.
[d] Solidification point of fatty acids.

sample of fruit collected in Panama contained 30.6% oil and 22.5% moisture. An anonymous report (22) on a specimen of so-called noli palm (*Elaeis melanococca*) from South America, which is probably identical with *Corozo oleifera*, indicated that the pericarp contained 29.0% oil and 8.1% moisture; a Brazilian specimen cited by Pesce (18) was stated to contain 47% of pulp oil. The pulp oil is orange-colored, is semi-liquid, has an odor and taste similar to African palm oil and can be used for the same purposes. The physical and chemical characteristics of the oil are presented in Table IV.

TABLE IV

Physical and Chemical Characteristics of American Palm (Pulp) Oil

Characteristic	Panama		Brazil	South America
	Jenkins (6)	Blackie (23)	Pesce (18)	Anon. (22)
Refractice index, $N_D^{40°}$	1.4618	....	....	....
Iodine value	84.8	87.1	78.2	83.5
Saponification value	186.6	187.1	197.1	199.0
Unsaponifiable, %	1.18	1.54	....	0.7
Acid value	1.12[a]	....	29.8	29.7
Reichert-Meissl value	0.44	....	....	0.7[b]
Polenske value	0.8	....	....	0.5[c]
Melting point, °C	13-14	....	21.9[d]	33.6[d]

[a] Free fatty acids as per cent palmitic.
[b] Soluble volatile acids, %.
[c] Insoluble volatile acids, %.
[d] Solidification point of fatty acids.

A study was made by Blackie and Cowgill (23) of the occurrence of carotene in the pericarp and kernel oils of *Corozo oleifera*. These oils were examined for the presence of carotenoids by chemical and spectroscopic methods, and a lipochrome of the carotene type was found. A biological assay of the vitamin A content was made on white rats. The pericarp oil contained the equivalent of 158 international units of vitamin A per gram. This specimen was obtained from the Chagres River, Republic of Panama. Both the kernel and the pulp oils of the American palm are used extensively by the natives in this region for cooking, and it is said to provide the principal and possibly the only source of pro-vitamin A.

The pulp oil from the sample of fruit collected at Old Panama was analyzed spectrophotometrically at the Southern Regional Research Laboratory. The spectrophotometric curve resembled that for carotenes. The total carotene content was determined by the tentative chromatographic procedure of the Association of Official Agricultural Chemists. Three determinations gave 231, 233, 238 (av. 234) p.p.m. of total carotene. If all the carotenes were β-carotene, it would be equivalent to 398 I. U. of vitamin A per gram of oil.

Because this indigenous palm is in many respects similar to the African oil palm and because it possesses other previously mentioned advantages, it has been suggested (6) that efforts be made to establish it in plantation cultivation on an experimental scale of sufficient magnitude to allow a thorough comparison to be made with the African oil palm under American hemisphere conditions. Such an experimental planting should be designed to obtain data on the proper spacing of the trees, yields of fruit, cost of production, methods of harvesting and handling, recovery of pulp oil, cracking the nuts, and separation and processing of the kernels. It is possible that it would prove more highly adaptable and more profitable than the African palm or any other oil-bearing plant in this hemisphere.

7. Conclusions

The American hemisphere is dependent on the Orient, the South Pacific, and West Africa for the bulk of its supplies of lauric acid-type oils such as coconut and palm kernel and of palm oil, requirements for which are estimated at more than 375,000 tons annually.

The coconut palm, *Cocos nucifera*, and African oil palm, *Elaeis guineensis*, are entirely adaptable to plantation cultivation in the American hemisphere.

In addition, the American oil palm, *Corozo oleifera*, an indigenous palm, is probably also adaptable to plantation cultivation.

Wild oil-bearing palms, while numbered in the tens and perhaps hundreds of millions, cannot be depended on at present as an economic source of lauric acid oils.

In order to insure an uninterrupted supply of these essential oils in or near the consuming countries, and especially in close proximity to the United States, every conceivable effort should be made to develop large-scale plantation cultivation of coconut and African oil palm, and experimental plantations of the American oil palm in the American hemisphere.

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Testing of Drying Oils. III. Correlation of Evaluation Data*

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THE method used by the National Lead Company for the preliminary evaluation of drying oils has previously been described in detail (1) and the experimental data for a number of natural and synthetic oils has been published (2). Since the possible uses of drying oils are so varied, even a preliminary evaluation entails the gathering of a large amount of data. After even a few oils have been evaluated, the data are so voluminous as to be unwieldy. An accurate summary of the performance of one oil is difficult to obtain while comparisons between several oils are definitely cumbersome. Therefore, it became necessary to devise some method of presenting or summarizing the data which would permit the various oils to be compared rapidly if the evaluation results were to achieve their maximum usefulness.

It is not possible to group all the data together onto one large chart. This would simplify the problem only slightly since the chart would be much too large and complicated for easy reading and study. The method finally adopted therefore was to divide the performance of the oils under each test into groups and assign to each group a numerical value. The performance of an oil in all tests could then be summarized by a single number by the use of a suitable method of averaging.

One method of averaging or weighting is suggested here chiefly as an example. It is realized that the various weights assigned to each test are one of opinion and will vary with individuals, depending on their interests and their personal reliance on the particular test. Discussion and use of the weighting scheme would result in an optimum weighting factor of most general usefulness.

The tests performed under the evaluation program were divided into three groups: first, those performed on the oil; second, those performed on varnishes made from the oil; and third, those performed on paints made from the oil. Since the information gained from the oil tests is of a more fundamental character than that from the paint or varnish tests, it was given slightly more weight in making up the final average. The maximum number of points possible in each of the three groups of tests is:

Oil tests	40 points
Varnish tests	30 points
Paint tests	30 points

The final figure is then obtained by adding up the points scored in each group of tests.

The performance of an oil on an individual test is rated from 0 to 10, inclusive. This permits the classification of the oils into 11 divisions on each test although on some tests a smaller number of divisions is satisfactory. The relative importance of the individual tests is indicated by a factor by which the rating of the oil is multiplied in obtaining the group average. An asterisk is used in the charts to indicate the presence of some unusual factor. When it appears next to the rating of an oil on an individual test, it means the original experimental data should be consulted. An asterisk appearing with one of the weighted averages indicates something unusual in the method of computing the average. For instance, if an oil cannot be used in varnishes, the varnish tests are ignored entirely instead of being given a rating of zero, and the final average is attained by adding the points scored in the oil and paint tests, and then multiplying by a factor of 10/7, and an asterisk placed along side the final average. This is done because the oil would suffer a handicap if a rating of zero was given to the varnishes and its possible advantages as a paint vehicle might be overlooked entirely if only the total averages were considered.

In the following discussion, the tests and methods used in arriving at the weight factor and rating are discussed.

Oil Tests

Appearance—Weight Factor=0.4

Rating: Numerical values applied are 0, 3, 6, 10. The oil shall be bright and clear, have a light color (maximum of 10 Gardner), and not give more than a slight precipitate after 18 hours at 40°F. to earn a value of 10. The odor of the oil shall be normal.

Bodying Rate—Weight Factor=0.8

Rating for A to G viscosity oils:

Rating	Gel Time (minutes)
10	0 to 50
9	51 to 100
8	101 to 150
7	151 to 200
6	201 to 250
5	251 to 300
4	301 to 350
3	351 to 400
2	401 to 450
1	451 to 500
0	over 500

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