THE BRAZILIAN CHAULMOOGRA:
CARPOTROCHE BRASILIENSIS

A REVIEW

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HISTORICAL

Plants belonging to the genus *Carpotroche* have been known for about a century, and of five species known to occur in Brazil four were described by de Martius ([18]) in his Flora Brasiliensis (1841-1872). One of these is *C. brasiliensis* Endl., described with the synonym of *Mayna brasiliensis* Raddi. This plant, considered as native to Brazil by de Martius, Zuccarini, and Peckolt, is well known among the natives as sapucainha (little sapucaia—*Lecythis*, the seeds of which are edible), pau de caximbo (pipe wood), fructa de cotia (aguti fruit), fructa de macaco (monkey fruit), fructa de lepra (leprosy fruit), pau da lepra (leprosy wood), etc.

In several papers which appeared between 1861 and 1899 Theodore Peckolt, the Brazilian chemist, described the plant, its fruit and seeds, and the analysis of its oil, this being the first analysis of chaulmoogra oil on record.

In his first article (19) Peckolt describes the fruit as containing from 60 to 90 seeds, from which he obtained a yellowish oil of agreeable, apple-like odor. This had a specific gravity of 0.9618 at 16° R. and was of greasy consistence at 17° R. From it he isolated carpotrochic acid, homologous with chaulmoogric and hydnocarpic acids. In 1866 he reported (21) an analysis of the pulp of the fruit and the isolation from the seeds of a crystalline alkaloid which he called *carpotrochina*. From the oil he had isolated a crystalline fatty acid, designated as stearocarpotrochic acid. The seeds, he said, furnished an excellent fuel, the pulp was edible, and the plant was used as an insecticide.

In a monographic paper published in Vienna in 1866 (20), Peckolt said that the plant loses its leaves in July, grows new ones in December and January, and has ripe fruits in June, each well-laden tree having about 140 fruits. He pointed out that the oil content of the seeds is quite variable, gave further descriptions of the fatty acids that he had obtained from it, and gave analyses of different parts of the plant, including the fresh bark of twigs which he concluded had no medicinal importance. In 1867 he showed his products from sapucainha fruit at the Universal Exhibition in Paris and was given an award, and in 1869 he recommended carpotroche oil as a substitute for the Indian chaulmoogra oil. In 1899 he published an amended monograph on the subject (28), from which I have taken the data given later in this paper.

It may be noted here that it was not until 1879 that Moss (cited by Tomb 36) isolated from the commercial chaulmoogra oil a crystalline fatty acid with a melting point of about 30°C., which was named gynocardic acid under the erroneous belief, prevalent until recently, that the *Gynocardia odorata* was the botanical source of chaulmoogra oil.

In 1911 Pio-Corrêa (25) confirmed the statements of Peckolt that carpotroche oil was strongly insecticidal and a good medicine for skin diseases, including leprosy. In 1920 Lindenberg and Rangel Pestana (13), of Sao Paulo, compared the true chaulmoogra and carpotroche oils and proved that the latter is as active as the former in inhibiting growth of the avian tubercle bacillus; both inhibit it in dilutions between 1 : 100,000 and 1 : 200,000. This confirms the findings reported by Walker and Sweeney in the same year (37). In 1921 the Brazilian chemist, de Carvalho Delvecchio, prepared ethyl esters of carpotroche oil that were employed by various leprologists with good results; and since then there have appeared on the market various other preparations of the oil and its ethyl esters. In 1925 André (3) recorded an analysis of carpotroche oil, showing that its specific rotatory power (considered an index of its therapeutic activity) is higher (+53.4) than that of *Taraktogenos kurzii* (+48°). Perrot, in 1926 (24), recognized that *C. brasiliensis* belongs to the chaulmoogra group of plants.

CHAULMOOGRA-GROUP PLANTS OF BRAZIL

GENERA AND SPECIES

The family *Flacourtiaceae* (7) is represented in Brazil by many species. Oils from plants belonging to the genera *Carpotroche, Lindackeria* and *Mayna* are included in the chaulmoogra group because of their specific rotatory power.

Of the eight known species of *Carpotroche* five occur in Brazil; the remaining three species (*C. glaucescens, C. platypatera* and *C. crassiramea*) were described by Pittier from Costa Rica. The Brazilian species are:

1. *C. brasiliensis,* (Raddi) Endlicher.
2. *C. amazonica,* Martius.
3. *C. grandiflora,* Spruce.
4. *C. longifolia,* Benth.
5. *C. integrifolia,* Kuhlmann.

Of the thirteen species of *Lindackeria,* five are known in Brazil; the species *L. laurina* (Presl.) Gilg, and *L. vernicosa* (Karst) Gilg exist in Colombia and elsewhere; and the remaining six species are from tropical Africa.

1. *L. maynensis,* Poep et Endl.
2. *L. paraensis* (*Oncoba paraensis,* Hub. nomen solum), Kuhlmann.
3. *L. latifolia,* Benth.
4. *L. pauciflora* (*Oncoba pauciflora,* Eich.), Benth.
5. *L. ovata,* Benth.

Of the seven species of *Mayna* only one is known in Brazil, namely, *Mayna odorata,* Aubl. The remaining six were described from Colombia, Peru and the Guianas.

For descriptions of these plants we refer to the monograph on Brazilian species of the tribe *Oncobeae* by Professor Kuhlmann (12).

GEOGRAPHICAL DISTRIBUTION

Carpotroche brasiliensis is the most widely distributed species in Brazil. It is found in the mountainous forests in various places in the States of Rio de Janeiro, Minas Geraes, Espirito Santo, Bahia and Piauhy; more than two thousand trees from 10 to 16 meters high are known in the Federal District, and they are found within and in the vicinity of the city of Rio de Janeiro. According to Machado (15) and Pio-Corrêa (27) this species also occurs in the State of Sao Paulo. Recently Kuhlmann discovered a virgin forest of it in the Rio Doce valley (Espirito Santo), and he thinks that it originated there. Hoehne (9) says that its seeds are to be found in the herbalists everywhere in Brazil, and are used as a drug for several dermatoses and for leprosy.

With regard to the other species, *C. amazonica* is only known in the caatingas and stony territories near the Solimôes, Uapés and Amazonas rivers, in the State of Amazonas. *C. grandiflora* was discovered by Spruce in the forests of the Rio Negro region, in Amazonas. *C. longifolia* is known from various places in the States of Pará and Amazonas, in the regions of the Tapajoz, Teffé and Solimôes rivers, and also in the forests of Peru. *C. integrifolia,* discovered recently by Ducke and described by Kuhlmann (12), is found in the forests near Puerto Cordoba, on the Caquetá River at the boundary between Brazil and Colombia.

The species of *Lindackeria* are distributed as follows: *L. maynensis* has been found, between 1851 and 1927, by Spruce, Ducke, Kuhlmann and others in the valleys of the Tapajóz, Mapuera and Trombetas rivers (Pará); at Jamary and Ouro Preto, on the Madeira-Mamoré Railway (Matto Grosso); near the Rio Negro, at the mouth of the Teffé river, at Morcego, near Madeira River, and in the valley of the Solimôes river (Amazonas). It has also been found in Yumiraguas and Iquitos (Peru), and in British Guiana. *L. paraensis,* a new species which has many affinities with *L. latifolia,* has been found by Huber, Ducke, and Kuhlmann in the forests of Benjamin Constant (Braganca), Sierra Almeirim, Belém, and in "silvis secundariis" of Piquiatuba (Santarém), all in Pará. *L. latifolia* has been found, between 1849 and 1924, by Spruce, Ducke, Snethlage, and Kuhlmann in various places of the region of the Tapajóz river, Pará. *L. pauciflora* is frequent in Pará, where Huber, Ducke, and Siqueira have found it in Belém, Cametá, Almeirim, Logar Francez, Periquito (Tapajóz river), Poço Real, and the region of Capim river. *L. ovata* is known only from the State of Ceará, where Gardner and Freire Allemao found it.

Mayna odorata has been found, between 1901 and 1924, by Huber, Ducke, and Kuhlmann, in the valleys of the Tucandeira river (Pará), the Purús, Juruámiry and Madeira rivers (Amazonas), and in Yurimaguas (Peru).

SPECIFIC ROTATORY POWER OF THE OILS

The Brazilian chaulmoogras are classified below according to the specific rotatory power of their oils as determined by Professor Carneiro Felippe, of the chemical department of the Instituto Oswaldo Cruz.

1. *Carpotroche brasiliensis* Endl.	$[a]D^{30}$ +52.8
2. *Mayna echinata* Spruce	$[a]D^{30}$ +50.4
3. *Lindackeria maynensis* Benth.	$[a]D^{30}$ +48.5
4. *L. paraensis* Kuhlmann	$[a]D^{30}$ +43.4
5. *L. latifolia* Benth.	$[a]D^{30}$ +41.5
6. *C. longifolia* Benth.	$[a]D^{30}$ +41.0
7. *L. pauciflora* Benth.	$[a]D^{30}$ +39.1
8. *C. integrifolia* Kuhlmann	$[a]D^{30}$ +25.5

It is to be seen that oils of the different species of *Carpotroche* differ in their composition. Those of the other species previously mentioned have not yet been examined. Hoehne (9) recommended special study of "guassatonga" (*Casearia sylvestris*), which he thought might have properties similar to the *Carpotroche;* but Felippe examined the oils of four species of *Casearia* and of two other *Flacourtiaceae* and found them inactive. Eighteen other species of plants belonging to nine families have also given oils without any specific rotatory power (12). Because of the high optical activity of the *C. brasiliensis* oil, and also the widespread distribution of the tree in this country, it is the one which we call "Brazilian chaulmoogra."

CHARACTERISTICS OF CARPOTROCHE BRASILIENSIS

THE PLANT

The plant is a tree with asymmetric branches, of variable size, attaining the height of 16 and even 20 meters, top clipped and spread (Fig. 1). Other botanical features (Fig. 2) are: leaves obovals, stretched, pointed or obtuse, finely toothed at the point and cuneiform at base; flowers polygamodioiceous, numerous, together forming isolated clusters; the corolla is like a rose, of pale rose color, odoriferous, the androgyneous flower being larger than the flower of the apple-tree (Peckolt 23). The male specimens flourish much better than the hermaphroditic ones. The male inflorescence is an axillary raceme with 3 to 5 flowers forming a corymb; the hermaphroditic flowers are axillary and solitary. The male ones are 3 to 4 cm. in diameter and have a subglobulous alabaster; the hermaphroditic ones are 4 to 5 cm. and have an ellipsoid alabaster. According to Kuhlmann ([12]) only 6 per cent of the trees in the forest are hermaphroditic. He writes:

> This species has its habitat along the hill-sides of Serra do Mar, but it does not go beyond a certain altitude (600 feet according to Peckolt). It prefers the fertile soils of vegetable humus, argil and disintegregated rock. It is found in ravines in the gravel, along the margins of small streams which flow down the hill-sides, on solid and compact soils, etc.

The tree loses its leaves in June, re-acquires them in September, blooms in December and has ripe fruits in June (Peckolt). Decoctions of the bark are used as an insecticidal wash for cattle and domestic animals, but have no medicinal value.

THE FRUIT

The fruit is a capsule of brown color, ligneous, oval, 8 to 12 cm. long by 7 to 10 cm. in diameter (i.e., about the size of a fairly large orange), unilocular, polyspermous (Figs. 2, 4, etc.). It is covered with 12 to 14 longitudinal wings of pale green color and a second transverse series of small ones between them. The larger wings, extending from the base to the point of the fruit, are 27 mm. wide at the centers; and resemble sheets of paper with transverse veins and undulations; the intermediate wings are only 4 to 7 mm. wide at the center. Usually the wings are turned down (Plate 3), but there is a ''fringed'' variety (Figs. 6 and 7). The ligneous capsule is full of seeds embedded in a fleshy orange-colored mass (Figs. 5 and 7); this mass when removed from the bark is of the size of a goose egg and of firm consistence. One tree furnished 140 fruits that averaged 330 gm. in weight, with 96 seeds and 27.6 gm. of sarcocarp each, but the weights may vary from 100 gm. to more than a kilogram, of which about 65 per cent is seed (Jamieson [10]). Ripe fruits collected by Felippe in Rio City weighed from 140 to 410 gm., the average after drying being 70 gm. Fruit coming from Lagoa Santa, Minas Geraes, are especially smooth, full, and rich in seeds (Kuhlmann [12]).

The fresh pulp of ripe fruits is very succulent, of a clear yellowish-orange color, has an agreeable apple odor, and is acidulous in flavor and aromatic; when dried it makes a powder of the same taste. According to Peckolt (23) it is appreciated as a food by the Indians and common people; mixed with water and honey it is used as a beverage. On pressure the pulp gives a juice that ferments quite rapidly, when put into flasks and kept in a cool place it furnishes an agreeable gaseous drink, like champagne. If the fermentation is not interrupted there is produced a peculiar vinegar of *sui generis* odor and taste, not at all disagreeable. It has been said that the macerate of triturated green fruits is used as a head-wash against parasites.

Analysis of the pulp.—Peckolt, in 1866 (21), published an analysis of the fresh pulp. In 1926 da Silva (34) gave this analysis, with a few modifications but without criticism, as being the original though Peckolt himself in 1899 had corrected it to the following, the figures being for 1,000 gms.

Water	815.340 gm.
Fatty oil	0.853 gm.
Resin (yellow)	0.905 gm.
Resin (brown)	11.183 gm.
Protein substance	1.050 gm.
Glucose	75.760 gm.
Pectic substances, malic acid, extracts, etc.	89.573 gm.
Butyric acid	0.150 gm.
Ash	3.333 gm.

The resins are odorless and tasteless. The yellow one is soluble in chloroform, ether, alcohol and boiling potassium hydroxide; the solution gives a goldish yellow color to the tongue and skin. The yellow resin is insoluble in ammonia, but the brown one is soluble.

THE SEEDS

The seeds separated from the succulent pulp are obovals (Figs. 9 and 10), irregularly angulated, the size of a small hazel-nut—much smaller than most *Hydnocarpus* seeds. The peeled seeds have a greasy taste, not disagreeable, but a little bitter. They are so rich in oil that the natives peel and triturate them to obtain a greasy mass that is used as a fuel. The seeds may be perforated, strung on a thin stick and used as a candle; they are also boiled in water to obtain the oil for fuel. Dried, peeled seeds extracted with carbon disulphide give 69 per cent of oil; by triple hot expression they give 52 per cent; seeds dried but not peeled give 41 per cent with carbon tetrachloride and 28 per cent by triple hot expression; fresh unpeeled seeds treated give 32 per cent with carbon tetrachloride. Felippe gives for oil in seeds from 43 to 45 per cent and Jamieson from 63 to 69 per cent.

In 1932 G. Emmerich[1], professor of chemistry of the Agricultural and Veterinary School, in Viçosa, Minas Geraes, analyzed sapucainha seeds from six different sources in the State of Minas and found: water in the seeds, 3.8 per cent; kernels in the seeds, 64.9 per cent; oil in the peeled seeds, 60.2 per cent.

Carpotrochina.—Peckolt (21) isolated from the seeds a crystalline organic product which he named "carpotrochina." The method of obtaining it, and its properties, he described (23) as follows:

The peeled seeds, after extraction, were treated with boiling alcohol (sp. gr. 0.830), the liquid concentrated to one-quarter volume, the oil separated by means of a wet filter, the filtrate evaporated until the odor of alcohol disappeared, then treated with boiling water. Lead acetate solution was added, the filtrate freed of lead by hydrogen sulphide, evaporated until syrupy, and kept in a cool place. After a long time crystals formed which, when washed with boiling alcohol (sp. gr. 0.840), were colorless needles, fine and brilliant like silk, odorless, of a mild and peculiar alkaline taste. Heated on a platinum plate they melted and then volatilized without flame or residue; they sublimated in very thin needles, leaving a little brown residue, like a resin. They were insoluble in petroleum-ether, chloroform, and ether, slightly soluble in cold water, more soluble in hot water (the solution being weakly alkaline), and easily soluble in alcohol or slightly acidulated water, from which they were precipitated by alkalis.

With acids the substance formed crystalline salts; with hydrochloric acid it formed needles grouped in stars. Precipitates were produced with gold chloride, Mayer's reagent, sublimate, palladium protochloride, potassium iodide, iodine and tannin. The characteristic reaction was that the crystals, wet with ether, triturated, dissolved by a few drops of sulphuric acid, and evaporated in mild heat, left a dark-green residue that gave a brown solution with water. The mother-liquor after removal of the crystals did not give any crystalline product with various solvents. The etheric solution furnished 0.72 per cent of a yellowish, bitter, amorphous substance which was soluble in ether, amylic alcohol and water.

THE OIL

Sapucainha oil may be obtained by expression, by extraction with organic solvents, or by heating the triturated seeds in hot water and decanting, the last being the procedure most used by the natives of the country. At 22°C. the oil is fluid, of thick consistence, its color varying from pale- to brownish-yellow, with the characteristic odor of chaulmoogra oil. It solidifies below 16°C. and liquefies at

[1] Personal communication.

20°C. It is easily dissolved in ether, chloroform, benzol, carbon disulphide, petroleum-ether, amylic alcohol and vaseline-oil. According to Peckolt (23):

. . . . The oil is thick, pale-brown, odorless, having at first a mild taste of butter, later becoming rancid and irritating to taste. At 15°C. it has a greasy consistence (sp. gr. 0.940); at 19°C. it is thick; at 21°C. it is thin, yellowish, with an apple-like odor. When heated it develops the characteristic carpotroche odor, like that of butyric acid. Reaction weakly acid. Soluble in carbon tetrachloride, petroleum-ether, benzol, chloroform, ether, and etheric oils; also (1 to 25) in absolute alcohol, and (1 to 80) in boiling alcohol. Easily saponified, forming a white, strongly foaming soap.

With mercuric nitrate the oil becomes fixed after 3 hours as a dark yellowish-orange paste. With sulphuric and nitric acids it becomes dark yellow after 2 minutes, forming after 5 minutes a dark-red jelly-like paste. With sulphuric acid it is burned, becoming a viscous, dark-brown paste after 10 minutes. Fuming nitric acid reacts so violently that it must be added drop by drop; the oil is reduced to a viscous lemon-yellow paste. Nitric acid after 15 minutes produces an ash-brown color that turns to brilliant brown-violet; the yellowish color returns on heating, but the oil darkens again when cooled and, after many hours, becomes a viscous, blood-colored paste. It does not react with hydrochloric acid in the cold; on heating it becomes colorless.

Iodine is soluble in the oil, slowly, without change of temperature; the oil becomes dark green by transmitted light and is no longer soluble in alcohol (sp. gr. 0.830), though with absolute alcohol it gives a transparent brown solution. On evaporation the oil becomes thick and dark-brown, giving with sulphuric acid a transparent brown solution. With the addition of water a brown fat is separated; this, when exposed to air, becomes violet; the acidulated water does not give the iodine reaction with starch solution. With ammonia the iodized oil gives a brownish emulsion, with water a turbid brown solution. On adding chlorine the oil absorbs 9 per cent, forming a white emulsion which on the following day furnishes, at 23°C., a fatty paste as white as snow. This melts at 36°C., becoming transparent and colorless; its specific gravity at 15°C. is 0.960.

From the oil there have been obtained: (1) a white, crystalline, volatile fatty acid of peculiar and penetrating odor (25 per cent); (2) carpotrochinic acid (31 per cent), which is yellow, of goose-grease consistence, with a characteristic odor and a very disagreeable taste; (3) carpotrocholeinic acid (32 per cent), a thick fat which at 27°C. is an oil of yellowish transparent aspect, and that at first has a mild taste of rancid butter but later becomes irritant and quite disagreeable; (4) palmitinic acid (12 per cent) crystalline, white, odorless and tasteless, melting point 60°C.

Recent analyses.—In 1925, André (3) extracted the oil from seeds and published its physical constants. His figures, and those of other authors who have reported on the matter since then, are given in Table 1.

TABLE 1.—*Constants of Carpotroche brasiliensis oil.*

Author and reference	Specific gravity	Refractive index	F.p. or M.p.	Specific rotatory power	Iodine number, Hanus	Saponification value	Acid value
André, 1925 (3)	0.95(32°)	1.475(31°)	M.p. 21-23°	+53.4	106.1	183.7	
Machado, 1926 (15)...	—	1.472	—	+52-54 [a]	102-110	185-200	1.25-3.8
Da Silva, 1926 (33)...	0.95(25°)	1.472	F.p. 16°	+54 [b]	108	185	2-6
Jamieson, 1931 (10)...	—	1.479(25°)	—	+58.9	112.8	201	0-4
Rothe, etc., 1931 (30)..	0.9486(20°)	—	—	+52.0	101.6	204.4	—
Emmerich, 1932 [c]	0.9488(20°)	1.479(25°)	—	+51.9	101.9	203.2	—
Paget, etc., 1934 [d]	0.9563(25°)	—	—	+54.0	101.3	199.7	21.7
Gonsalves, 1934[e]	0.9584(20°)	1.478(27°)	M.p. 15° [f]	+51.2	111.7	198.8	6.53
Gonsalves, 1934[e]	0.9577(20°)	1.478(27°)	M.p. 15° [g]	+51.5	108.1	200.7	15.86

[a] Determined in a 1:20 solution in chloroform. [b] Between +52° and 56°, determined in a 1:10 solution in chloroform at 25°C. [c] Averages of six samples; personal communication. [d] See footnote, p. 56. [e] Hitherto unpublished; two samples examined. [f] Freezing point 12°C. [g] Freezing point 9°C.

Constants additional to those shown in the table are given by da Silva as follows: index of volatile and soluble fatty acids (Reichert-Meissl-Polenske) 1.21 cc.; the same for the insoluble acids, 0.6 cc. Rothe and Sorerus give the following additional data: refractive index $nD^{24} = 1.4822$; $nD^{40} = 1.4761$; acidity 13.21 cc.; molecular weight of the fatty acids 286.77; melting point of the fatty acids 29.5; Reichert-Meissl index 0.55; Polenske index 0.12; neutralization of the fatty acids 195.83; Pehner 95.08.

The last two analyses shown in this table were made at my request by Dr. N. Botafogo Gonsalves, chief of laboratory, chemical department, of this institute. The first sample was from Miracema, State of Rio de Janeiro, bought on the market in Rio. The second was from Leopoldina, Minas Geraes, kindly sent us by Messrs. A. Machado & Co. A sample of carpotrochic acid, also furnished by Machado, is being studied with regard to its constants and its bacteriolytic power.

The chaulmoogra-group acids.—Machado (15) points out that Peckolt found four acids: carpotrochic, carpotrochinic, carpotrocholeinic and palmitinic, all of unknown constitution. He himself claimed to have isolated in purity the acids of the said oil (the number isolated not stated), and investigated their constitution and properties. He holds that the first two of the Peckolt's acids have the same characteristics as the chaulmoogric acids.

Carpotrochic acid he describes as whitish, scaly, melting at 36°C., easily soluble in 80 per cent alcohol and ether. White precipitates are formed with lead, calcium and strontium salts. It reduces trinitrophenol in picramic acid, with a red color. Its empirical formula is $C_{11}H_{18}O_2$, it being an isomer of undecolic acid of the propiolic series, the general formula of which is CnH_2n4O_2. It resembles chaulmoogric acids in the presence of a closed ring of five carbon atoms, and in its strong dextro-rotatory power.

Carpotrochinic acid is a thick fluid, density 0.86, easily soluble in cold alcohol. It does not reduce trinitrophenol, this distinguishing it from carpotrochic acid. Machado gives it the general formula of $C_{10}H_{16}O_2$, this being isomeric with the geranium acid of the propiolic series. It has a high dextro-rotatory power, and the five-carbon-atom ring structure that characterizes the chaulmoogra group.

The chaulmoogric series is now represented, says Machado, by chaulmoogric acid (M.p. 68°C.), hydnocarpic acid (M.p. 58°C.), carpotrochic acid (M.p. 26°C.), and carpotrochinic acid (liquid). Their formulae and other data are given in a table here reproduced (Table 2). This shows that carpotrochic acid has a comparatively high rotatory power, a high iodine number, and the lowest melting and neutralization points. Machado holds that this acid, having only five methylenic (CH_2) radicals, must be seven times more effective than chaulmoogric acid and five times more active than hydnocarpic acid, and that carpotrochinic acid must be still more active. That the carpotroche acids have lower melting points than the chaulmoogric acids is a further indication that they are more active, he holds, asserting that the activity of chaulmoogra oil depends upon (a) high rotatory power (Swartz); (b) high iodine saturation index (Hubl); and (c) low hyperglycemiant action (Muir, Machado). Lee showed that the hyperglycemiant effect of chaulmoogra drugs is due to the unsaturation of the fatty acids and the even number of carbon atoms. Carpotrochic acid is the only one in the table with an uneven carbon number. Machado found by injecting dogs and sheep intravenously that carpotrochic acid is only slightly hyperglycemiant, if at all, "which makes it convenient for use against leprosy."

TABLE 2.—*Constants of the fatty acids from different chaulmoogra oils* (*Machado*).

Source	Acid	Rotatory power $[\alpha]D^{25}$	Iodine number	Melting point	Neutralization index
Taktogenos and *Hydnocarpus* oils	Chaulmoogric $C_{18}H_{32}O_2$	+62	90.1	68°C.	280.3
Do.	Hydnocarpic $C_{16}H_{28}O_2$	+68	100.2	59°C.	256.2
Oncoba equinata	Gorlic $C_{18}H_{32}O_2$	+50.1	170.0	—	199.5
Carpotroche brasiliensis	Carpotrochic $C_{11}H_{18}O_2$	+54.0	139.2	26°C.	128.2
Do.	Carpotrochinic $C_{10}H_{16}O_2$	+69.4	150.4	18°C.	168.3

Da Silva (33) disagreed with the findings of Machado, holding that the acids obtained by Peckolt are only mixtures of fatty acids in different proportions, and that chaulmoogric and hydnocarpic acids predominate among them and are responsible for the specific action of the oil against acid-fast bacilli. By repeated fractionations he obtained a product with M.p., 59°-60°C., specific rotatory power $[\alpha]D^{25}+68.3$ (1:10 in chloroform) and iodine value 100.2; this he identified as pure hydnocarpic acid. One fraction gave him another product with M.p. 68°-68.5°C. (i.e., the same as pure chaulmoogric acid), $[\alpha]D^{25}+62.2$ and iodine value 90.1. He concluded not only that the active acids of carpotroche oil are the same as those of the true chaulmoogra oil, but also that the specific rotation shows that the proportions of chaulmoogric and hydnocarpic acids in them are nearly the same. He insisted on the impossibility of isolating the acids "in an absolute state of purity," a view concurred in by Cole (6) who, speaking of the chaulmoogra-group oils, says:

> Their analysis is not without difficulty, for it has not been possible up to the present to separate quantitatively the hydnocarpic acid from the chaulmoogric, or these from other fatty acids.

Rothe and Sorerus, in 1931 (30), reported on comparative analyses of chaulmoogra (hydnocarpus) and carpotroche oils. From both they obtained acids melting at 68.5°C., with specific rotations of +62.4 and +62.53, respectively, that seemed to be alike, and they concluded that carpotrochic and chaulmoogric acids are identical. By repeated recrystallization of the fatty acids of carpotrochic oil (which gives 85 per cent fatty acids), they obtained in ethyl alcohol an acid melting at 68.5°, optic activity +62.53, which was similar to chaulmoogric acid. Their principal conclusion is that carpotroche oil contains chaulmoogric acid in the form of glycerides.[2]

EXPERIMENTAL CULTIVATION OF CARPOTROCHE

In 1931 P. H. Rolfs and C. Rolfs (29) published a booklet summarizing their six years' experience with the cultivation of sapucainha, from which the following data are borrowed:

> Seeds from a native tree were planted; 16 per cent germinated. The sprouts were transplanted to shaded places. After fourteen months the average height of 136 young plants was 76 cms.; 18 per cent were between 26 and 50 cms., 24 per cent between 51 and 75 cms., and 28 per cent between 76 and 100 cms. After 41 months the average height was 197 cms.; 20 per cent being from 101 to 150 cms., 31 per cent from 151 to 200 cms., and 28 per cent from 201 to 250 cms. About 10 per cent had died. The authors concluded that they should have destroyed all trees below 71 cm. (41 per cent). For grafting only the vigorous trees are useful.
>
> When unopened dried fruits are planted they take one to two years to germinate, about 20 per cent of the seeds sprouting. Many of the others remain

[2] While the present articles was in press there appeared in this JOURNAL [2 (1934) 149-158] an article by Paget, Trevan and Attwood reporting certain investigations of sapucainha oil. Their yield by extraction with carbon tetrachloride was 41.2 per cent. The bulk of the fatty acids they identified as chaulmoogric and hydnocarpic. The constants of the oil which they reported have been included in Table 1, for the sake of completeness.—EDITOR.

for a long time in good condition but without signs of germination. The fruits undergo putrefaction within one to two years in the earth or below decayed leaves. In the forest the ripe fruits on the trees are eaten by monkeys; on the ground most of them are eaten by "cutia" (*Dasyprocta aguti*) or other gnawing animals, for which reason most of them rot quickly.

In January, 1929, a total of 1,771 young sprouts were changed to a nursery. They were divided into three classes: (1) 350 sprouts more than 15 cm. high; (2) 471 sprouts from 8 to 15 cm. high; (3) 950 sprouts smaller than 8 cm. They were protected from the sun by means of palm leaves; sapucainha lives naturally in the shade, beneath big trees; and shade to protect the new plants is imperative for a long time. When they get to be 25 cm. in height they can bear the sun, but they grow better when shaded. Thirteen months after transplanting 1,114 (68 per cent) had died. In May and July, 1930, 505 small trees were moved from the nursery to the orchard. After 14 months 3 per cent of these had died; the living ones averaged 63 cm. in height, only 28 per cent of them being more than 76 cm. Freezing did not hurt the young trees greatly.

By January, 1931, 37 per cent of the plants had bloomed. Of these many proved to be hermaphroditic; the ratio of these to the staminifers was 16:21, these figures being the percentage of all the plants represented by these groups; the remaining 63 per cent had not yet bloomed. Among the native trees encountered in the forest only 6 per cent give hermaphroditic flowers, according to Kuhlmann, though other observers have found about 10 per cent.

Grafting succeeded in 85 per cent of instances when the sprouts were inserted in "horses" of from 12 to 23 mm. in diameter. On 106 young trees 540 buds were grafted, about 5 per tree, and 133 (20 per cent) succeeded, which was considered very satisfactory; before that it was not known whether sapucainha could be grafted. The method of grafting was in "T", as for citrus trees, the binding of the buds being covered with bee-wax. By improving the method 34 per cent success was obtained. After four months the buds had become branches from 23 to 78 cms. long.

Trees obtained from seeds gave ripe fruits in two and a half years[3]. In 1929 Tree No. 1 produced 798 fruits weighing 171 kilograms and yielding 28 kilograms of seeds. This yield is extraordinary. Tree No. 2 produced, in 1930, only 600 seeds, which shows the irregularity of the production.

The authors concluded that it is necessary to make nurseries for the production of trees for grafting, those coming from the forest being of poor quality and doubtful productivity. Sapucainha is easily domesticated, and technical grafting succeeds in high per-

[3] In 1861 Peckolt wrote that trees obtained from seeds fruit in the eighth or ninth year, giving abundant fruits every year.

centages of instances. The best time to graft a plant is when new buds appear. For each good plant 15 to 50 seeds must be sown in the seed-bed.

My personal experience in this matter began in September, 1933, when I visited the forest of Trapicheiro, near Rio City, and found the well-known *Carpotroche brasiliensis* trees to be covered with leaves but without flowers or fruit. Branches that were cut then and planted in the orchard of the Instituto Oswaldo Cruz all died. In January, 1934, when I again visited the forest, with Prof. Kuhlmann, we found the trees in leaf and bearing some green fruits. On the ground around the trees there were innumerable young plants, and below the dirt or decayed leaves were some rotten fruits and many seeds that had sprouted (Fig. 8). The sprouts and germinating seeds were collected (Fig. 10) and planted on the same day in Manguinhos. The majority of them died, but at the time of writing (August, 1934) we have in the garden about one hundred small plants gotten from seeds or sprouts.

COMMERCIAL PRODUCTS OF SAPUCAINHA OIL

There are on the market several products of the Brazilian chaulmoogra oil, of which the principal ones are:

(1) HANSENYL, ethyl esters of carpotroche oil with ethyl morrhuate. Recommended for leprosy and tuberculosis. (Granado & Co., Rio de Janeiro).

(2) CARPOTRENOL (L.C.L.), ethyl esters of carpotroche oil. For intramuscular use in leprosy.

(3) CARPOIDIL, tabloids of magnesium iodocarpotrochate, for internal use. (The last two products from Laboratorio Chimico Leopoldinense, Minas Geraes, Prof. A. Machado & Co.).

(4) KARPOTRAN, "a physiohydrosol of cupric carpotrochate, sterile, with an absolute titre of 1:1,000, isotonic," marketed in ampules. (Instituto Therapeutico Orlando Rangel, Rio de Janeiro).

(5) AUROCARPOL, of two kinds: "A", iodine carpotrochate of gold and sodium 0.064, water q.s. 2 cc.; "B", iodo-carpotrochate of gold and sodium 0.096, water q.s. 3 cc. For intravenous and intramuscular injections.

(6) PROTOCARPOL, a sodium carpotrochate, iodized, 0.06; iodo-protein (carpotroche oil) 0.20. In ampules of 2 cc., for intramuscular use with aurocarpol.

(7) CARPOL, in tabloids: sodium carpotrochate iodized, 0.40; calcium phospho-caseinate, 0.20. For internal use.

(8) CARPOL in gelatin capsules (perles): iodized ethyl esters of carpotroche oil, 0.50; ethyl esters of cod liver oil 0.20. (The last four products by Dr. Raul Leite & Co., Rio de Janeiro.)

In Sao Paulo there are other products of sapucainha oil on the market. The seeds of this plant, its oil, esters and acids are obtainable commercially in Rio de Janeiro. The cost of the oil is 20$ milreis per kilogram (about $1.50 U. S. currency).

LEGISLATION

The Brazilian pharmacopoeia, approved by decree No. 17,509 of November 4, 1926, and enforced since August, 1929, requires for the chaulmoogra oil a minimum dextro-rotatory power of $[a]D+44.5$. The United States pharmacopoeia (10th edition, 1926) requires a minimum of $[a]D+44.5$.

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DESCRIPTION OF PLATES

All photographs in Plates 1 to 5 from the collection of the Instituto Oswaldo Cruz. The expense of the extra plates used to illustrate this article is met from a special fund provided by the author.

PLATE 1.

FIG. 1. A large *Carpotroche brasiliensis* tree in the Andarahy forest, Rio de Janeiro City. Prof. Kuhlmann and Dr. Souza-Araujo, left and right, respectively.

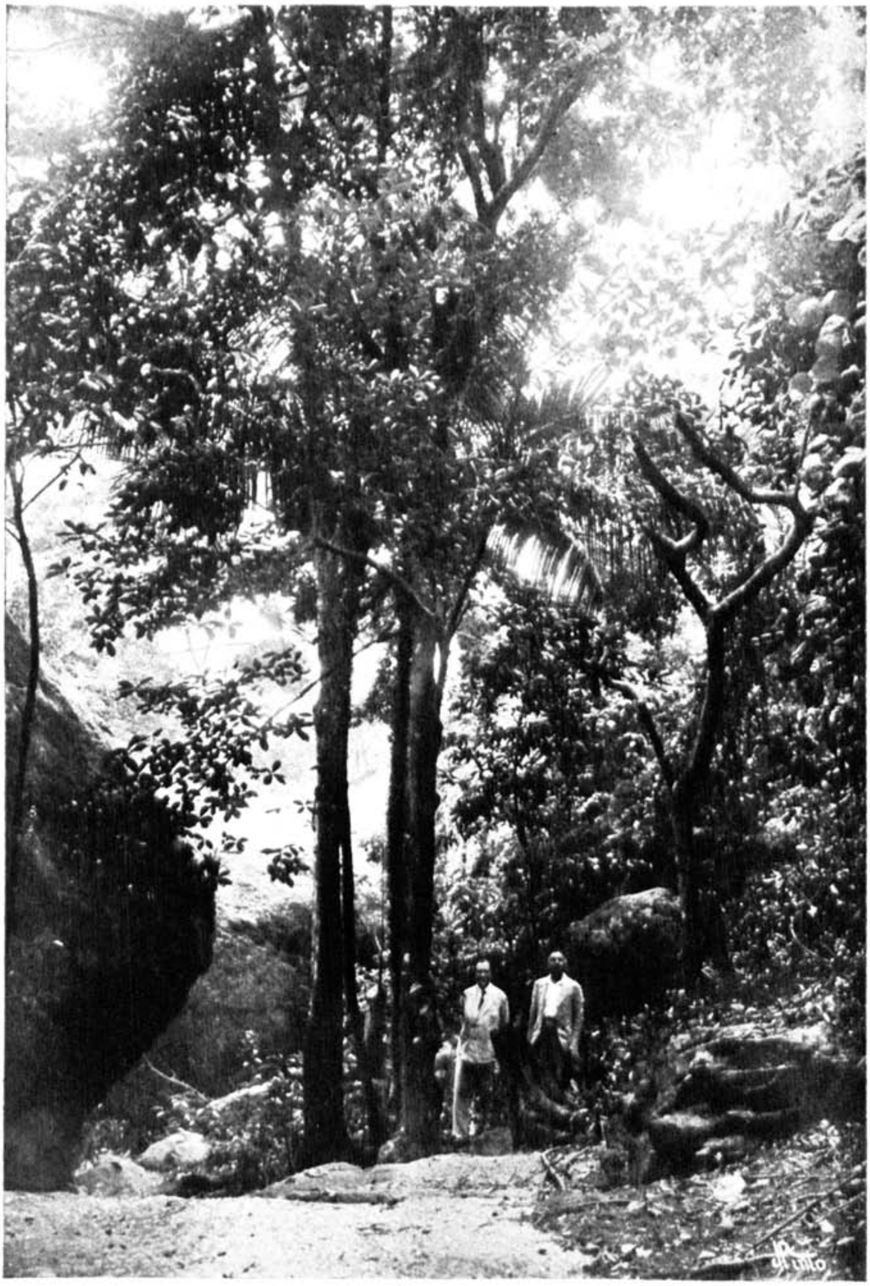

PLATE 1.

PLATE 2.

FIG. 2. *C. brasiliensis*, Endl. Branch with male inflorescence; branch with hermaphroditic flowers; fruit full and entire, and cut transversely; floral diagram, etc. Apud Martius, *Flora* Brasiliensis, vol. 13, pars. 1, fig. 88. Monachi, 1841-1872.

PLATE 2.

PLATE 3.

FIG. 3. The usual aspect of the dried fruit of *C. brasiliensis*. Lateral view of fruits of different sizes.

FIG. 4. End views of the usual fruit of *C. brasiliensis*.

FIG. 5. The same fruit as in the preceding figure, cut transversely to show the seeds.

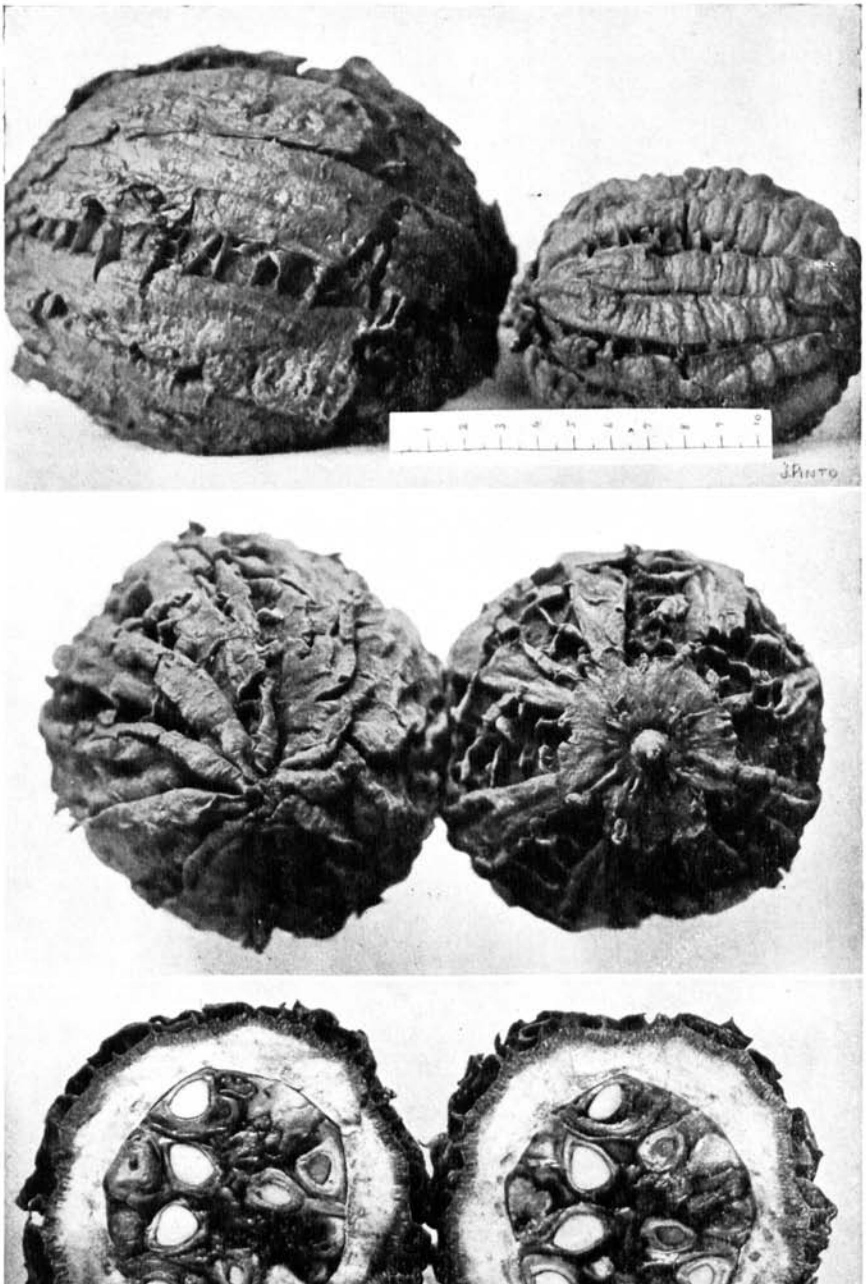

PLATE 3.

PLATE 4.

FIG. 6. The fringed variety of the fruits of *C. brasiliensis*, end view.

FIG. 7. The same fruit as in the preceding figure, cut transversely to show the seeds.

FIG. 8. An opened fruit with scattered seeds on the ground in the Andarahy forest. Note that some of the seeds have germinated, the sprouts entering the ground.

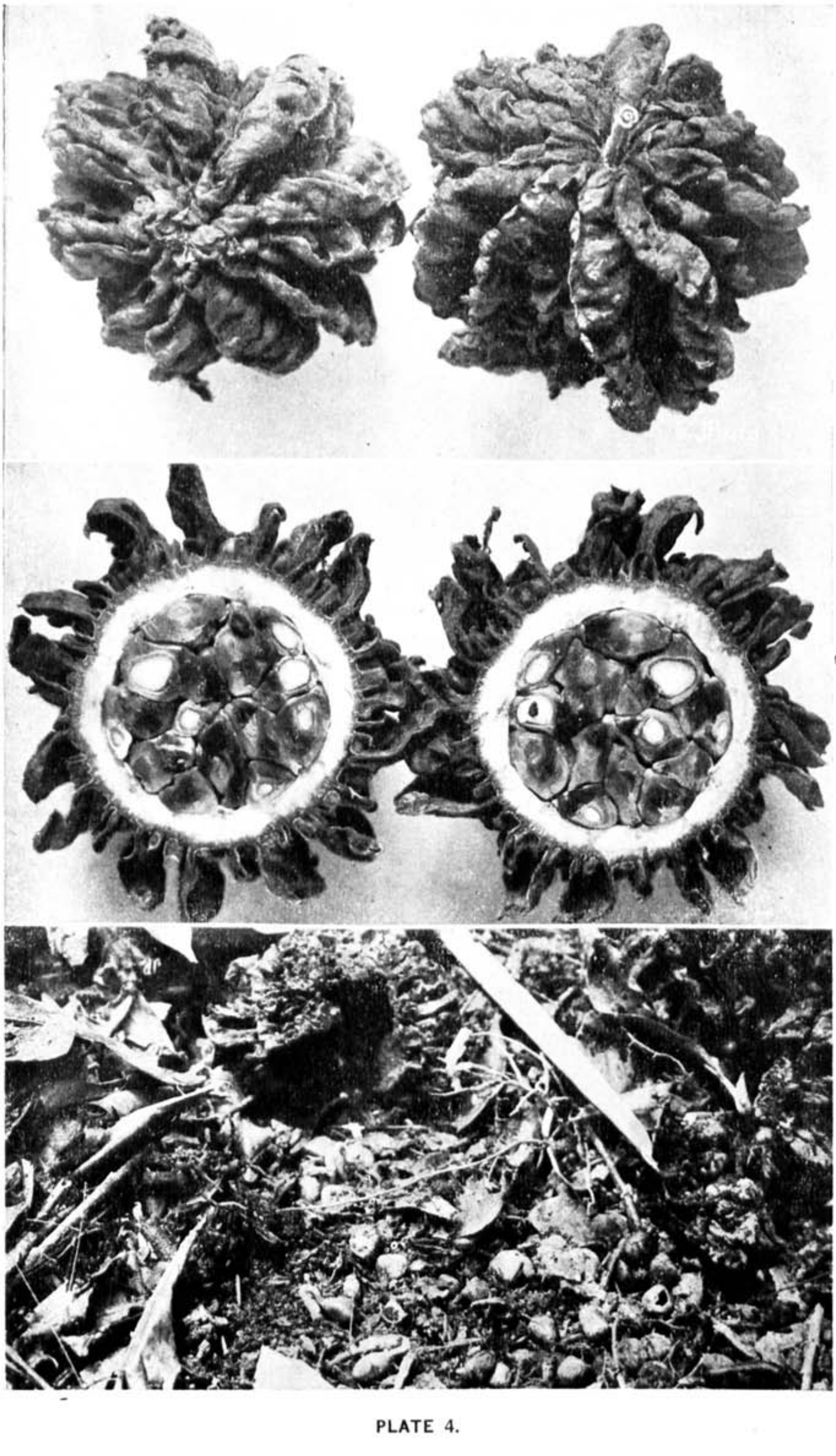

PLATE 4.

PLATE 5.

FIG. 9. Dried fruits and seeds of *C. brasiliensis* collected near Rio de Janeiro.

FIG. 10. Germinating seeds of *C. brasiliensis*. The portions of the sprouts which had penetrated the ground have withered since removal. Sizes are indicated by the scale.

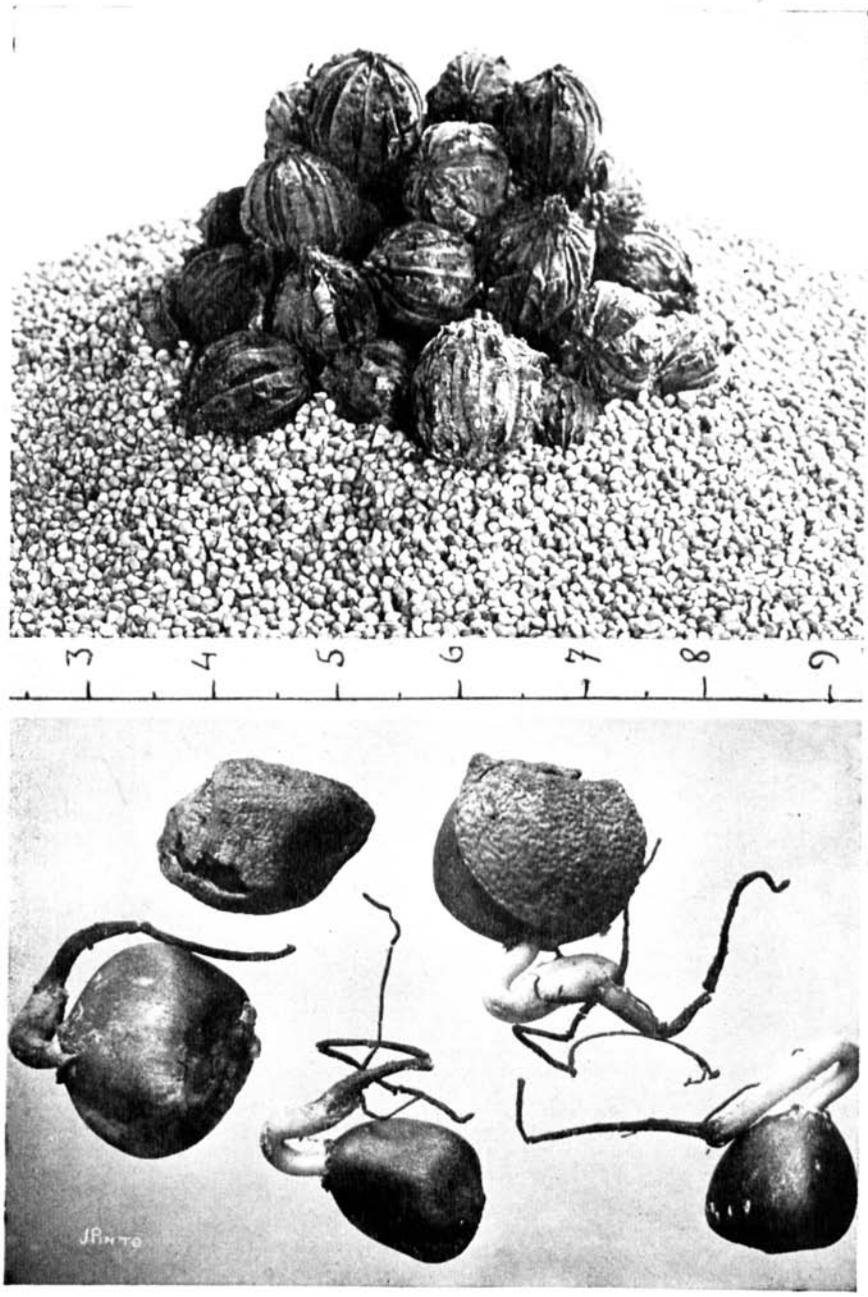

PLATE 5.

PLATE 6.

Chaulmoogra plantation at the School of Agriculture, Viçosa, Minas Geraes.

FIG. 11. A male tree of *Taraktogenos kurzii*, eight years old. (Dr. Carvalho Araujo.)

FIG. 12. An eight-year *T. kurzii* tree with fruits. (Dr. Souza-Araujo.)

FIG. 13. Plants of *C. brasiliensis* two to three years old.

FIG. 14. Young *C. brasiliensis* trees covered with fruits.

FIG. 15. Nearly ripe fruit on a young tree.

PLATE 6.