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Cocobolo

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COCOBOLO

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Cocobolo tree *(Dalbergia hypoleuca* Pittier) in Costa Rica.

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COCOBOLO

BY SAMUEL J. RECORD AND GEORGE A. GARRATT

INTRODUCTION

COCOBOLO is a valuable timber of commerce that has been in use in this country, particularly for handles of cutlery, for more than fifty years. It is produced by certain species of *Dalbergia* indigenous to Central America and southwestern Mexico. The present commercial sources are Panama, Costa Rica, and Nicaragua.

Cocobolo was first introduced into the trade from Panama. The tree was briefly described by Hemsley in 1878 and named *Dalbergia retusa;* but the fact that this tree was the source of cocobolo of commerce appears to have been discovered first about 1911 by Mr. Henry Pittier, and made public in a paper read at a meeting of the Biological Society of Washington, November 18, 1916, and published in the Journal of Forestry (16: 1: 76-84) January, 1918. The Costa Rican cocobolo tree was described by Pittier[1] in 1922 and named *Dalbergia hypoleuca,* the specific name referring to the grayish or whitish under surface of the leaves. A third species, a Mexican tree, was described by Pittier *(loc. cit.)* in 1922 and named *Dalbergia GranadiZlo.* This tree is also described by Standley[2] from the same botanical material and named *Amerimnon Granadillo.*[3] The fact that this species produces cocobolo has been established by the present authors from material collected by Mr. John A. Gamon. The additional fact that the Nicaraguan cocobolo is the product of both *D. retusa* and *D. hypoleuca* has been determined from material supplied by Messrs. E. Palazio and Co., of

1 PITTIER,-H.: On the species of *Dalbergia* of Mexico and Central America. Journ. Wash. Acad. Sci., **12**: 3: **62,** Feb. 4, 1922.

2 STANDLEY, PAUL C.: Trees and shrubs of Mexico. Contr. U. S. Nat. Herb., **23**: 2, 1922.

3 According to Pittier *(loc. cit.,* p. 55), "The resuscitation of *Amerimnon* as a substitute for *Dalbergia* would cause a great and useless confusion, even omitting the fact that it cannot be applied to the genus as understood today."

Corinto. The existence of cocobolo in Honduras has been ascertained through a study of the woods from that country in the Yale collections.

The literature on cocobolo is very meager. In 1921, the senior author[4] published a preliminary report embodying the results of investigations concerning the poisonous properties of the wood. It is believed that this paper had a beneficial reaction on the trade in bringing into the open what the editor of Raw Material called a "whispering campaign against cocobolo." It also stimulated laboratory and clinical research by Dr. Ettore Ciampolini, a student in the Graduate School of Yale University. Since he has not published his results, only brief reference to them can be made in this bulletin.

The purpose of this publication is to bring together all of the important information available concerning cocobolo, both from the botanical and the commercial standpoint. It is herein shown that the cocobolo of Costa Rica and Nicaragua is true cocobolo and not a substitute as commonly believed, and the attention of the trade is directed to Honduras and the west coast of southern Mexico as possible new sources of supply.

[4] RECORD, SAMUEL J.: Cocobolo-The truth about the cutlery trade's principal wood. Raw Material, New York, 4: 11: 402-406, Nov. 1921.

PART I: FROM THE BOTANICAL STANDPOINT

THE FAMILY

COCOBOLO belongs to the sub-family Papilionatae, one of the three great divisions[1] of the family Leguminosae. There are about 500 genera and 15,000 species of trees, shrubs, and herbaceous plants in this family, and it is represented in every country of the world. Among the herbaceous forms are such well-known and useful plants as beans, peas, and clovers. Of the comparatively few trees of the family in the United States, mention may be made of the black locust, *Robinia Pseudacacia* L., the honey locust, *Gleditsia triacanthos* L., the Kentucky coffee tree, *Gymnocladus dioicus* K. Koch, the red-bud or Judas tree, *Cercis canadensis* L., and the mesquite, *Prosopis julifiora* DC. The family is abundantly represented in the tropics, and from this source come some of the most valuable woods known for cabinetwork, musical instruments, carving, inlaying, and for a great many other purposes, including dyestuffs. The woods range in density from as light as cork to as heavy as lignum-vitae. Their colors embrace the whole spectrum and while some of the woods are plain and dull, others are beautiful and highly figured. Many are fragrantly scented and to this group belong most of the rosewoods of commerce. A few kinds have a characteristic taste which may be pleasant, astringent, or exceedingly bitter.

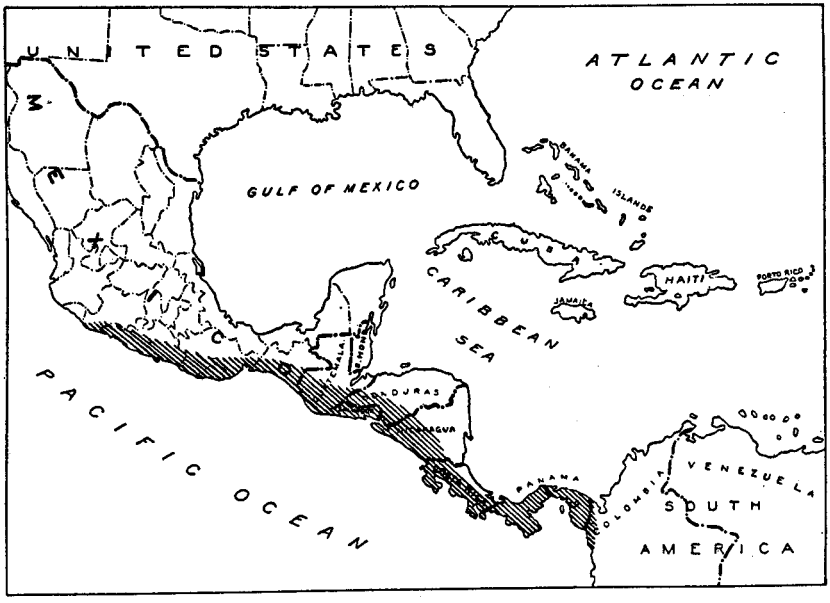
THE GENUS

The genus *Dalbergia* consists of over 200 species of trees and shrubs widely distributed throughout the tropical regions of the world. According to Gamble[2] there are about 36 species in India, about half that number being trees and the others climbing or straggling shrubs. The "sissoo," *Dalbergia Sissoo* Roxb., and the blackwood or rosewood of southern India, *D. latifolia* Roxb., are said to be "two of the most valuable and important of Indian forest trees." The African blackwood or Senegal ebony, *D. Melanoxylon* G. & P., is well known in the manufacture of musical instruments

1 Some botanists consider each of these divisions as a separate family and call the Papilionatae the Fabaceae.

2 GAMBLE, J. S.: A manual of Indian timbers, London, 1920, p. 246.

and in carving. The Madagascar rosewood, probably *D. Baroni* Baker, is used for cabinetwork and to some extent as a substitute for cocobolo; one New York dealer sells it under the name of "African cocobolo." There are many tropical American species, but only one, *D. Ecastophyllum* (L.) Taub., a shrub in southern Florida, occurs in the United States. The "jacarandá" of Brazil, *Dalbergia nigra* Fr. Allemão, is the source of the true Brazilian rosewood, one of the best-known timbers of South America.



Map showing the range of cocobolo.

The identity of the Honduras rosewood, prized for certain musical instruments because of its resonance, has not been determined, but the structure of the wood indicates *Dalbergia,* rosewood type.

The Species Producing Cocobolo

The three species known to produce cocobolo have a combined range extending from southern Panama to southwestern Mexico, inclusive.[3] (See map.) The trees are of limited occurrence and are found scatteringly

[3] The statement in the dictionaries that cocobolo is a wood of West Indian origin is incorrect.

or in small clumps in mixed hardwood forests, usually in the drier uplands. The specific ranges are imperfectly known, but evidently they are overlapping. *Dalbergia retusa* Hemsley is the only species reported from Panama and it also occurs in Costa Rica and Nicaragua; it probably extends southward into northern Colombia, though there is no record of its having been found there. *Dalbergia hypoleuca* Pittier, the common species in Costa Rica, occurs also in Nicaragua, and is probably the source of the wood specimens in the Yale collections from Honduras. *Dalbergia Granadillo* Pittier (=*Amerimnon Granadillo* Standley) has been reported only from southwestern Mexico, but doubtless extends into Guatemala. Two other species, *D. calycina* Benth. of Guatemala and *D. lineata* Pittier of Costa Rica, are classified by Pittier[4] in the same section with the three species known to produce cocobolo, but no wood specimens are available for study. Regarding *D. lineata* he says (*loc. cit.*, p. 64): "The affinities of this species are evidently with *Dalbergia retusa* Hemsley." According to the collector, Mr. Tonduz, this tree is a preponderant one in the forests of Nicoya, "being gregarious and giving a characteristic bluish-gray color to the forests in April, the flowering time."

PITTIER'S KEY TO THE MIDDLE AMERICAN SPECIES OF DALBERGIA, SECTION MISCOLOBIUM

Flowers not less than 14 mm. long; style long and strongly arcuate; legume more or less lanceolate, 1 to 5-seeded. Stamens 10. (*Miscolobium.*)
- Leaves entirely glabrous, 5 to 7-foliolate, the leaflets 3 to 4 cm. long. — *D. calycina.*
- Leaves more or less pubescent, 7 to 15-foliolate.
  - Leaves and pods hardly changing color in desiccation; leaflets 7 to 11, ovate, glaucous beneath; legume 1 to 5-seeded, rounded-obtuse at the apex. — *D. hypoleuca.*
  - Leaves and pods turning black in desiccation.
    - Leaflets suborbiculate or broadly ovate, not over 5 cm. long, the margin not revolute. — *D. Granadillo.*
    - Leaflets ovate or oblong, up to 10.5 cm. long, the margins revolute.

[4] PITTIER, H.: On the species of *Dalbergia* of Mexico and Central America. Journ. Wash. Acad. Sci., 12: 3: 54-64, Feb. 4, 1922.

Flowers about 15 mm. long, the pedicels 4 to 5 mm. long; standard suborbiculate, more or less emarginate at the base. *D. retusa.*

Flowers about 16 mm. long, the pedicels about 5 mm. long; standard ovate or oblong, attenuate at the base. *D. lineata.*

BOTANICAL DESCRIPTION OF THE SPECIES KNOWN TO PRODUCE COCOBOLO

Dalbergia retusa Hemsley, Diagn. PI. Nov., 1: 8 (1878).

"Puberula, foHis 4-5 jugis petiolatis, foliolis breviter petiolulatis ovato-oblongis retusis 1½-4 polL longis, floribus corymbosis."

"Panama: in sylvis propre Paraiso, *Sutton-Hayes* 642. (Hb. Kew)." (Hemsley, *loco cit.)*

The following description of the species is contributed by Pittier:

"Deciduous tree up to 25 m. high, the trunk 40 em. in diameter more or less. Very variable in its habit, being sometimes low and spreading, sometimes high with a straight trunk and a more elongate crown.

"Leaves alternate, 9 to 14-foliolate, the green color turning to black in desiccation, the rachis, sparsely pubescent, 14 to 20 em. long. Leaflets at first tender and drooping on freshly picked leaves, later coriaceous, the petiolules ferruginous-pubescent, 4 to 6 mm. long, the blades ovate or ovate-oblong, rounded at the base, bluntly acuminate and often retuse at the apex, 3.5 to 10.5 em. long, 2.3 to 4 em. broad, glabrous, dark green above, paler beneath, revolute on the margin. [See Plate I.]

"Floral racemes axillary, few-flowered, sparsely branched, 6 to 10 em. long, the rachis minutely ferruginous-pubescent. Pedicels 4 to 5 mm. long. Flowers white, about 15 mm. long. Calyx campanulate, 6 to 7 mm. long, ferruginous-pubescent, the interior lobes broad and connate, the lateral ones narrower, the posterior lobe more or less mucronate and longer. Petals glabrous, with long claws, the standard suborbiculate, about 14.5 mm. long, the wings free, ovate, about 14 mm. long, the carina falcate, obtuse, shorter than the wings. Stamens 10, the vexillar one usually free. Ovary long stipitate, 3 to 6-ovulate, the style long and slightly arcuate, with a minute, capitellate stigma.

"Legume ovate-elliptic, flat, glabrous, usually 1-seeded and 7 em. long, 2.5 em. broad, or 2 to 4-seeded and then up to 12 em. long. Seeds oblong, subreniform, flat, 11 mm. long, 6.5 mm. broad." (See Plate I.)

The following is taken from Pittier's paper *(loc. cit.)* p. 63) :

"TYPE LOCALITY: Paraiso, Panama *(Hayes 642).*

"SPECIMENS EXAMINED:

"PANAMA: Penonome, Coclé, 1908, *Williams* 425; Chagres River above Alhajuela, 1911, *Pittiel'* 3511; vicinity of La Palma, southern Darien, 1914, *Pittiel' 6606.*

"COSTA RICA: Salinas Bay, between the littoral plain and La Cruz de Guanacaste, 1908, *Pittiel' 2737.*

"This is the Panama 'cocobola,' a hardwood very well known commercially and obtained probably from several species of the same genus. I have seen no specimens from the type collection, but ours agree generally with the description. The leaflets, however, are more numerous and not usually retuse and the flowers seem to be smaller.

"In Panama this tree has been exploited with such diligence as to have become very scarce in the central and western districts. In 1914 the more important logging camps were at Sumacate and Rio Congo in Darien."

Specimens of the leaves (see Plate II) collected by Messrs. E. Palazio and Co., Corinto, Nicaragua, have been identified at the United States National Herbarium as *Dalbergia l'etusa* Hemsley.

Dalbergia hypoleuca Pittier, Journ. Wash. Acad. Sci., 12: 3: 62 (1922).

"Tree; young branchlets ferruginous-pubescent.

"Leaves 7 to II-foliolate, the rachis terete, pubescent, glabrescent, 10 to 20 cm. long. Leaflets coriaceous, often opposite or subopposite, the petiolules canaliculate, grayish-pubescent, 5 to 7 mm. long, the blades ovate or ovate-oblong, rounded at the base, obtuse and subretuse at the apex, 3 to 7 em. long, 2 to 3 em. broad, glabrous and finely reticulate with the venation prominulous above, beneath grayish or whitish, minutely pubescent, with the costa very prominent and the veins slightly so; margins strongly revolute. [See Plate III.]

"Inflorescence axillary or tenninal. Flowers not known.[5]

"Legume coriaceous, glabrous, long-stipitate, rounded-attenuate at the base, rounded and mucronulate at the apex, 1-seeded and then 8 em. long

[5] Rachis about 6 cm. long, several branched, minutely ferruginous-pubescent. Pedicels 3 to 4 mm. long. Flowers about 12 mm. long. Calyx cupulate, 3 to 4 mm. long, ferruginous-pubescent, unequally lobed. Petals with claws 3 mm. long, glabrous; the standard rounded and 8 mm. in diameter; the wings obovate-falcate, free, 12 mm. long, 3 mm. in widest portion; carina falcate, obtuse, 9 mm. long. Stamens 10, the superior one free; anthers capitate. Ovary long-stipitate.—S. J. R., from material supplied by Messrs. Alberto Fait & Co., Puntarenas, C. R., and identified by Dr. S. F. Blake;

and 2 em. broad, or 2 to s-seeded and up to about 16 em. long, the breadth varying between 1.7 and 1 em.

"Type in the John Donnell Smith Herbarium, collected at EI Escobal, near Atenas, Costa Rica, by Federico Golcher. Represented also in the U. S. National Herbarium (No. 716263) by the same collection, without date, and numbered 1747, which probably corresponds to the series of the Instituto fisico-geografico.

"This is the Costa Rican *Cocobola,*[6] equal in value to that of Panama, but even scarcer. It is probably a close relative of the latter, but the leaflets are less numerous, and the pods much narrower." (Pittier's description, *loco cit.)*

Dalbergia Granadillo Pittier, Journ. Wash. Acad. Sci., 12: 3: 62 (1922) *(==Amerimnon GranadiUo* Standley, described below).

"Tree. Leaves 7 to 13-foliolate, the rachis terete, at first pubescent, 9 to 17.5 em. long. Leaflets submembranous, often subopposite, the petiolules sparsely pubescent or glabrescent, canaliculate, 4 to S mm. long, the blades suborbiculate or ovate, broadly rounded at the base, obtuse or subacuminate at the apex, 3 to 5.5 em. long, 2 to 4 em. broad, glabrous and reticulate with the venation prominulous above, glabrous except on the prominent, sparsely pubescent costa, and the veins prominulous, beneath, margins not revolute. [See Plate IV.]

"Inflorescence paniculate, axillary or terminal, the rachis few-branched, ferruginous-pubescent. Flowers few. Calyx cupulate, ferruginous-pubescent, persistent. Other floral details not known.

"Legume lanceolate, long-stipitate, attenuate at the base, acute at the apex, glabrous, lustrous, 1-seeded and about 9 cm. long and 1.8 or 2 em. broad, or 2 to 4-seeded and then up to 17.5 em. long. Seeds oblong-reniform, not mature.

"Type in the Gray Herbarium, collected at EI Tibor, in the valley of the Balsas River (between the States of Guerrero and Michoacan), Mexico, August 22, 1898, by E. Langlasse (No. 294).

"-Like *D. retusa* and *D. hypoleuca,* this species furnishes a precious wood, which is hard, fine, and red-veined, and is known locally as *granadillo.*

"The specimens at hand are hardly satisfactory for a description, but

6 The name cocobola is applied by the natives of Costa Rica to *Lecythis costaricensis* Pittier, family Lecythidaceae. This tree is well known on account of its fruit, called "olla de mono" or monkey-pot, the seeds of which are almost identical with the paradise or cream nuts which reach our markets from Brazil. The wood is used locally for making carts, but does not enter the export trade and has none of the attributes

they belong to a section heretofore not known to be represented in Mexico, and differ from the other Middle American species of the group in the shape, consistence and indument of the leaflets, and in the shape and appearance of the pods. It is consequently pretty safe to consider them as corresponding to a type specifically distinct." (Pittier's description, *loco cit.)*

Amerimnon Granadillo Standley,[7] Contr. U. S. Nat. Herb., 23: 2: 507 (1922).

"Oaxaca to Michoacan; type from EI Tibor, Michoacan or Guerrero, altitude 100 meters *(Langlasse* 294; U. S. Nat. Herb. No. 385583).

"Tree, the branchlets slender, glabrous; leaves glabrous, the rachis 9.5 to 18 em. long, slender, glaucescent, the petiolules 2.5 to 3 mm. long; leaflets 7 to 11, elliptic-oval or ovate-oval, 3 to 7 em. long, 1.7 to 4 em. wide, rounded at base, obtuse or rounded-obtuse at apex, sometimes with a somewhat abrupt obtuse tip, thin, bright green and lustrous on the upper surface, paler beneath, the venation prominent and reticulate on both surfaces; cymes lax, few-flowered, the pedicels in fruit 4 to 5 mm. long, very stout; calyx persistent in fruit, thinly sericeous with short brown hairs, the lobes obtuse; fruit very flat and thin, 1 to 3-seeded, 8 to 15 em. long, 1.7 to 2 em. wide, sometimes slightly constricted in the middle, acuminate at apex, attenuate at base, lustrous, glabrous, reticulate-veined, the slender stipe 10 to 12 mm. long.

"Collected also at Apango (Cerro Huatulco), Oaxaca, altitude 400 meters, October 10, 1917, by B. P. Reko (No. 3517).

"Related to *Dalbergia retusa* Hems!., a species of Panama, which is distinguished by the sericeous lower surface of the leaflets and broader, shorter fruit.

"*Amerimnon Granadillo* is a well-known forest tree of the west coast of Mexico, and there are several references to it in literature under the vernacular name of 'granadillo.' It is highly valued for use in cabinetwork. A specimen of the wood has been forwarded by Dr. Reko. It is very heavy and hard, of a beautiful purple color, with broad stripes of purplish black; it takes a fine polish."[8] (Standley's description, *loco cit.)*

which give value to the cocobolo of commerce. (See PITTIER, H.: The Lecythidaceae of Costa Rica. Contr. D. S. Nat. Herb., 12: 2: 100.)

[7] Although *Amerimnon Granadillo* Standley is considered as a synonym for *Dalbergia Granadillo* Pittier, the description is included for purposes of comparison and for the additional data it contains.

[8] Standley's description of the wood is based upon a specimen (D. S. Nat. Herb. No. 3517) of weathered heartwood forwarded by Dr. Reko, and a portion of this

COCOBOLO

DESCRIPTION OF THE WOOD

Macroscopic Features

Color.-The sapwood; which varies in thickness from 1 to 3 inches, depending upon the age and size of the tree, ranges from light cream to dingy white in color and is sharply defined.

The heartwood, the only commercial part of the tree, has an oily appearance and feel, and varies in color from light yellow to deep rich red, usually variegated orange. In fresh specimens one may be able to distinguish red, rose, orange, yellow, purple, and black; in fact some pieces can best be described as rainbow-hued. The wood soon begins to darken superficially upon exposure to the air, assuming a deep red which eventually permeates the whole of the material, while immersion in water causes it to blacken. If the fresh wood is shellacked the oxidizing process is retarded, but the brilliant hues are not permanent, though the wood remains beautiful in more subdued tones. The black markings are frequently regular enough to simulate annual rings, but a close inspection reveals that they are pigmented areas independent of the layers of growth. This dark striping gives rise to attractive figures, particularly on tangential surfaces and in the vicinity of small knots. Burly growths are especially ornate.

The claim that is sometimes made that the coloring matter in cocobolo will not leach out and stain has not been substantiated by the tests made by the authors. Pieces of the wood from all available sources were placed in contact with wet filter paper and in every instance produced a reddish-brown stain. Water in which the wood has been soaked for several days, or in which chips have been boiled, assumes a peculiar yellowish or orange-brown color. Attempts to extract dyestuffs and to obtain steam distillates of commercial value from the sawdust have been unsuccessful.[9]

material has been deposited in the Yale collections (Yale No. 4764)· Written upon it is the name "granadillo morado," meaning purple granadillo. This agrees in every detail with a specimen (Yale No. 5251) collected by Mr. John A. Gamon (his No. 47) under the name of "granadilla meca," the specific name signifying blackish-red. These woods are probably produced by a species of *Dalbergia,* but they are readily distinguishable from cocobolo. That they are not the wood of *Dalbergia Granadillo* is proved by wood samples collected by Mr. Gamon from the same tree from which he obtained botanical material that has been identified by Dr. Paul C. Standley as his *Amerimnon Granadillo.* These authentic specimens (Yale Nos. 5243 and 5250) are cocoholo.

9 The following is an extract from a letter of September 1, 1921, from Charles V. Sparhawk, Inc., 278 Pearl Street, New York: "Regarding our results with the distillation of cocobolo wood, we had five bags of this material and distilled it for almost a week without getting a trace of oil. The water was very much discolored, showing

The infusion of the heartwood of cocobolo exhibits a distinct fluorescence of a bluish color and also responds to the saponin test. The fluorescence is much less pronounced, however, than in the case of the two leguminous woods comprising the famous "lignum nephriticum," namely, *Eysenhardtia polystachya* (Ort.) Sarg. of Mexico and *Pterocarpus indicus* Willd. of the Philippines.[10]

General properties.-The wood is very hard, heavy, and compact. Specific gravity (thoroughly air-dry) 0.99 to 1.24, average (11 tests) 1.11; (oven-dry, on oven-dry volume) 0.96 to 1.23, average (11 tests) 1.07. Weight per cubic foot 60 to 77 pounds; average (thoroughly air-dry) about 69 pounds. The specimens tested had been in the laboratory for periods varying from a few weeks to several years, and most of them contained less than 5 per cent moisture; the maximum was 10.3 per cent. One specimen had a sp. gr. of 1.22 at 4.1 per cent moisture; 1.17 oven-dried four days at 100°C.; 1.27 after soaking in water at room temperature for a week.

The grain varies from fairly straight to much interwoven and finely roey. Split surfaces are usually rough and splintery on the radial and fairly smooth on the tangential; transverse fracture indicates a rather brittle material. The texture is fine and uniform.

The wood is not very difficult to work, turns readily, finishes smoothly, and takes a natural waxy polish. It holds its shape well when properly seasoned and is comparatively inert to moisture changes, but is inclined to warp, case-harden, and check when kiln-dried from a green condition. The best results are obtained when material is permitted to season slowly in the air for a year or more before kiln-drying. The heartwood is highly resistant to decay when employed in exposed situation, but the living trees are subject to heart rot. The wood is unsuited for gluing.

Fresh heartwood is very mildly rose-scented, but dried specimens are practically odorless. There is no distinct taste.

Growth rings.-False growth rings are often present and conspicuous in the heartwood as a result of the concentric arrangement of the darker

a decided stain, although we did not find any permanent dye properties. There was quite an irritating effect from the steam which we attributed to some tropical resins that probably are found in the sap."

10 See SAFFORD, W. E.: *Lignum nephriticum-Its* history and an account of the remarkable fluorescence of its infusion. Smithsonian Report for 1915, pp. 271-298.

For methods of testing, see KANEHIRA, R. : Detection of flavone and the fluorescence of the watery extract of woods as aids in identification. Journ. of Forestry (Washington, D. C.), '19: 7: 736-739, Nov. 1921.

colored zones. True growth rings are also present, due principally to limiting parenchyma, and, while sometimes fairly distinct in the sapwood, are usually indistinct without lens in the heartwood.

Parenchyma.-The terminal parenchyma lines are slightly wider than the rays and are usually visible in the sapwood but not in the heart. Within the growth rings are very numerous, minute, wavy, concentric lines visible under the lens and producing a very fine network with the rays. There are also very narrow zones about the pores, but they are not distinct without lens. The parenchyma appears of somewhat lighter color than the background.

Pores.-Variable in size; mostly distinct; rather few; usually solitary but sometimes in radial groups of 2 to 4; irregularly distributed though occasionally tending to zonate arrangement; mostly closed in heartwood with lustrous gum deposits; tyloses absent.

Vessel lines.-Usually distinct; rather short and wavy; generally darker than background due to gum deposits.

Rays.-Minute; invisible without lens on cross and tangential sections and not very distinct with it; faintly visible on radial surface and usually darker than background; uniform in size and spacing; bending about pores; storied.

Ripple marks.[11]-Present; faintly visible without lens; fairly uniform; all elements storied, although occasional rays occupy more than one tier; number per inch of length varies from 108 to 160, average (based upon 130 counts on different portions of 34 specimens) 128. Owing to the overlapping range of variation, the number of ripple marks per inch appears to be without specific significance. The variation in the count on different parts of the same specimen ranged from 0 to 16, average about 7. Secondary seriation of the individual cells of the parenchyma strands is not visible with the lens. Ripple marks also characterize the laminated inner bark.

Remarks.-Woods used for the same purpose as cocobolo or otherwise associated with it may be briefly distinguished as follows: Brazilian rosewood is brown and black, has a very pronounced scent, and the parenchyma lines are few, irregular, and comparatively coarse. In the "quira," "ñambar bastardo" or bastard cocobolo *(Platymiscium)*, the parenchyma is in

11 See RECORD, S. J.: Storied or tier-like structure of certain dicotyledonous woods. Bul. Torrey Bot. Club, 46: 253-273, July 1919.

distinct patches about the pores and not in fine concentric lines, except very indistinctly at limits of growth rings. Ebony and ebonized boxwood, beech, birch, maple, and holly, which are often used for handles of cutlery, are without ripple marks, are black in color, and, with exception of the first, have minute vessel lines. Hickory (*Carya*), which is sometimes dyed red to imitate cocobolo and used for small tool handles, is ring-porous and has no ripple marks. The woods of *Astronium*, sometimes used as a substitute for cocobolo in the manufacture of tool handles, have gum ducts in some of the rays and are without storied structure.

Minute Anatomy

The elements composing the wood of cocobolo are vessels, libriform wood fibers, wood parenchyma, and rays. No tracheids were found. (See Plates V and VI.)

VesseIs.-In cross section the vessels (pores) are rather few and irregularly distributed, occurring singly or less commonly in small radial groups. The solitary pores vary from circular to elliptical, the longest axis being radial. The dimensions of the solitary pores, based upon 300 measurements, are as follows: Radial diameter, 0.063 mm. minimum, 0.513 mm. maximum, 0.231 mm. average; tangential diameter, 0.081 mm. minimum, 0.329 mm. maximum, 0.184 mm. average. The three species were equally represented in the foregoing measurements, and the range of variation between the different species was not found to be appreciably greater than in different specimens of a single species. The pore walls have approxi.. mately the same thickness as those of the fibers. (Fig. 1, No. I.)

The vessel segments are more or less barrel-shaped and are in horizontal seriation, both radially and tangentially, the junctions occurring between the rays. The length of the segments, based upon 400 measurements, varies as follows: Minimum 0.109 mm., maximum 0.255 mm., average 0.175 mm. The plane of contact of the segments is nearly horizontal and the perforations, as is the case in all woods of the Leguminosae so far as reported, are exclusively simple. The annular ridge is narrow but distinct. No tyloses were found, but lustrous deposits of gum, varying in color from yellow to deep red, are very common in all the vessels in the heartwood and in some of those in the sapwood.

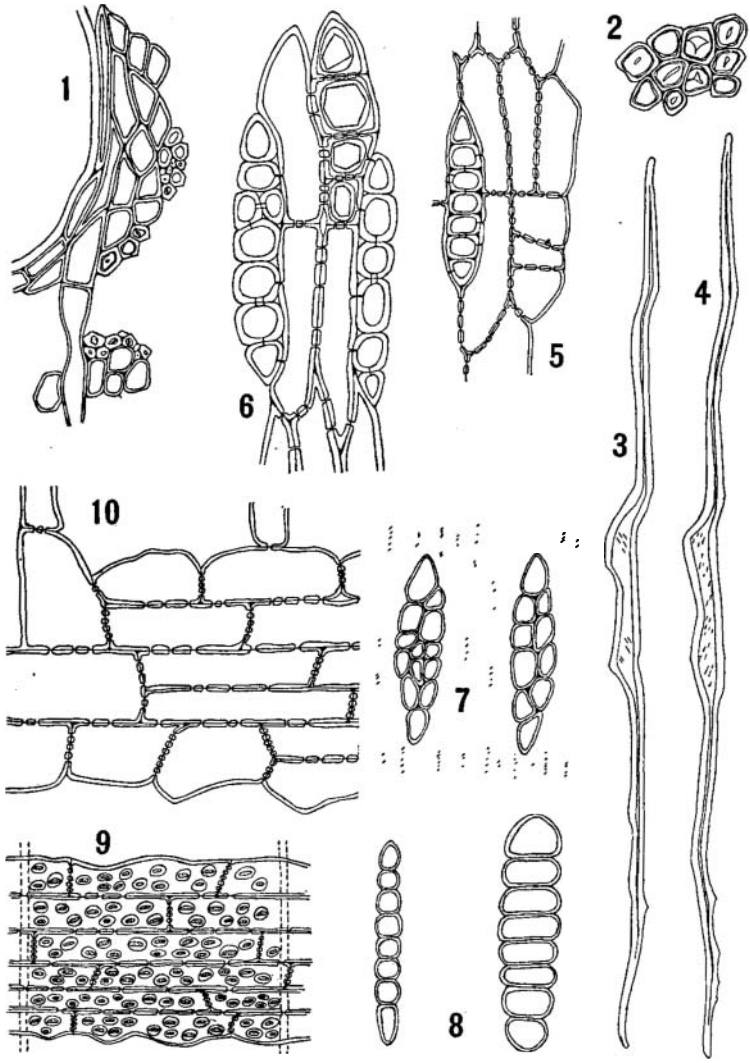


Fig. 1. Details of Wood Structure.

FIG. 1. EXPLANATION OF DRAWINGS

No. 1.—Transverse section of *Dalbergia retusa* (No. 2094), showing displacement of ray by vessel, and enlargement of ray in passing through band of parenchyma. X 200.

No. 2.—Transverse section of *Dalbergia retusa* (No. 2094), showing mucilaginous thickening of fiber walls. X 200.

No. 3.—Wood fiber of *Dalbergia hypoleuca* (No. 4469), showing aggregated condition of pits. X 100.

No. 4.—Wood fiber of *Dalbergia retusa* (No. 2094), showing pits distributed throughout enlarged median portions. X 100.

No. 5.—Tangential view of *Dalbergia retusa* (No. 2094), showing change in parenchyma strands in vicinity of vessel. X 200.

No. 6.—Tangential view of *Dalbergia retusa* (Hvd. No. 2158), showing chambered parenchyma strand with crystals, seriation of parenchyma strands and rays, and secondary seriation of parenchyma cells. X 200.

No. 7.—Tangential view of *Dalbergia hypoleuca* (No. 4469), showing horizontal seriation emphasized by aggregated fiber pits. X 200.

No. 8.—Tangential view of *Dalbergia hypoleuca* (No. 2094), showing contrast between normal rays and rays flattened by displacement by vessels. X 200.

No. 9.—Radial view of *Dalbergia retusa* (No. 2094), showing normal ray with bordered vessel-ray pits and perforated pit membranes. X 200.

No. 10.—Radial view of *Dalbergia retusa* (No. 2094), showing enlarged ray in vicinity of vessel. X 200. A space of 0.028 mm. separated this ray from that in Fig. 9.

Spirals are absent. The intervascular pits have a narrow lenticular mouth and a roughly elliptical border. Their average size is 0.0076 mm: by 0.0102 mm. They are usually numerous and often so crowded that the border assumes a polygonal outline. Their typical arrangement is alternate, but tendencies to opposite pitting were noted. Scalariform pitting was not observed though occasional elongated pits were found. The pit membranes have a characteristic dotted appearance due to the sieve-like perforations so common in woods of the Leguminosae and certain other families.[12] Pits into parenchyma cells are of about the same size as the others, have a distinct border on the vascular portion, and the membranes are dotted.

Wood fibers.-Libriform wood fibers make up the ground mass of the wood. In cross section they show a very irregular arrangement without any tendency to the formation of radial rows. There is considerable variation in the size, 0.011 mm. to 0.034 mm., depending upon the part of the cell cut across, the median portions being comparatively large while the constricted portions are extremely small. The diameters of the lumina vary from 0.003 mm. to 0.022 mm. The cells have double walls, a thin outer one polygonal in outline and a thick rounded inner one that is gelatinous. (Fig. 1, No.2.) Such fibers have been reported in representatives of various families[13] and the effect of such structures seems to be a reduction in the tendency of the wood to shrink and swell with changes in humidity. A possible explanation is that the mucilaginous thickening has greater hygroscopicity than the ligna-cellulose and is free to shrink and swell independently of the other parts of the tissue.[14]

As seen on longitudinal sections and in macerated material, the fibers are slender cells varying in length from 0.609 to 1.629 mm., averaging (400 measurements) 1.17 mm. Where the constricted portions are in contact with the side of a ray, the outer surface of the wall shows a series of scallops, the effect of the pressure of the cells across it. (Fig. 1, NO.4·)

12 Sieve-like structure of the pit-membrane is recorded in Amygdalaceae, Araliaceae, Asc1epiadaceae, Combretaceae, Compositae, Guttiferae, Fagaceae, Hippocastanaceae, Leguminosae, Melastomaceae, Myrtaceae, Oleaceae, Onagraceae, Rhamnaceae, Scrophulariaceae, and Vochysiaceae.

13 Amygdalaceae, Bixaceae, Calycanthaceae, Casuarinaceae, Ebenaceae, Euphorbiaceae, Fagaceae, Flacourtiaceae, Hippocastanaceae, Lauraceae, Leguminosae, Linaceae, Moraceae, Myrtaceae, Onagraceae, Piperaceae, Proteaceae, Salicaceae, Simarubaceae, Ulmaceae, and Violaceae.

14 In this connection see BROWN, FOREST B. H.: The preparation and treatment of woods for microscopic study. Bu!. Torrey Bot. Club, 46: 143-144, May 1919.

When, during the process of elongation, a fiber comes in contact with the marginal ray cells it is likely to be bent at right angles and is sometimes bifurcated. On tangential sections the fibers usually appear more or less interwoven with each other and with the rays.

The median portion of every fiber is enlarged, the length of this portion corresponding to that of the cambial mother cell which produced it and comprising about one-sixth or one-seventh of the total length of the fiber after elongation. (Fig. 1, Nos. 3, 4.) These enlarged parts are of approximately the same length as the wood parenchyma strands and the vessel segments and are in horizontal seriation with them. In tangential section, the width of the enlarged lumen may be nearly as great as the breadth of the uniseriate rays. These cavities are open in the sapwood, but in the heartwood are usually more or less filled with colored gum, which in the dark streaks is deep red or purplish and appears to have darkened the walls materially.

The pits are minute, variable from rounded to much elongated and slit-like. They are simple, though sometimes in face view they have the appearance of being slightly bordered. The pits are for the most part limited to the radial wall and well distributed over the enlarged portions of the fibers. (Fig. 1, NO.4.) Sometimes, however, they are aggregated at the shoulders where the lumina become constricted (Fig. 1, NO.3), and by affecting the light refraction there make the lines between ray tiers more distinct. (Fig. 1, NO.7.)

Wood parenchyma.-Parenchyma is of three distinct types, namely, paratracheal, metatracheal, and terminal. The paratracheal consists of numerous flattened, irregular cells surrounding the pores. The metatracheal is well distributed in the form of irregular, broken, wavy, concentric lines, one cell in width. The terminal limits the rings of growth, and varies in width from 1 to 4 cells. The individual parenchyma cells are of about the same size as the wood fibers, but appear considerably larger because of their thinner walls and more distinct cavities. In the deeply colored zones the cells are commonly filled with dark red gum deposits.

In the specimens studied the following specific differences were noted. In *Dalbergia retusa* and *D. Granadillo* the terminal parenchyma layer is 1 to 3 cells wide, mostly uniseriate; in *D. hypoleuca* it is 1 to 4, mostly 1 or 2, cells in width. In the first two species, also, the paratracheal parenchyma is fairly constant, being 1 or 2, rarely 3, cells in width; in the Mexican species, however, it is often much more conspicuous, being frequently 4 to 5 cells thick.

The strands of the metatracheal and terminal parenchyma consist of 2 cells each; in the paratracheal the number varies from 3 to 8, although there are usually 4. (Fig. 1, Nos. 5, 6.) Substitute or intermediate fibers occur, occasionally in association with the ordinary parenchyma strands. Conjugate parenchyma cells are sometimes found in the vicinity of vessels. Dimensions of the strands are as follows: Length, minimum 0.129 mm., maximum 0.238 mm" average (560 measurements) 0.189 mm.; diameter, minimum 0.111 mm., maximum 0.043 mm., average (550 measurements) 0.024 mm.

The parenchyma strands are in distinct horizontal seriation with the rays, vessel segments, and enlarged portions of the fibers. The individual cells of adjacent strands frequently exhibit pronounced secondary seriation, visible only under the compound microscope; but in those strands in which the number of cells exceeds 4, or in which the cells are distorted and irregular in shape, this tendency toward secondary seriation is obscured.

Chambered parenchyma strands containing crystals of calcium oxalate are common. (Fig. 1, No.6.) The predominate number of crystals in a full strand is 8, although often but 4 are found, in which case they are confined to one-half of the strand; sometimes there are as many as 14. These crystals are rhombohedral in shape and are surrounded by a membrane. They are unaffected by the nitric acid used in the preparation of macerated material.

Rays.-On cross section there are normally from 10 to 19 rays per mm. (measuring tangentially); since the rays are storied, however, a section between two tiers shows many wide gaps, and were the stories uniform enough the rays might be missed completely. The individual ray cells are of irregular shape, with horizontal or oblique cross-walls, and have a tendency to enlarge when passing through the terminal and metatracheal parenchyma. (Fig. I, No. I.) They are marked by numerous simple pits which are rounded in outline and variable in size from small to minute. Frequently 3 and occasionally 4 rays are in contact with a single pore, and, as a result of the enlargement of the pores, the ray cells lose their normal shape and become short and flattened and often are scarcely distinguishable from the paratracheal parenchyma cells in association.

In tangential section, the rays are in distinct horizontal seriation with the other elements and occupy the median portion of the tiers, the height of which usually exceeds that of the rays. The number of cells to a ray varies from 2 to ro, and each of the three species exhibits about the same range of variation. In width, however, there is a noticeable difference. In *Dalbergia retusa* the rays are mostly uniseriate, only occasionally biseriate

in part; in *D. hypoleuca* they are both uniseriate and biseriate, and sometimes triseriate in part; in *D. Granadillo* they are mostly uniseriate and biseriate, but frequently are entirely triseriate. The interior cells are fairly uniform in size and shape, being small and rounded; the marginal ones are more or less elongated vertically. The cells of a ray displaced by a vessel are flattened vertically at the side of the vessel, but just beyond in either direction they become much flattened horizontally. (Fig. 1, No.8.) This is due to distortion from the pressure exerted by the enlarging vessels.

In radial section the great majority of the cells are elongated horizontally and are fairly regular in size and shape. The marginal ones, however, are, for the most part, somewhat higher than the others and are irregular in shape. (Fig. 1, NO.9.) In immediate proximity to a vessel the cells are likely to be square or upright. (Fig. 1, No. 10.) In rather thick sections the effect of the displacement by the vessels during their enlargement is noted, the bent portion of the ray showing the ends of the cells as they would appear on tangential section. Such cells are likely to be mistaken for wood parenChyma, but by changing the focus of the microscope their true nature is readily determined. Libriform wood fibers and wood parenchyma strands where in contact with the marginal cells of a ray may bend sharply and run along the ray.

The pits between rays and parenchyma strands are rather few, fairly small, and very irregular in shape. (Fig. 1, NO.9.) Those between contiguous ray cells are small, rather numerous, and fairly regularly disposed. The pits into the vessels are distinctly half-bordered, and are mostly in two horizontal rows per cell, and are slightly larger than the intervascular pits; average size, 0.0093 mm. by 0.0102 mm. The pit membranes have a dotted appearance.

TABLE GIVING MEASUREMENTS OF THE RAYS OF THE THREE SPECIES KNOWN TO PRODUCE COCOBOLO

SCIENTIFIC NAME	REGION	YALE NO.	NO. CELLS HIGH	TANGENTIAL SECTION						RADIAL SECTION									CROSS SECTION
				Height (mm.)			Width (mm.)			Length of cells (mm.)			Height of Marginal cells (mm.)			Height of all other cells (mm.)			No. of rays per mm. (tang.)
				Av.	*Max.*	*Min.*	*Av.*	*Max.*	*Min.*	*Av.*	*Max.*	*Min.*	*Av.*	*Max.*	*Min.*	*Av.*	*Max.*	*Min.*	
D. retusa	Panama	2094	3-10	.117	.185	.059	.017	.039	.008	.146	.213	.087	.024	.031	.013	.017	.022	.011	13-19
D. retusa	Panama		2- 8	.121	.185	.050	.021	.034	.011	.133	.190	.078	same as other cells			.019	.027	.017	12-16
D. hypoleuca	Costa Rica	4467	3- 7	.096	.127	.059	.025	.051	.011	.148	.198	.096	.022	.025	.013	.016	.023	.009	11-18
D. hypoleuca	Nicaragua	4469	2- 8	.138	.173	.071	.028	.045	.014	.138	.260	.039	.028	.036	.021	.020	.028	.021	10-15
D. Granadillo	Mexico	4410	2- 8	.120	.174	.062	.024	.042	.012	.186	.314	.104	.026	.036	.015	.024	.027	.013	11-16
D. Granadillo	Mexico	5243	2- 8	.140	.193	.045	.026	.045	.014	.128	.255	.034	.030	.039	.016	.020	.028	.014	11-16

COCOBOLO

Material Studied

Dalbergia retusa: Type material collected by Mr. H. Pittier in vicinity of La Palma, southern Darién, 1914; his No. 6606; Yale No. 2094.

Dalbergia hypoleuca: Type material (Yale No. 5344) collected by Messrs. Alberto Fait & Co., Puntarenas, C. R., with leaves, flowers, and fruits from same tree. Botanical material identified by Dr. S. F. Blake, Washington, D. C.

Dalbergia Granadillo: Type material collected by Mr. John A. Gamon, American Consulate, Acapulco, Mexico, with leaf specimens from same trees; his Nos. 11 and 46; Yale Nos. 4410 and 5250. Botanical material identified by Dr. Paul C. Standley, Washington, D. C.

Miscellaneous cocobolo: Yale Nos. 95, 131 (Honduras); 4090, 4323, 4466 (Panama); 4467, 4776, 5344, 5887 (Costa Rica); 4468, 4469, 4775, 5232, 5891 (Nicaragua); 5243 (Mexico); also various unnumbered trade samples.

Dalbergia nigra: Yale Nos. 3107, 3273, 3301, 3302, 3303, 3308, 3486, 3508, 3509, 3525, 4146, 4250, 4452 (Brazil).

Dalbergia Baroni: Yale No. 5927 (Madagascar).

Dalbergia spp.: Yale Nos. 4764, 5251 (Mexico); 4092, 4978 (Honduras); 1431, 3933, 5955 (Brazil).

Platymiscium: Yale Nos. 2991, 4328, 4977 (Panama); 404 (Colombia); 4470, 4471, 5237 (Nicaragua).

Lecythis costaricensis: Yale No. 4778 (Costa Rica).

Coccoloba: Yale Nos. 2687, 2713, 4546, 4592, 4632 (Porto Rico); 2732, 2753, 2769, 2791 (Curaçao); 3021 (Panama); 5183, 5184, 5185 (Florida).

Check List of Common Names

Cocobolo or cocobola;[15] also coco bolo, coca bola, coccobolo, cocobollo, cocobolas, etc. (Trade, general); ñambar, ñambar de agui, nnambar, ñamba, cocobolo, cocobolo ñambar, cocobolo negro, rosewood (Costa Rica); ñambar, ñambar legitimo, rosewood (Nicaragua); cocobolo, cocobolo prieto

[15] Formerly confused with *Coccoloba,* a genus of the family Polygonaceae, because of the similarity of the names. (See Wiesner, Julius: Die rohstoffe des pflanzenreiches. Leipzig, 1903, p. 911.) According to Dr. Fortunato L. Herrera (Contribucion a la flora del Departmento del Cuzco. Cuzco, 1921, p. 68), *C. nutans* Kunth is known locally as "cocobolo." Mr. Herbert Stone writes: "There is a cocobola in Réunion (Bourbon) with which the stone masons mark their work, its 'streak' not being readily washed out by rain."

(Panama); granadillo (Mexico); granadillo, palo negro (Honduras); cocoboloholz, foseholz[16] (Germany); red foxwood[17] (England, obsolete).

[16] NESTLER, A.: Die hautreizende wirkung des cocoboloholzes. Berichte der deutschen botanischen Gesellschaft, 30:3:120, 1912.

[17] See reference to letter from Mr. Alexander Howard, p. 31. According to Dr. Paul Krais (Die hölzer. Stuttgart, 1910, p. 725), "foxwood" or "vicadóholz" is a Brazilian cabinet wood of a yellowish-red color, either plain or striped with red or reddish-violet, and without luster. Its identity has not been established.

PART II: FROM THE COMMERCIAL STANDPOINT

SOURCES OF SUPPLY

Mexico.-The range of the Mexican cocobolo, *Dalbergia Granadillo,* locally known as "granadillo," is very imperfectly known, but it is rather extensive along the Pacific watershed of southern Mexico. The species has been collected in the valley of the Balsas River between the States of Guerrero and Michoacan; at Apango (Cerro Huatulco), Oaxaca; and from the vicinity of San Luis de la Lorna and Dos Arryos, Guerrero. It is said to be a well-known forest tree supplying a wood highly valued locally for cabinetwork, but there is no evidence that it has ever been exported. It is not unlikely, however, that it will prove of considerable commercial importance and it is worthy of further investigation.

Guatemala and Salvador.-There is no positive evidence available that cocobolo exists in these countries, but it seems very likely in view of its occurrence in the countries immediately to the north and south. *Dalbergia calycina* Benth. is a Guatemalan species showing affinities to species which produce cocobolo, but nothing is known regarding its wood.

Honduras.-The existence of cocobolo in Spanish Honduras is established by the presence in the Yale collections of two specimens of the wood from that country. They are labelled "palo negro" and "granadillo," respectively, and their structure seems to be nearest to *Dalbergia hypoleuca.*

Nicaragua.-The cocobolo exported from Nicaragua is produced by two species, namely, *Dalbergia hypoleuca* and *D. retusa,* which are distributed sparingly in the dry forests along the entire Pacific watershed. The wood from this country was introduced to the trade as a substitute for Panama cocobolo, and its identity as true cocobolo was first definitely established by the authors through material supplied by Messrs. E. Palazio & Company of Corinto. The vernacular name of the tree is "fiambar," but the wood has been commonly exported as rosewood.[1] It has been absorbed

[1] The original rosewood of commerce and the one that is still considered the true or standard rosewood of the trade is the Brazilian timber known locally as "jacaranda." *Dalbergia nigra* Fr. Allemao. There are now several rosewoods of commerce, but cocobolo has been kept separate from them and because of its peculiar properties it would seem to the best interest of the trade that this practice be continued.

Year	*Amount and Value*	*Total*	*United States*	*Germany*	*Holland*
1900	Pounds	1,865,973			
	Value	$6,417.00			
1901	Pounds	780,869			
	Value	$3,580.50			
1902	Pounds	1,760,505			
	Value	$8,072.40			
1904	Pounds	47,767		47,767	
	Value	$1,922.31		$1,922.31	
1906	Pounds	513,138	511,467		
	Value	$2,093.43	$2,087.38		
1907	Pounds	200,619		200,619	
	Value	$427.80		$427.80	
1908	Pounds	271,838	57,216	211,641	
	Value	$820.73	$337.13	$446.40	
1909	Pounds	1,273,675			
	Value	$8,557.86			
1910	Pounds	2,668,311	1,382,494	856,487	
	Value	$13,631.94	$6,540.69	$5,324.25	
1911	Pounds	1,233,961	1,233,961		
	Value	$5,212.03	$5,212.03		
1912	Pounds	489,977	489,977		
	Value	$2,970.65	$2,970.65		
1913	Pounds	622,337	350,351	271,986	
	Value	$3,730.33	$2,073.65	$1,656.68	
1914	Pounds	5,194,069	4,107,201	1,053,799	33,069
	Value	$28,420.28	$21,988.26	$6,282.36	$1,396.08
1915	Pounds	1,352,892	1,352,237		
	Value	$7,932.25	$7,976.27		
1916	Pounds	936,593	936,593		
	Value	$4,435.81	$4,435.81		
1917	Pounds	2,374,070	2,360,909		
	Value	$38,196.75	$37,868.21		

EXPORTED FROM COSTA RICA

France	*Italy*	*Spain*	*Panama*	*Other Countries*
	1,671			
	$6.05			
				2,981
				$37.20
385,459				43,871
$1,627.50				$139.50
	397	258		
	$4.65	$2.33		
			13,161	
			$328.54	

by the trade, however, as cocobolo, as is indicated by the following extract in substance from a circular letter to the trade from a New York dealer, under date of January 22, 1916:

COCOBOLO:-The users of this wood will well remember the great difficulty we experienced many years ago introducing' cocobolo from Central America as a substitute for cocobolo from Panama, but the results obtained by the buyers and users of the material of Central American origin are the best demonstration of its value. In former years we knew only Panama cocobolo; but to-day we have a cocobolo which not only yields more product to the ton, but also gives equal satisfaction to the ultimate buyers of the finished product. It has become difficult to secure Panama cocobolo sound and well grown, regardless of price, but we can secure cocobolo from the west coast of Nicaragua and Costa Rica free from sap, fairly sound, and well grown. Cocobolo from Central America reaches this market via the Isthmus of Panama, the ships loading at west coast ports and transferring shipments at Panama to cross the Isthmus and be loaded at Colon for New York.

Shipments of cocobolo from Nicaragua frequently contain logs of *Platymiscium trifoliatium* Benth.,[2] known locally as "fiambar bastardo" and on the New York market as "bastard cocobolo" or, less commonly, as "yama cocobolo." It is much like the Panama "redwood" or "quira" and is used for billiard cue-butts and miscellaneous purposes, but is not an acceptable substitute for cocobolo.

Details regarding exports of cocobolo from Nicaragua are obscured by the confusion of names used in the reports. Cocobolo, as such, is first listed in the Memoria Recaudador General de Aduanas for 1920, in which year 662,669 kilos (1,461,020 lbs.) valued at 19,324 cordobas (1 cordoba== $1) were shipped to the United States. The principal ports of shipment are San Juan del Sur and Corinto, the latter being the more important. The export duty is 10 per cent.

Costa Rica.-So far as has been demonstrated the cocobolo entering the trade from Costa Rica is the product of *Dalbergia hypoleuca.* It is known locally as "fiambar." The Panama species, *D. retusa)* is, however, known to occur there and presumably does now or will contribute to the supply. Whether or not *D. lineata* Pittier, a Costa Rican species, yields cocobolo is yet to be determined, but it seems not unlikely in view of Pittier's[3] statement that "the affinities of this species are evidently with *Dalbergia retusa*

2 The identity of this material has been established by the authors from botanical material supplied by Messrs. E. Palazio & Company, Corinto.

3 PITTIER, H.: On the species of *Dalbergia* of Mexico and Central America. Journ. Wash. Acad. Sci., 12: 3: 64, Feb. 4, 1922.

Hemsley." Attempts by the authors to determine this matter from a comparative study of small twigs were not conclusive.

The principal port of shipment is Puntarenas. The exports are chiefly to the United States, and prior to the war Germany was second on the list. Other countries receiving occasional shipments are Holland, France, Italy, Spain, and Panama. The export duty is 10 per cent. The accompanying table giving the amounts and declared values of cocobolo exports to various countries is based on data supplied by the Bureau of Foreign and Domestic Commerce, Washington, D. C. The original source of the figures, at least those from 1911 to 1917 inclusive, is the Anuario Estadistica de Costa Rica. The following converting factors were used: 1 kilo == 2.2046 lbs.; 1 colon == $0.46536.

Panama.-Cocobolo trees occur scatteringly or in small clumps in the understory of the mixed hardwood forests on the foothills and rocky cliffs and in the gorges in the provinces of Panama (including Darien), Coclé, and Verguas. They seem to be of rare occurrence on the northern watershed and in Chiriqui. The timber from the more accessible regions has been removed and in places almost eradicated. So far as known there is only one species, *Dalbergia retusa*. The native name is cocobolo or cocobola.

The original cocobolo of commerce came from Panama. The exact date of its introduction into the foreign markets is unknown, though a Connecticut company claims to have used it for over 50 years in the manufacture of table cutlery. Mr. Alexander L. Howard, of the firm of W. W. Howard Bros. & Co., London, states in letters of September, 1921, that his personal recollection of it extends back more than 40 years and that it was for a time known as "red foxwood." According to J. F. Muller & Sohn, Hamburg, in letter of December 1, 1921, cocobolo had been imported into Germany before 1889. There is a specimen of Panama cocobolo in the Yale collections, the gift of Dr. George Eaton, New Haven, Conn., that is known to be at least 40 years old.

The principal port of shipment is Colon. There are no records available concerning exports prior to 1909, but in that year nearly 4,000,000 pounds were exported, of which over 80 per cent was to the United States, the remainder to Germany, France, and Great Britain. The first recorded shipment to South America was in 1920, when 45,000 pounds were shipped to Peru. The accompanying table, giving the amounts and declared values of cocobolo exports to various countries, is based on data supplied by the Bureau of Foreign and Domestic Commerce, Washington, D. C. The original source of the figures, at least those from 1912 to 1920, is the

COCOBOLO

Direccion General de Estadistica de Panama. The following converting factors were used: 1 kilo = 2.2046 lbs.; 1 balboa = $1.00.

AMOUNT AND VALUE OF COCOBOLO EXPORTED FROM PANAMA

Year	*Amount and Value*	*Total*	*United States*	*Germany*	*France*	*Great Britain*	*Peru*
1909	Pounds	3,922,052	3,367,187	272,323	170,107	112,435	
	Value	$44,320	$37,865	$3,255	$2,200	$1,000	
1910	Pounds	2,653,285	2,276,298	194,005	116,844	66,138	
	Value	$35,662	$31,512	$2,500	$1,200	$450	
1911	Pounds	3,418,171	3,172,653	172,766		72,752	
	Value	$40,312	$37,847	$1,715		$750	
1912	Pounds	5,689,903	5,456,656		66,138	167,109	
	Value	$83,729	$79,519		$600	$3,610	
1913	Pounds	5,033,134	3,843,652	120,206	642,125	427,151	
	Value	$58,121	$42,717	$3,054	$9,450	$2,900	
1914	Pounds	2,360,287	2,305,172		55,115		
	Value	$38,703	$37,703		$1,000		
1915	Pounds	649,623	649,623				
	Value	$9,624	$9,624				
1916	Pounds	1,776,493	1,776,493				
	Value	$25,628	$25,628				
1917	Pounds	5,731,960	5,731,960				
	Value	$92,818	$92,818				
1918	Pounds	850,530	850,530				
	Value	$15,664	$15,664				
1919[4]	Pounds		488,372				
	Value		$5,005				
1920	Pounds		1,978,159			82,531	45,084
	Value						$377

[4] First half of year only.

GETTING THE TIMBER TO MARKET

The cocobolo trees comprise only a small proportion of the mixed hardwood forest in which they are found. The region of growth is for the most part deficient in rainfall, and the conditions are not favorable for rapid growth or the attainment of large dimensions; consequently the trees are usually poorly formed. They are now largely confined to the less accessible interior uplands.

The wood is so hard that the felling of the trees with axes is too arduous to appeal to the natives, who prefer to burn them down, a method made possible by the highly resinous character of the stump portion. The sapwood is usually hewn off in the woods since it has no commercial value and adds greatly to the weight of the logs. (See Plate VII, No. I.) Under average conditions one laborer can fell and hew about one ton of wood in a day. Panama cocobolo, however, is frequently exported with the sapwood on.

Hauling from the stump to the boat landings on the nearest stream is difficult and slow. Two-wheeled ox carts are commonly used and roads have to be cleared to each log. The heaviest hauling is generally done at night so as to avoid the intense heat of the day. An ox team works, on an average, only four or five days a week for about four months in the year. Tractors have been introduced to a limited extent, particularly in Costa Rica, and have made it possible to get out longer and larger logs. In some cases the men carry the wood out, but only small-sized material can be handled in this way.

An American importer, speaking from several years' experience, says: "Taking the season's operations as a whole, the results are often very disappointing to the man who advances the money to get out the wood. Contracts are made, say for 1000 tons of cocobolo, but by the end of the season, through delays of one sort or another, only a fourth or at most one-half of the wood is delivered to the creekside. No one can anticipate all the hindrances to the progress of the work, the only certainty being that something will occur to prevent the completion of the contract within the specified time. Considerable capital is involved and the returns are slow and uncertain."

Cocobolo from Costa Rica and Nicaragua reaches the market in the form of whole logs, hewn free of sapwood, and not less than 6 feet long. The usual range in weight is between 150 and 500 pounds per log, averaging about 200 pounds. The largest log of Nicaraguan cocobolo the authors have seen measured 34 inches in diameter. The wood from Panama is in shorter lengths (usually less than 4 feet) and is often irregular, hollow, and

split into pieces. Some of the material shows signs of weathering and appears to have come from old dead and down timber, but much of it has considerable worthless sapwood present. The smaller size of the Panama wood may be accounted for by the fact that the native methods are very primitive and with little or no supervision.

Some of the logs from the west coast of Central America are transshipped at Panama, but larger cargoes are coming direct to New York via the Canal. The freight rate varies from 62½ cents to 90 cents per cwt., though in special cases it is as low as 50 cents. The logs are weighed in New York by the official weighmaster and the shippers are paid on the basis of these landed weights. The market values in New York have ranged about as follows: Pre-war, $35 to $40 per ton of 2,240 lbs.; war-time, $75 to $100; present, $60 to $75. The price is dependent both on the quality of the wood and the size of the shipment. The demand of the trade is now largely for Nicaraguan and Costa Rican wood because there is about 20 per cent less waste in its manufacture than in the case of cocobolo from Panama.

Uses of Cocobolo

About three-fourths of the supply of cocobolo is consumed by manufacturers of cutlery for the handles of table and carving knives and forks, butcher knives, pocket knives, etc. The wood is used in the form of thin, narrow pieces known as "scales," which are riveted to the metal. (See Plate VII, No. 2.) The logs are cut into planks, usually two inches thick. Some of the manufacturers do their own sawing, others have it done by the New York dealers; the loss in sawing an average lot of logs is about 15 per cent. The planks are kiln-dried at the factory, and, unless thoroughly air-seasoned material is used, are likely to case-harden. This condition must be relieved by steaming and redrying before the scales are cut, otherwise they are likely to warp even after attachment and may pull loose from the rivets. Properly dried material holds its place remarkably well under all sorts of conditions met with in daily use. The oily nature of the wood tends to waterproof it and also permits a high natural finish with a mere rubbing of the surface. No filler is required as in the case of larger-pored woods. The trade prefers the more deeply colored material to that of lighter hue, but even the yellow soon darkens upon exposure. Handles get very dark with use and after numerous immersions in water become almost jet black.

Cocobolo is also used for turned articles such as small tool handles, chessmen, canes, beads, buttons, jewelry boxes, knobs on cabinet drawers

and doors, policemen's clubs, and novelties. It is also employed in the manufacture of fancy brushes and mirrors, the demand being for wood that is of beautiful grain and color. It makes excellent billiard cue-butts, though usually considered too expensive for this purpose. Makers of automobile bodies and accessories employ cocobolo to a limited extent in steering wheels, instrument boards, and various attachments. Though formerly in considerable demand in England for cabinetwork, it is now rarely so used, except for inlaying, because of the cost and the small sizes available. In the countries of its growth the timber is appreciated because of its durability in contact with the ground, and some of it was employed for crossties in the construction of the first transisthmian railway in Panama.

The amount of cocobolo consumed annually in the United States can only be approximated. Bulletin No. 605 of the Department of Agriculture gives statistics showing the average annual consumption of wood by the wood-using industries of this country, the basis being studies by states covering a period of twelve months in each case, though the work extended over the period 19°9-1913. According to this report, the consumption of cocobolo was 279,400 feet, board measure, distributed as follows: handles, 210,000; professional and scientific instruments, 64,800; novelties, 2,400; brushes, 2,000; ship and boat building, 200. Since cocobolo is always sold by weight, the board foot is a fictitious standard of measurement; no converting factor is given in the report, but from official sources it is learned that a basis of 6 pounds per board foot was used. On this basis the amount consumed was 1,676,400 pounds or about 750 tons. According to the C. H. Pearson & Son Hardwood Co., Inc., of New York City, the present annual consumption of cocobolo in this country is about 2,500 tons or 5,600,000 pounds. On a basis of 70 pounds per cubic foot this amounts to 80,000 cubic feet. During the year 1922, according to Mr. Pearson's records, 25,997 logs of cocobolo were received in New York, of which about 50 per cent were from Nicaragua, 30 per cent from Costa Rica, and 20 per cent from Panama. Assuming the average weight per log to have been 200 pounds, the total was 5,199,400 pounds or 2,321 tons. The estimated consumption by European countries is at present about 500 tons annually.

DERMATITIS CAUSED BY COCOBOLO

The fine dust arising in working cocobolo is poisonous to some people, and when a factory begins to use this wood for the first time a considerable number of the workmen are likely to develop a dermatitis resembling ivy poisoning. The eruptions may appear on any part of the body and may

spread from one part to another. Sometimes the eyes are affected (conjunctivitis). The trouble is annoying and irritating, but usually responds readily to treatment and is not seriouS' unless neglected. Usually, however, an infected employe will be unable to work again in a room where exposed to cocobolo dust, since once infected, a person seems to become more susceptible to the poison instead of acquiring immunity. As in the case of ivy poisoning, some people are apparently immune while others exhibit various degrees of susceptibility. Manufacturing plants in which cocobolo has been used for years have comparatively few cases of poisoning because they have gradually acquired a group of immune workmen.

There is a disagreement of opinion regarding the relative poisonous properties of cocobolo from different regions. The dealers usually try to ignore the matter entirely or insist that only the Panama wood is at fault. Definite information on this point is very difficult to obtain because of the uncertainty as to the origin of any particular lot of wood. Several factors serve to complicate the problem. The species which produces the Panama cocobolo grows also in Costa Rica and Nicaragua; and, in the latter country at least, the logs of the two species are shipped without distinction. Possible confusion may sometimes result from transshipment at Panama. Information from the manufacturers is based on that supplied them by the dealers, and the latter may not always know or may not care to disclose the source of the material. As likely as not, also, a plant is operating on a mixed lot of wood. Under the circumstances, therefore, generalizations seem unwarranted. It is not improbable, however, that some lots of wood cause more trouble than others from the same source because of their condition as to soundness, dryness, age of tree, preliminary treatment, etc., though to what extent such factors are involved remains to be determined.

Reports from Manufacturers

1. From a Connecticut cutlery company: "We use only two varieties of cocobolo, Nicaragua and Panama. So far as we know they are equally poisonous. Roughly our experience has been that one man in ten is poisoned from working in this wood. With this small proportion the simplest way out of the difficulty for us has been to assign the susceptible employes to other work.

"In effect the poison is similar to a severe case of poison ivy. Only rarely are other than the exposed parts of the body affected, although several years ago we had one man who was confined to his bed for several months as a result of the poison which broke out in the form of sores and cracks all

over his body. As a preventative, a mask covering the nose and face has proved fairly effective, but not absolutely so. As a remedy, various skin preparations have been used according to the individual whim of the men."

2. From another Connecticut cutlery company: "We have been using cocobolo for over 50 years in the manufacture of table cutlery. The man who has been superintendent of the cutlery division for 53 years has only known of four or five cases where people have been poisoned and it was always in the hot summer months that it occurred. In view of the fact that we have more than 100 people working in the departments where this cocobolo is used, it can be seen that only a few people are troubled in that way. The writer has been with the company 17 years and he knows of only one case during that time."

3. From a Massachusetts cutlery company: "During the past year we have had perhaps four or five cases of cocobolo poisoning, occurring usually in warm weather, or to a furnace operator, as a result of cocobolo sawdust getting on his skin when perspiring. It appears that one out of every three persons is susceptible to cocobolo poisoning, the rest apparently being immune. We have had men working in cocobolo dust, that is, inhaling small quantities of it, for twenty years with no apparent ill effects or indications of poisoning. On the other hand, we have had men get cocobolo poisoning from walking through a room in which cocobolo logs were being sawed. The poisoning appears to be entirely a skin affection, resulting in inflamed and reddened condition of the affected surfaces with itching and irritation.

"All such cases have been referred to the local physicians who presumably prescribe an antiseptic and soothing lotion for external application to the affected parts, and in a few days the rash would disappear. In some cases the cure is a somewhat difficult matter while in others a day or two is sufficient to clear away the irritation, apparently depending entirely upon the susceptibility of the person affected."

4. From another Massachusetts cutlery company: "We have been using cocobolo for many years for handles of the cheaper grades of cutlery, cutting same from logs, and we have found that the dust from this wood is decidedly poisonous in certain cases. We have had men who could not work on cocobolo over a day without having their bodies covered with an eruption from head to foot. Others would be afflicted with violent headaches. On the other hand, we have had many men who have worked year after year on this wood without bad effect. All our machines, such as saws and wheels, are protected by blowers which are supposed to carry off the dust, but it is impossible to prevent certain fine particles remaining in the air."

5. From the works manager of a cutlery company in New Hampshire: "I have recently recovered from a case of cocobolo poisoning. There was a sudden swelling of the flesh around the face and eyes with a good deal of redness in the form of blotches. This swelling came and went for a few days, meanwhile burning and itching severely. The only treatment I had was a solution of menthol, etc., which tended to dry up the blotches and reduce the swelling. The latter disappeared after a time, only to reappear on other parts of the body not exposed to the dust and which did not come in contact through handling.

"Our superintendent, who has been here sixteen years, has never had an attack of the poisoning. As a matter of fact, we have a large number of men and women who have worked here for many years and who have never been poisoned by cocobolo. On the other hand, we have a man in our employ who is foreman of the department that saws up the logs who has to put up a continuous fight against cocobolo, and he has used sugar of lead occasionally to kill it out. About the same time the writer became poisoned, this man reported that the cocobolo he was working was the worst he ever saw. At this time there were two men in his department who were so badly poisoned that they had to give up the work, and there was one man who was so valuable to us that we had a physician see him several times, giving him daily baths, etc. ; and through the efforts of the physician we were able to retain this man's services, although the attacks were recurrent at times in a minor way.

"Our men seem to think that people with a dark skinS are not affected by the dust or other contact with the wood; the foreman just mentioned, however, is very dark. It so happens that the others who have been poisoned are, like myself, of light complexion."

6. A cutlery company in Chicago using about 90 per cent Nicaragua cocobolo has had a few cases of poisoning. The physicians who treat such patients report as follows: "We do not have a case oftener than once in three or four months. The reaction generally assumes the form of acute dermatitis of the hands and face which yields readily to treatment. Some employes are unable to continue working in the wood as they are especially susceptible to the poison. A recent case of conjunctivitis was caused by the dust."

7. From a knife manufacturing company in New York State: "The dust from all cocobolo is a skin irritant. We do not class it as a poison, and we

[5] It was demonstrated in a manufacturing plant in New Haven that even negroes are not always immune.

think it is not properly so classed, since if this dust is inserted into the flesh it has no poisonous affect. If the person working cocobolo bathes his face and hands in salt and water it generally effects a remedy."

8. From an Ohio manufacturer of brushes and mirrors: "According to the records we have of poisoning from cocobolo wood, not more than one worker in five was affected and that one only when the work was sawing, boring, or sanding, thus creating dust. Workers are never affected beyond a radius of four or five feet. We have had no cases of poisoning from the mere handling of the wood. The effect of the poisoning is similar to that caused by the ordinary poison ivy. The hands and face become puffy and later suppuration ensues. We have resorted to the treatment usually accorded ivy poisoning, generally zinc ointment, and the results have been satisfactory."

Laboratory Investigations by Dr. Ciampolini

Cocobolo poisoning has been the subject of extensive investigation by Dr. Ettore Ciampolini, a student in the Graduate School of Yale University. The ethereal extract of the sawdust was found to be active when applied to the depapillated skin of guinea pigs, rabbits, and white mice.

According to his findings the toxic principle of cocobolo is an oleoresin, soluble in ether and to a certain extent in alcohol, with violent irritant properties and capable of producing an inflammatory condition on the skin, of the type of "dermatitis venenata." The poisonous principle is also soluble in alkalis but is precipitated by acids. Dr. Ciampolini believes that this has a definite bearing upon susceptibility, the workmen whose perspiration gives an acid reaction being immune while those with an alkaline reaction are not.

As to treatment he advises that measures to ensure removal of the poison from the affected areas of the body be instituted promptly upon discovery of the infection. Applications of ether or of an alkaline solution are recommended at the beginning; later bland sedative local applications should be instituted.

Conclusions

(1) Cocobolo is one of several[6] tropical woods which are known or reported to cause a dermatitis to certain persons exposed to the dust arising

[6] See GARRATT, GEORGE A.: Poisonous woods. Journ. of Forestry, 20: 5: 479-487, May 1922.

Also MATTHES, HERMANN, und EMIL SCHREIBER: Über hautreizendende holzer. Sonder-abdruck aus den Berichten der deutschen pharmazeutischen Gesellschaft, Berlin, 1914.

in manufacture. The toxic principle of cocobolo is an oleoresin. The wood in solid form is not known to be poisonous, hence there is no danger in the use of articles made of cocobolo.

(2) Some workmen are apparently immune, others slightly susceptible, others very susceptible. Persons of this last class should never be permitted to work with cocobolo wood. Susceptibility is increased if the person exposed is perspiring; hence the danger is less in cool weather.

(3) Some lots of cocobolo seem to be much more irritating than others. Any condition, such as rottenness, which increases the amount of fine dust may be expected to aggravate the trouble. There is no positive evidence to support the belief that wood from Nicaragua and Costa Rica is less poisonous than that from Panama.

(4) Every reasonable precaution should be taken to protect workmen from cocobolo dust, such as the use of blowers and the segregation of the dustier operations so as to limit the number of employes exposed. Workmen should be informed regarding the symptoms of the dermatitis and advised to secure medical treatment promptly at the first signs of infection. The trouble is rarely of a serious nature and usually responds promptly to treatment.

SUMMARY AND CONCLUSIONS

1. Cocobolo is a valuable timber produced in Central America and southern Mexico, chiefly on the west coast. It was first introduced into the trade from Panama over fifty years ago. The present commercial sources are Panama, Costa Rica, and Nicaragua. Possible new sources are Honduras and southwestern Mexico.

2. Cocobolo is the product of at least three species of leguminous trees, namely, *Dalbergia retusa* Hemsley, *Dalbergia hypoleuca* Pittier, and *Dalbergia Granadillo* Pittier. The first was described and named in 1878, but it was nearly thirty-five years afterward before the relation of the botanical species to the commercial timber was discovered. The other two species were not named until 1922. Their woods were accepted by the trade first as substitutes and later as genuine cocobolo; the latter classification has proved correct.

3. Cocobolo trees are not large and grow in the understory of the mixed hardwood forests in rather inaccessible regions. The trees are scattered and the extremely heavy logs are difficult to transport over the rough

country, thus making the woods operations slow and expensive. The supply of timber is in many places being seriously depleted.

4. The exports of cocobolo are subject to great fluctuation. The largest amount exported in one year from Panama was 5,195,000 pounds in 1914, of which nearly four-fifths was to the United States. During each of the years 1912, 1913, and 1917, Costa Rica exported over 5,000,000 pounds, the maximum being 5,732,000 pounds in 1917. Nicaragua has until recently exported all cocobolo as rosewood.

5. The principal use for cocobolo is for the handles of cutlery, for which it is well suited on account of its hardness, beauty of color, and grain, ease of working and polishing, and resistance to the effects of moisture. Other uses are brush and mirror backs, small tool handles, and miscellaneous fancy articles of turnery. The amount consumed annually in the United States is estimated to be about 2,500 tons or 5,600,000 pounds, equivalent, at 70 pounds per cubic foot, to 80,000 cubic feet.

6. The dust arising in working cocobolo is toxic to some persons and gives rise to a dermatitis resembling ivy poisoning. Many people are apparently immune and others only slightly susceptible. The effects are rarely of a serious nature. The wood in solid form is perfectly harmless.

7. No satisfactory substitute for cocobolo has been found. Several other woods, such as rosewood and ebony, are used in cutlery manufacture, but they have their own recognized place and cannot be classed as substitutes. American hickory is sometimes dyed red to imitate cocobolo for small tool handles. The wood of *Astronium* (Anacardiaceae) has been used successfully for certain classes of tool handles and may prove of considerable importance.

ACKNOWLEDGMENT

The authors are indebted to Mr. C. D. Mell, New York City, for information about cocobolo logging operations in Central America and also for some of the photographs used to illustrate this bulletin. Material assistance has been given by New York dealers, especially the C. H. Pearson & Son Hardwood Co., Inc., 29 Broadway, and the J. H. Monteath Company, 202 Lewis Street. The following firms cooperated in the investigations of cocobolo poisoning: Winchester Repeating Arms Company, and The Sargent Company, New Haven, Conn.; Stanley Rule and Level Company, and Messrs. Landers, Frary & Clark, New Britain, Conn.; Salisbury Cutlery Handle Company, Salisbury, Conn.; Northampton Cutlery Com-

pany, Northampton, Mass.; John Russell Cutlery Company, Turners Falls, Mass.; Goodell Company, Antrim, New Hampshire; Ontario Knife Company, Franklinville, New York; Ames-Bonner Company, Toledo, Ohio; American Cutlery Company, Chicago, Illinois. Credit for other assistance is given in the text.

Plate 1. Leaves and fruits of *Dalbergta retusa* Hemsley from Panama. Specimen in U. S. National Herbarium.

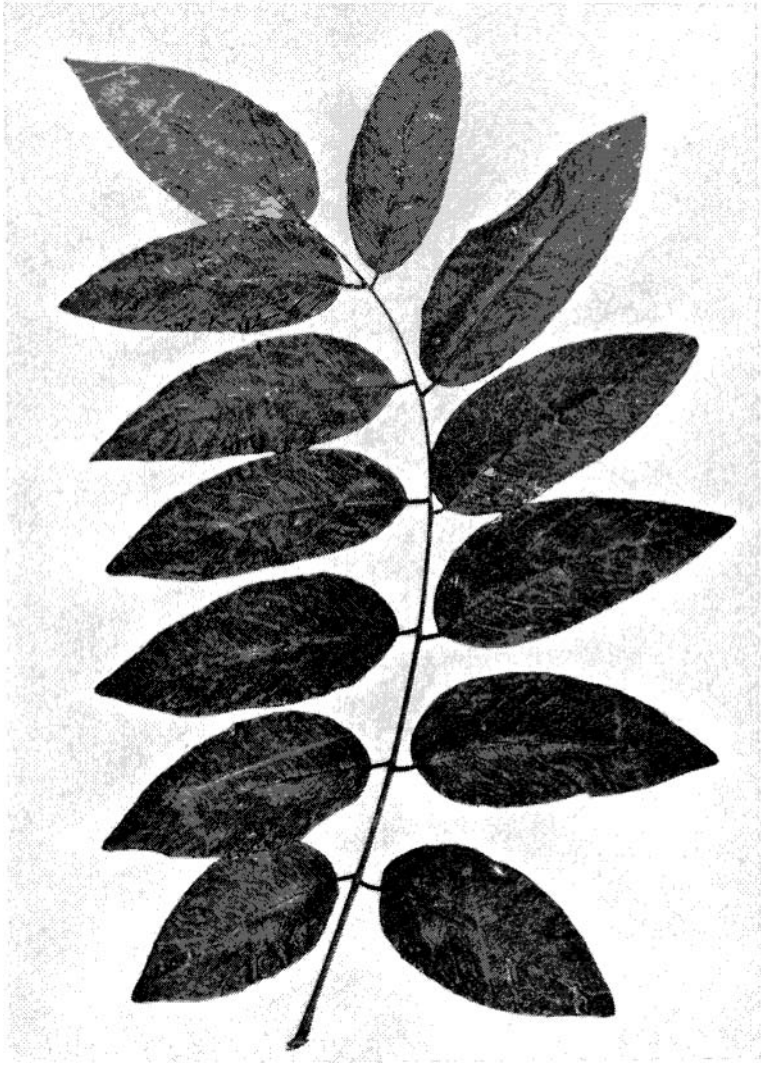


Plate **II.** Leaf of *Dalbergia retusa* Hemsley from Nicaragua. X ½. Collected by l\1essrs. E. Palazio & Co., Corinto; identified by Dr. S. F. Blake.

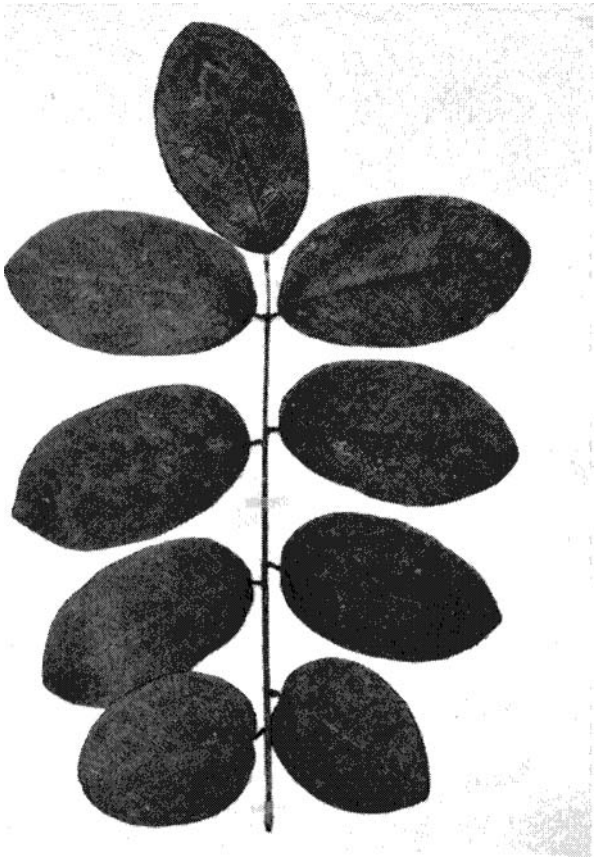


Plate **III.** Leaf of *Dalbergia hypoleuca* Pittier from Costa Rica. X ½. Collected by Messrs. Alberto Fait & Co., Puntarenas; identified by Dr. S. F.Blake.

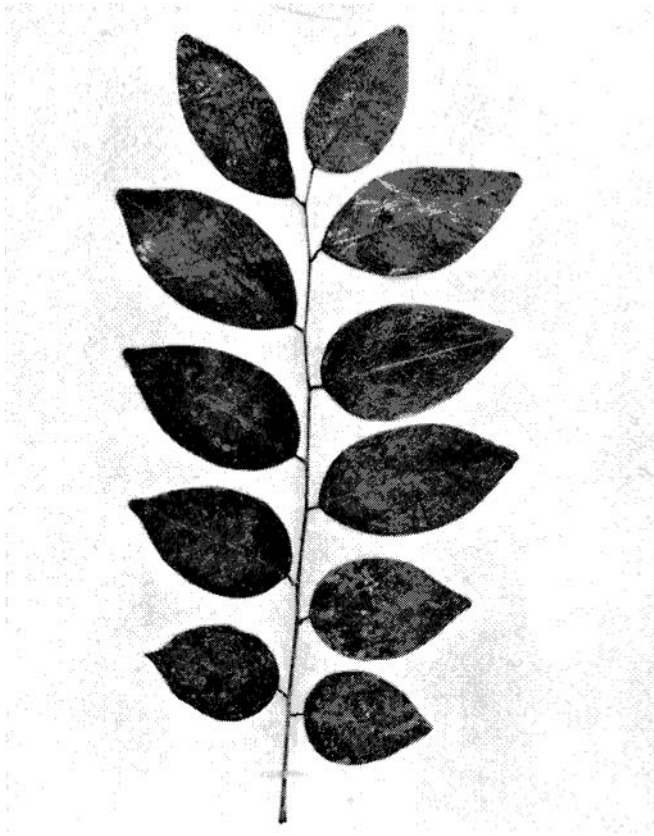


Plate IV. Leaf of *Dalbergia Granadillo* Pittier from Mexico. X ½.
Collected by Mr. John A. Gamon; identified by
Dr. Paul C. Standley.

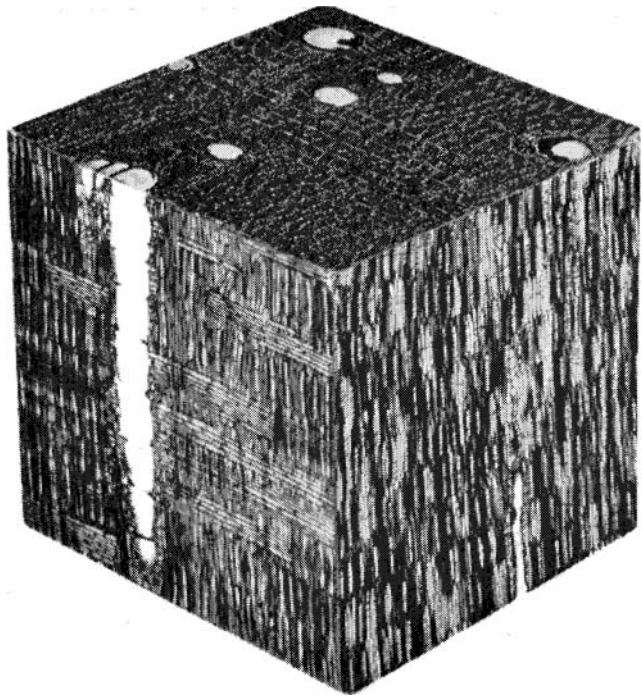


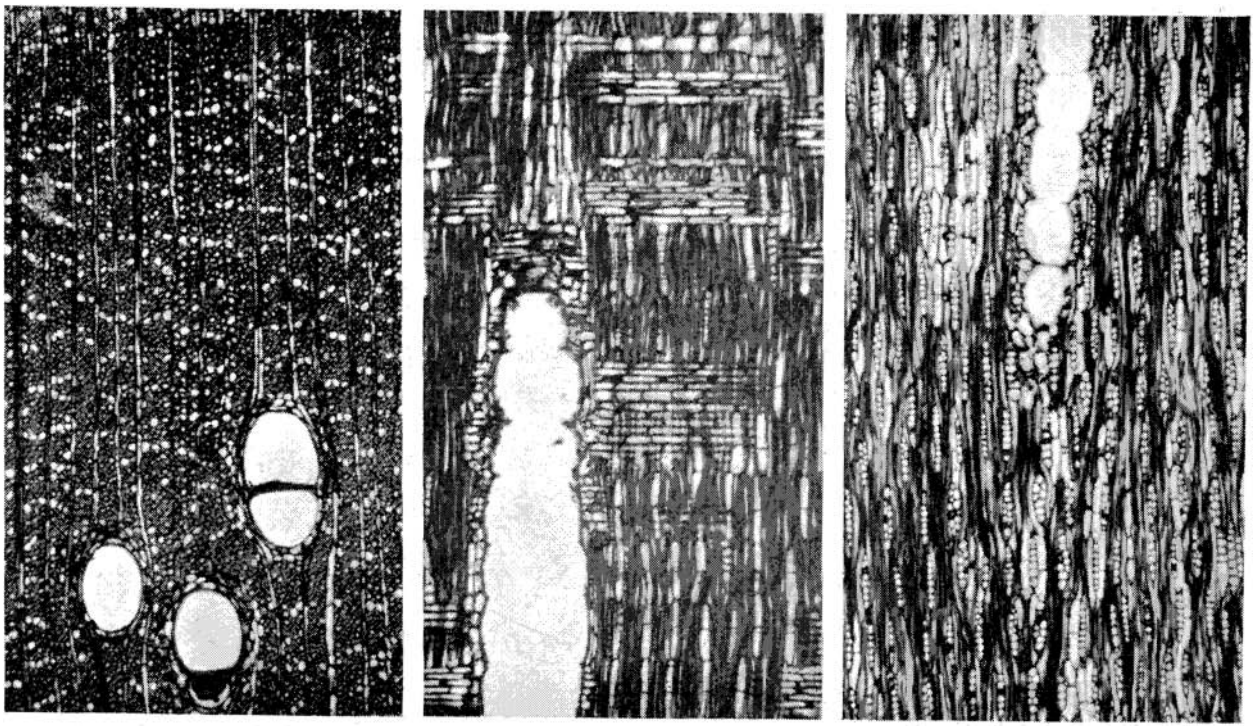
Plate V. Photomicrographs of the wood of *Dalbergia retusa* Hemsley from Panama. X 30.

Arranged in their natural positions. The cross section at the top shows 6 solitary pores and a radial group of 3; the rays and the wavy parenchyma lines at right angles to them; and the darker ground mass composed of thick-walled wood fibers. The radial section at the left shows an open vessel and a ground mass of wood fibers and wood parenchyma strands crossed by the rays. The tangential section at the right shows the horizontal seriation of the elements, 9 tiers or stories being visible; the cross-markings thus produced are called ripple marks.

Transverse

Radial

Tangential



PIate **VI.** Photomicrographs of the wood of *Dalbergia hypoleuca* Pittier from Costa Rica. X 50.

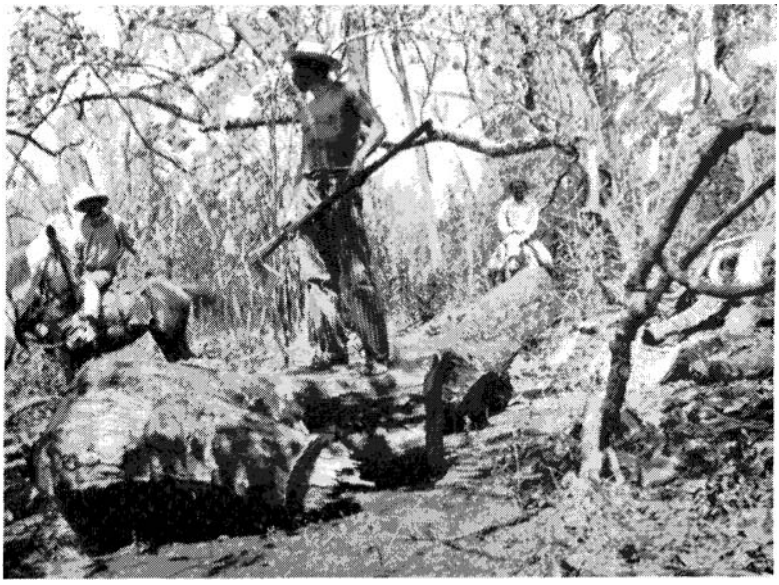


Plate VII, No. ı. He'wing the sapwood from cocobolo logs in Costa Rica.

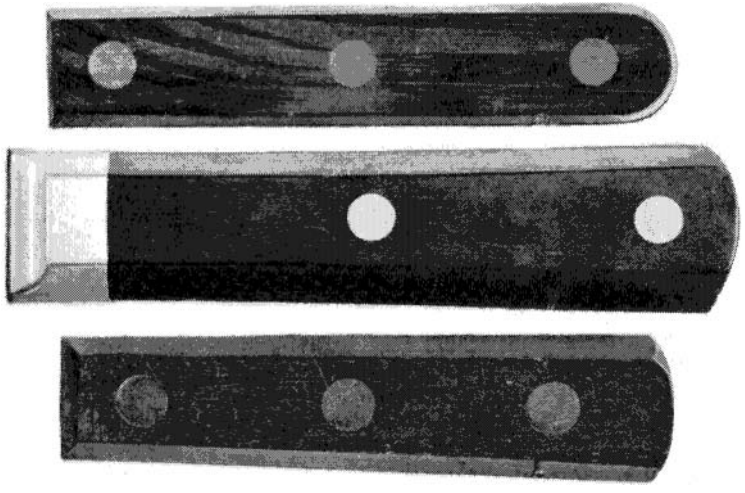


Plate VII, NO.2. Winchester knife handles of cocobolo.
Cutlery handles of this kind consume three-fourths of the cocobolo imported into the United States.

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