Castilla as a Western Hemisphere Rubber

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Castilla trees are indigenous to Latin America from Mexico to Peru, and have yielded a wartime supply of rubber in excess of 18,000 tons. Hevea, guayule, Cryptostegia, and Castilla have each had large-scale trials as rubber producers in the Western Hemisphere. Information now available on Castilla, in comparison with the other types, suggests that this tree may be developed to meet the needs of Latin American small farmers who could produce it as a secondary or cash crop. Castilla has advantages over Hevea of simpler culture, possibly lower labor costs, and resistance to most diseases, especially to the South American Leaf Disease. The quality of the rubber is good. The latex is stable for periods of days or weeks which would permit transportation in small lots to central blending and coagulating stations. It has other peculiar properties which could be exploited to find specialized uses. These possibilities should not be overlooked by agencies of the United States and Latin American Governments which are now working on rubber development in the Western Hemisphere.

CASTILLA trees were planted extensively in Mexico, Central America, and northern South America before 1900. In Mexico, plantings were multiplied many times in the decade 1900–10, and in 1910 rubber production reached its peak. The total was 17,381 tons of which 9542 tons were guayule and the remaining 7939 were practically all Castilla. In the same year rubber production from all areas in the Americas, outside of the Amazon Valley, was 19,627 tons. This total was composed almost entirely of Mexican guayule and Castilla[2].

In the Amazon Valley also Castilla was an important producer in the first part of this century. There both Castilla and Hevea were almost entirely wild. In 1910 the imports of Castilla rubber (caucho) into Manáos, Brazil, which included transit from Peru, Bolivia, and Venezuela, were 7410 tons (*1*). In the same year the imports of Hevea rubber into Manáos were 22,655 tons.

In Mexico the planters' reason for choosing Castilla rather than Hevea was the free flow of latex from the tapping cuts which gave more rubber with less labor than was possible with Hevea (*5*). The local availability of seed may also have been a factor. However, the discovery by Ridley in 1897 of a new method of tapping greatly boosted the yields obtainable from Hevea trees and lowered production costs of Hevea from the Far East. Since Castilla and guayule costs were not reduced, after 1910 rubber began to be abandoned in this hemisphere. The Castilla plantations were given over in large part to bananas, coconuts, and cacao. Nevertheless, a few plantations remain which have been exploited continuously in Mexico and elsewhere. These plantations and wild trees account for all Castilla rubber produced during the present emergency, a total of over 18,500 tons during 1942, 1943, and 1944.

In the beginning in the Far East, Castilla and many other rubber-bearing trees and plants were compared. Castilla lost out and Hevea was adopted; but this experience is not necessarily a precedent for the Western Hemisphere. For example, although Hevea seems to have produced better in the East than in its native habitat, Castilla seems to have done worse. Another reason is the great discrepancy in labor conditions between East and West. Low labor costs which prevail in the East favor Hevea over Castilla because Hevea gives the highest yields of rubber per tree or per acre. On the other hand, high labor costs which prevail in the West favor the tree which gives the most rubber per man-hour. This tree may be Castilla. As an incidental or secondary crop, Castilla has the advantage that neither special cultural operations nor meticulous tapping methods are required.

The history of western rubber, both Castilla and Hevea, is discouraging. Nevertheless, it is possible to raise rubber in this hemisphere on an economic basis, and the Castilla tree may contribute to this end. Castilla's possibly lower labor costs, resistance to disease, and latex stability are fundamental advantages. Indications are that yields per tree could be greatly increased by selection alone, as in the case of Hevea. No appreciable systematic experiments on Castilla have been undertaken, but information now available justifies experiments parallel with those in progress on guayule, Cryptostegia, and Hevea.

GUAYULE AND CRYPTOSTEGIA

Guayule and Cryptostegia have recently had much attention in this country because they will grow within the United States or near-by, and because it was hoped that they would yield rubber quickly. In 1942–43, 32,000 acres of guayule were planted in California, and 1000 acres in Arizona and New Mexico. In Haiti about 40,000 acres of Cryptostegia were planted between January 1 and December 31, 1943. As quick rubber producers both plants have been disappointing. The guayule project has now been greatly curtailed and the Cryptostegia project has been abandoned (*7*).

The reasons given for curtailing the guayule project are economic rather than technical. However, the possibilities of the mature plant are definitely known. After years of intensive research and cultivation, strains of the guayule plant have been developed which have produced in the Salinas Valley, Calif., over 1600 pounds of guayule rubber per acre on a four-year rotation—i.e., 400 pounds per acre per year. However, fairly good cropland was used, in competition with other agricultural crops. It is doubtful if guayule can be economically produced on semimarginal land in this country. Prospects are more encouraging in Mexico where both land and labor are cheaper. The quality of guayule rubber is poor unless it is deresinated (Table I). However, because it can be machine-cultivated and harvested, and has possibilities of large-scale production, it is a serious contender for a permanent place among natural rubbers.

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[2] *Castilla elastica, Castilla ulei*, etc., are accepted botanical names for various species of this tree. It is called "Castilloa" in the older literature, however, and this name persists today, especially among rubber brokers and factory men.

Figure 1 (*Top*). Young Castilla Tree, Ecuador

Figure 2 (*Right*). Castilla Leaves and Fruit, Ecuador

Figure 3 (*Below*). Large Castilla Tree, Guatemala

Cryptostegia was planted on a large scale in Haiti because it was expected to produce rubber in commercial quantities within one year. It failed for two reasons: (*a*) The yields from whip bleeding, even on well-grown irrigated areas, proved to be only a fraction of what was expected; and (*b*) the plant which was expected to grow on a variety of soil types and sites failed to develop over large areas. Although Cryptostegia whip-latex rubber is better than guayule (Table I), it is not equal to Castilla and Hevea rubbers.

Many rubber-producing plants and trees in addition to Hevea, guayule, Cryptostegia, and Castilla have been examined and exploited during the war emergency. Rubber Development Corporation has been actively interested in the chilte tree of Mexico, in the mangabeira and manicoba trees of southern Brazil, and in the caucho blanco (*Sapium* sp.), a high-altitude tree of Ecuador and Colombia. Except for the wild Hevea of the Amazon, the biggest and most consistent producer has been Castilla.

CASTILLA TREE

PHYSICAL CHARACTERISTICS. Botanical descriptions of Castilla and its various species are given by Pittier (*10*). Figures 1, 2, and 3 show various phases of the Castilla tree. It has vigorous growth, a long clean trunk which may be free of branches as far as 30 feet above the ground, and a fairly soft, smooth, thick bark.

The latex is contained in vessels in the inner bark which are inclined at an angle of about 10° to the right. When the vessels are cut, the latex issues both above and below the incision. It may flow from 20 minutes to 2 hours, and is drained from a distance of about 3 feet. The drained area is not replenished quickly as is the case with the Hevea tree, but only after approximately 3 or 4 months. This is an important difference between Hevea and Castilla trees. Hevea can be tapped every other day by reopening a single cut; Castilla can be tapped only three or four times a year at most, and several cuts are made to drain the whole area of the trunk. Castilla latex may flow almost like water from the tapping cuts, in which case (typical of Mexico) it can be collected at the base of the tree in a convenient container; or it may exude slowly (typical of Ecuador) and hang in the tapping cuts like thick cream (Figure 2).

RATE OF GROWTH. The Castilla tree is often termed the fastest growing tree in the jungle. Published figures are scanty and are mostly on individual or small groups of trees, but in general, the rate of growth, as measured by girth, seems to be about the same for Castilla as for Hevea.

The situation of the tree influences its robustness just as it does any plant. In dense forests or in too close plantings thickness of trunk is sacrificed for height. Too close planting seems to have been a general mistake in Mexico (*13*) and perhaps explains many reports of low yields per tree.

The yield of latex increases with the age of the tree, and the quality of the rubber improves. Native tappers, who are interested only in yield, ordinarily pass up trees less than 7 to 8 inches in diameter. This size, we believe, indicates an age of 6 to 9 years. Fortunately the quality of the rubber as measured by the resin content becomes acceptable at about this same age.

HABITAT. In general, the Castilla tree grows where Hevea grows. It grows wild in many places where Hevea is not found, although Hevea might grow if planted in these areas. Castilla does not grow in extremely wet climates, or in swampy or dark jungles. It does well in western Guatemala, for example, where there is a dry season of several months. In Mexico's Isthmus of Tehuantepec it does better in the dry western than in the humid eastern part. An authoritative correlation of soil and climate with the incidence of the Castilla tree throughout its habitat has been given by Treadwell, Hill, and Bennett (*14*).

Wild Castilla is often found along the borders of streams or in forest pockets which are well drained and comparatively free of other large trees.

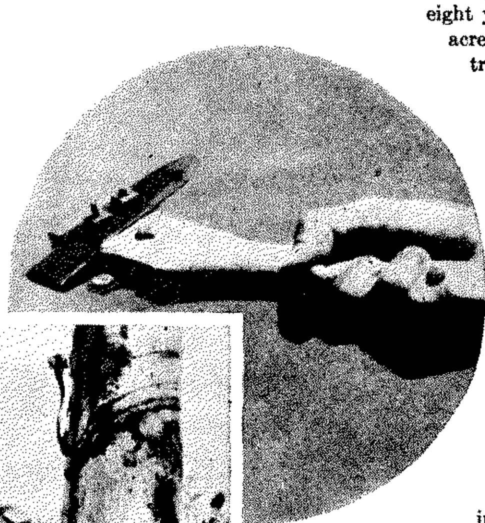

Figure 4 (*Right*). Mexican Tapping Knife

Figure 5 (*Below*). Mexican Method of Climbing the Castilla Tree, and Pattern of Tapping Cuts

PROPAGATION, DISEASES, INSECT PESTS

There is considerable literature on experience with Castilla in plantations (*2, 4, 6, 9, 11, 13*). Usually the trees have been grown from seed. Sometimes the seedlings were set out in partially thinned forests. In Mexico these trees grew slowly (*13*); nevertheless, they grew and in many cases held their own against competition with little or no care (*13*). There is now a stand of about 100,000 apparently wild trees at Mariato, Panama, which is said to have started from seed broadcast in partially thinned forests. On the other hand, large plantations were also begun on cleared and burned land, especially in Mexico. The seeds were planted at the end of the dry season in groups of about ten, at stakes at close intervals of around 6 × 6 feet. These seedlings were gradually thinned until at the end of two years only one plant remained at each stake. In theory, thinning was to continue as the branches interlocked. Generally about four hundred trees were left per acre at the sixth year. Thinning was often neglected, and Smith (*13*) states that trees eight years old could be found standing twelve hundred to the acre on some estates. Experience has shown that planted trees require deep, well-drained soil and wind protection.

On the whole, Castilla appears to be remarkably free from disease. The tree is more liable to suffer from disease where there is heavy rainfall than where there is a long dry spell. Smith notes that trees have been killed by canker on the Atlantic side of Mexico but not on the Pacific side. When tried in Malaya the trees showed a tendency to die at the top, a malady then attributed to excessive humidity. A root rot has been found in Guatemala, Honduras, and El Salvador, evidently caused by poor drainage and a high water table. Castilla appears not to be susceptible to the South American leaf disease.

Of insect pests, the only one known to us is a bark beetle which gets into the bark through the wounds caused by careless tapping. The heaviest infestations observed are in Ecuador where the machete is exclusively used for tapping and the trees are almost girdled with deep slashes.

YIELDS

Wild trees have been reported to yield as much as 50 pounds of dry rubber at a single tapping. This probably means exhaustive tapping in most cases. The best yields recently obtained by Rubber Development Corporation men on old trees, felled and ringed for complete recovery of the rubber, are only slightly over 50 pounds. By tapping without felling, the large tree shown in Figure 3 gave 66.72 pounds of latex which, when dehydrated, left 26.94 pounds of total solids, probably about 22 pounds of rubber. This tree was tapped after five months of a very dry season; and this was its third tapping. These are all good yields, but they are yields on wild trees.

The published data on plantation Castilla yields is inconclusive. In most cases essential information is missing, such as the age of the tree or the height to which it was tapped. From Mexico where it can be assumed tapping was adequate, annual yields per tree of 1 or 2 ounces at six to eight years and 2.25 pounds per year at twenty years are reported (*13*). In this case spacing appears to have been four hundred trees per acre, at least for the younger trees. The yield of 2.25 pounds per tree is stated to be for a group of several thousand trees.

A few figures on yields have been obtained by Rubber Development Corporation in the last three years. At Mariato, Panama, the trees of tappable size are, on the average, perhaps twenty years old. These trees are yielding 2 pounds of rubber per tree per year, with three tappings per year. The larger trees are yielding 4 to 6 pounds per year. The indications are that these are the maximum sustained yields. In western Guatemala and in Ecuador the average yield per tree per year is about 1.5 pounds.

Apparently mature unselected Castilla will yield 2 pounds of dry rubber per tree per year (*6*). The results in Panama indicate that better yields might be obtained. Unselected Hevea will yield 4 to 6 pounds per year. Selected Hevea will yield two to three times this amount. The best reported yields per acre for Castilla in this hemisphere are one third to one half as much as for the best Hevea in Malaya. Individual variations in yields between Castilla trees are enormous, however, which suggests the possibility of improvements in yield comparable to those which have been obtained in the past several years with Hevea.

PROPERTIES OF LATEX

Castilla latex when fresh is cream-colored, yellow, or light brown, depending presumably on the species, but the latex of all species rapidly darkens when left exposed. The darkening of Castilla latex, and of the rubber made from the latex, is characteristic.

The dry rubber content varies. In Mexico it ranges from 22 to 29%, in Ecuador from 30 to 36%, for latex as received at coagulating plants. These figures refer to the dry weight of sheet rubber obtained by coagulating the latex. The sheets are about 90% rubber hydrocarbon.

In Mexico the total solids figures for latex range from 31 to 40%, approximately; in Ecuador the average is higher but the top figure does not exceed 41 to 45%. The nonrubber content is mostly water soluble. When the rubber is coagulated, a brown serum remains laden with these soluble substances, the nature of which is mostly unknown. We do know, however, that they include an antioxidant.

The specific gravity ranges from 1.006 to 1.016. The latex is acid to litmus; pH values ranging from 4.5 to 6.0 are reported. The latex is quite stable and can be stored from two to three weeks in open containers.

One of the most characteristic properties of Castilla latex is its tendency to cream when diluted with water. When water is added, the rubber particles slowly rise, leaving a layer of more or less rubber-free serum roughly equal to the volume of water added.

These data are for latex as received at coagulating plants. Such latex is obtained from many trees of all ages and is an average. Olsson-Seffer (*9*) gave the following figures to show the change in rubber content of Castilla latex with the age of the tree:

Age, Years	Rubber, %	Age, Years	Rubber, %
1	17.3	11	33.2
3	19.4	13	36.6
5	21.8	15	38.3
7	25.5	17	39.5
9	29.3		

QUALITY OF CASTILLA RUBBER

Much poor-quality Castilla rubber has been and is now received in the United States. The wild rubber is always dirty, and the sheets, although clean, may be soft and sticky. It is possible, however, to make clean and dry Castilla rubber of good quality. Table I presents comparative data on Castilla, Hevea, guayule, and Cryptostegia rubbers. Each set of figures (with one exception) is for a single sample typical of the best obtained. The analyses and vulcanization tests were made by the rubber section of the National Bureau of Standards. The vulcanization tests were made on the same recipe (footnote *b*, Table I). This is the regular A.C.S. test formula with 4 parts of stearic acid instead of 0.5. The additional stearic acid is desirable with Castilla rubber and is not prejudicial to the others.

The Castilla samples tested for Table I were made from latex as received at coagulating plants. The data for such samples, like the data for the latex, represent averages as far as the ages of the trees are concerned. Rubbers from trees of known ages would probably show improvement in quality with age. There is a sharply decreasing resin content. Weber gives 42.33% resin at two years, 18.18% at five years, and 7.21% at eight years (*15*); also he gives a figure of 2.61% resin for a tree of unspecified age. These figures suggest the possibility of controlling quality by classifying latex according to the age of the tree. The average resin content of commercial Castilla rubber now received from Mexico is about 7.5%, from Ecuador about 5%.

Weber (*15*) reports marked differences in resin content between the rubber from the trunk and other parts of a Castilla tree:

Trunk	2.61%
Largest branches	3.77
Medium branches	4.88
Young branches	5.86
Leaves	7.50

Probably the tree was old; at least, it had a low resin content. We present the figures because of their theoretical interest.

TAPPING AND LABOR

The method used in Mexico for tapping Castilla trees is described in detail by Seeley (*12*). Briefly, the tapper uses a knife having a U-shaped blade and a fin blade (Figure 4); he ascends the tree with the aid of a special rope climbing belt, making V-shaped channels in the outer bark with the U-blade and then cutting into the latex vessels in the inner bark with the fin blade. The V-cuts are spaced about 3 feet apart up the main trunk of the tree. They extend around three quarters of the circumference of the tree. The latex flows down a central channel connecting the bases of the V-cuts and is caught in a bucket or gourd at the base of the tree. Figure 5 shows a tapper at work. Experience of Rubber Development Corporation has been that a skilled man can tap one 14-inch tree in 20 minutes by the Mexican method.

The Mexican method must be modified for trees from which the latex does not flow. Sometimes on these trees the latex flows freely for a few seconds and then stops, in which case the central canal is needed; otherwise it can be eliminated. On such trees a cut at least an inch wide is needed to contain the creamlike latex. In Ecuador, where the majority of the trees are of this type, the cuts are horizontal and are made with a machete. Although different kinds of tapping knives have been tried on the nonflowing trees in Ecuador, none has so far proved successful. The machete is used by everyone, and the latex is collected from the horizontal cuts by scraping it out with the fingers. This, however, results in a higher labor cost for latex collection than is the case with the free-flowing type of tree where the latex is collected in one container at the base of the tree. Therefore, if new plantings are made in Ecuador, a Castilla variety producing free-flowing latex should be tried.

On Hevea plantations in the East, one man can tap six hundred trees (three hundred each on alternate days). If each tree yields 5 pounds of dry rubber per year, this means that one man can tap 3000 pounds of dry Hevea rubber per year. On plantations of selected material or with bud-grafted trees, the production per tapper per year may equal 9000 or 10,000 pounds. In the West, presumably equal production per tapper could be obtained with Hevea. If, on a Castilla plantation, one man could tap fifteen mature trees per day and if each tree gave 2 pounds of dry rubber per year in three tappings, one man could produce approximately 3000 pounds of dry Castilla rubber per

Table I. Quality of Castilla, Hevea, Guayule, and Cryptostegia Rubbers

Description of Rubber	Origin of Sample	Chemical Analysis, %: Acetone extract[a]	Benzene insol. (8)	Rubber hydrocarbon (8)	Physical Tests[b]: Optimum cure, min.	Tensile strength, lb./sq. in.	Ultimate elongation, %
Castilla							
Whole latex coagulated with Aerosol OT	Mexico	7.5	3.1	89.4	45	3500	870
Whole latex coagulated with soap	Ecuador	7.5	2.6	88.5	45	3280	755
Whole latex coagulated with jalap resin	Ecuador	4.4	2.8	92.8	45	3550	815
Whole latex dried in smoke	Ecuador	5.2	12.4	83.2	30	3660	795
Whole latex dried in air	Guatemala	3.4	23.9	72.3	65	3470	685
Washed and dried scrap	Ecuador	5.1	7.6	86.3	90	1980	670
Hevea							
Blended smoked sheet (av.)	Far East	3.6	2.0	92.4	30	3730	780
Washed and dried upriver fine Para	Brazil	1.7	..	..	65	3550	760
Weak fine	Colombia	2.3	..	..	65	3100	770
Guayule							
Recent commercial sample (not deresinated)	Mexico	24.3	9.3	66.1	30	1710	855
Recent commercial sample (deresinated)	Mexico	7.2	1.7	90.5	60	2600	835
Cryptostegia							
Whip latex coagulated with water	Haiti	12.7	2.9	81.7	30	2790	805
Whip latex coagulated with Nacconal	Haiti	14.3	3.3	83.2	15	2620	910
Whip latex coagulated with salt, soaked 24 hr. in water	Haiti	13.8	3.2	81.2	30	2990	840
Trunk latex coagulated with Nacconal	Haiti	8.6	2.0	88.0	30	3120	870

[a] By A.S.T.M. method D297-43T.
[b] Test recipe: rubber, 100; zinc oxide, 6; stearic acid, 4; Captax, 0.5; sulfur, 3.5; cures at 141° C.; tensiles and elongations by A.S.T.M. method D412-41.

year. If each tree gave 3 pounds, one man could tap 4500 pounds per year. At Mariato, Panama, where the trees are growing under jungle rather than plantation conditions, but where tapping is under some supervision, the average rate of latex collection is 5.5 gallons per day per man, or approximately 11 pounds of dry rubber per day, or 3300 pounds per year. At Mariato the highest rate of collection for the best tapper is approximately 9000 pounds per year. With plantation facilities and trees of uniform size, better results could surely be obtained.

These figures indicate that comparing unselected Castilla trees in Panama, for example, with unselected Hevea trees in Malaya, the amount of tapping labor required per pound of dry rubber is no greater for Castilla than for Hevea; a strict comparison might show it to be considerably less. We believe, moreover, that the yields of Castilla could be increased so much by simple selection that in a comparison of tapping requirements between selected Castilla and selected Hevea the advantage would still be with Castilla. The yield per tapper is an important item to consider in this hemisphere, where labor costs are relatively high. Still other factors are involved, however. Specialized cultural methods are required in establishing Hevea plantations, such as bud grafting, disease control, and careful systematic upkeep. Castilla plantations, on the other hand, do not require such meticulous attention. These factors, together with the simple tapping system used which requires no special skill, make Castilla well adapted to labor conditions in Central and South America. On the other hand, although selection may considerably improve the yield per tree, it is doubtful if yields per acre from Castilla would ever equal those obtained from Hevea.

METHODS OF PREPARATION

Analyses and test data on various Castilla rubbers are given in Table I. To the best of our knowledge, Castilla sheet rubber should be made from strained but not diluted latex, and coagulated with jalap resin, with hot tallow or stearic acid soap solution, or with cold Aerosol OT solution. Alum is a coagulant but it is objectionable because it slows the curing rate. Plant extracts, such as batatilla or moonvine (*Calonyction aculeatum*), have been used for many years; but they are not available everywhere, the amount of active ingredient is not subject to control, and excessive amounts cause softening of the rubber.

The active ingredient in the moonvine is a resin (*16*) which is not commercially available. Jalap resin is equally effective, however, and is commercially available. It can be used as a dispersion, made by pouring the alcohol solution into water or by dissolving a soap containing jalap resin in water. A satisfactory jalap soap can be made by mixing 10 parts of the resin intimately with 100 parts of molten tallow soap and adding a little water if necessary. A 1% solution of this soap in hot water should be used. When jalap resin is employed as a soap solution, about 0.1 gram of resin per 100 grams of dry rubber in the latex is required for coagulation. Many other resins, including rosin and its derivatives, have been tested as coagulants with negative or indifferent results. Acids, used alone, will not coagulate Castilla latex.

The amount of soap required as a coagulant is about 2 grams, and of Aerosol OT, about 0.4 gram per 100 grams of dry rubber in the latex. These are figures obtained in experiments in Haiti. The concentration of the soap solution should be 5%, of the Aerosol OT solution, 1%. The soap solution must be used hot. With both soap and Aerosol OT, and with jalap resin also, the technique of coagulation is the same. The latex, undiluted, and the coagulant solution are mixed rapidly together, poured into a coagulating tray, and allowed to set. After a few minutes a loose gel forms which, by gentle stroking pressure or gentle rocking of the whole tray, can be quickly changed into a firm coagulum. Coagulation is 100% complete, and the serum is clear brown with on floating rubber particles. This coagulum is easily handled and rolled into sheets. Figure 6 pictures a typical Castilla coagulating plant in operation in Ecuador. Figure 7 shows latex arriving at the same plant, transported in rubber-coated bags.

As between soap and Aerosol OT as coagulants, on the basis of the figures given above and at present prices, the soap is a little cheaper. In some places, however, especially in Mexico, it does not seem possible to obtain results with this amount of soap and less Aerosol OT can be used; in this case the price situation is reversed. Soap has an important advantage in that it is easily obtained. Not all soaps are effective, but usually it is possible to find one soap on the local market that will work. Soap plus a weak solution of acid is also effective. The fact that soap solutions must be used hot is no disadvantage in fixed coagulating plants. The amount of soap required is immaterial since most of it is left in the rubber as fatty acid, which is desirable rather than otherwise in rubber goods. Where coagulated sheets are made by individual tappers, a coagulant is needed that can be dissolved in cold water. For this use, therefore, Aerosol OT or jalap resin in alcohol is to be preferred.

Coagulated sheets can be either air-dried or smoke-dried, but air drying is preferable. With smoke there is danger of overheating, which may cause the sheets to stretch.

The characteristic property of creaming previously referred to has been used by many but not all producers for years to prepare the latex for coagulation. The process is called "washing". Sometimes washing is repeated several times. The latex is improved in color. This practice is, however, to be discouraged. The freshly made sheets look good but tend to deteriorate rapidly, become soft and sticky, and increase in acetone extract.

Creaming is seldom complete. Often there is considerable loss of rubber in the serum. Creaming agents such as sodium alginate prevent this loss, although the cost may be more than the value of the rubber saved. Although creaming is not ordinarily desirable, it cannot be avoided in working with dirty latex, if it must be diluted to permit sand and grit to settle.

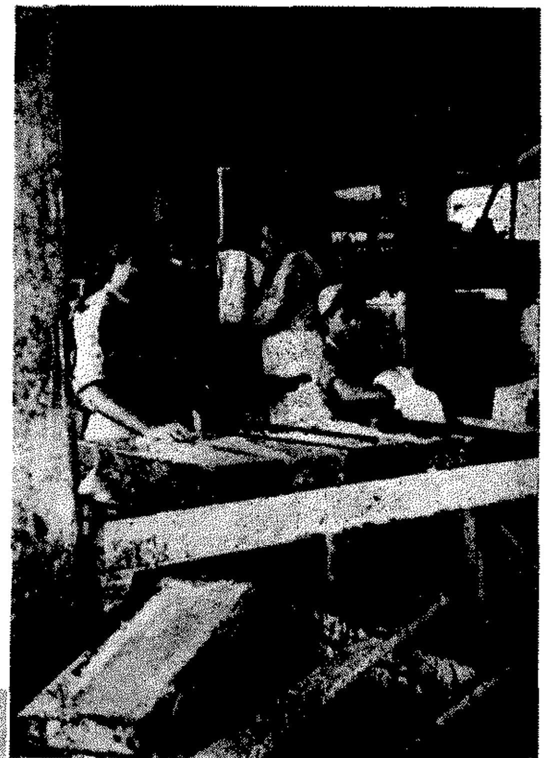

Figure 6 (*Above*). Castilla Coagulating Plant, Ecuador

Figure 7 (*Right*). Transporting Castilla Latex in Rubber-Coated Bags

Figure 8 (*Below*). Preparing Whole Latex Castilla Rubber by Drying on Panels

Since, presumably, the loss of water-soluble antioxidants causes Castilla rubber made from washed latex to deteriorate, it can be concluded that to cut down this loss further, sheet rubber should be made not only from unwashed but from undiluted latex. Undiluted latex may be very thick, but by using a deep box it can be screened through a 60-mesh screen readily enough.

The discovery that washing is harmful suggests that perhaps Castilla rubber should be made by dehydrating the whole latex, as by drying in air on boards or tiles. Castilla rubber made in this way not only has excellent aging resistance, but the highest tensiles and fastest cures have been obtained also. Moreover, in its preparation the operations are simple and the equipment requirements are negligible. Figure 8 illustrates one method. At present most of the rubber of Guatemala and Honduras is being so made—for example, by drying on concrete floors or on mats by the so-called *petate* method. However, some of this rubber has been found objectionable by the factories because of its high water extract. They find it necessary to wash and dry this dehydrated rubber and, therefore, penalize the product by the cost of these operations. Nevertheless, such rubber is good when it is washed and dried. Less labor is required to make dehydrated rubber than to make coagulated sheets.

The water-soluble content of dehydrated Castilla rubber need not necessarily be so high as the experience in Guatemala indicates. The source of the latex is important. Samples made in Ecuador have 82 to 83% rubber hydrocarbon as compared with 72 to 73% from Guatemala. Data on other properties of dehydrated rubber from these two sources are given in Table I. The particular Ecuador sample used was dried by spreading the latex on boards in a smokehouse. The quality is the same whether the latex is dried in smoke or in air.

PROBLEMS

The question of yield is unsettled. The figures given here are for wild trees or for trees grown from unselected seed, chosen as seedlings for appearance only, and probably planted too close and left standing too close.

The question of quality is unsettled. The data on Castilla in Table I are on rubber from wild trees of all ages and types. The ratio of resin to rubber changes markedly with age. It also seems to vary between individual trees of equal age. What quality of rubber could be made from latex from eight-year-old trees, for example, from which all five-, six-, and seven-year olds were excluded? What improvement of quality is possible simply by selection based on acetone extractions at, say, ages of two, four, and six years?

Although many substances have been tested as coagulants for Castilla latex, many remain to be tested. In particular, surface active agents are promising, not only for Castilla but also for Hevea and other latices. The action of these substances is by no means predictable. Aerosol OT is good for Castilla latex, although its effectiveness is different in latices from different sources; it will coagulate Hevea latex but seems to be ineffective with Cryptostegia whip latex. Nacconal NR is a good coagulant for Cryptostegia whip latex, but not for Castilla and Hevea latices. Aerosol OT is a sulfonated ester of a dicarboxylic acid; Nacconal NR is a sodium alkyl aryl sulfonate. The reactions involved are both theoretical and practical in interest. Not enough is known about them.

It is by no means certain that the most efficient method of tapping Castilla has been found. Many methods are in use, each stoutly defended by its proponents. Systematic experiments on tapping methods involving variations, for example, in the order of making the cuts and in the number of tappings per year might lead to increased yields and lowered labor costs.

The tendency of Castilla rubber to soften and become sticky on aging has been mentioned. We have found that by retaining as much serum solids as possible in the rubber this tendency is greatly reduced. There have been occasions, however, when it was not sufficiently reduced. Materials such as batatilla resin and rosin are apparently oxidation catalysts. Do the resins naturally present in Castilla latex contribute to softening? If so, younger trees and high-resin latex trees may be the source of the trouble. One solution would be to pass by the younger trees and to eliminate the high-resin latex trees. Another solution would be the chemical one of neutralizing the resin by adding an antioxidant at the plantation. Still another possibility is the chemical or physical separation of the resin from the rubber in the latex before coagulation. If the two substances exist as, or can be made to form, separate particles, their physical separation should be possible.

The resins of Castilla latex are no less interesting from the chemical standpoint than the serum solids. What is it in the serum that is a rubber preservative? Is it one component which makes up a small fraction of the total? If so, possibly this component could be separated in a pure form and later added back to washed latex to obtain a rubber at the same time age resistant and free of nonessential water-soluble substances. Adding a commercial antioxidant would accomplish the same purpose. The possibilities of such chemical treatment are particularly applicable to Castilla. Since the latex is stable for days without the addition of preservatives, it could be shipped long distances from remote plantations to central coagulating plants, and there be handled in the quantities required for such chemical manipulations. This stability of Castilla latex makes feasible at the same time the accurate control of quality and the production of latex in small lots by individual farmers. In this respect, at least, Castilla already has an advantage over Hevea unless ammonia-preserved Hevea latex is to be thus concentrated for bulk processing.

Castilla rubber is softer than Hevea. Its stress-strain curve is considerably below that of Hevea in the same recipe. This property suggests many special uses for which Hevea is unsuited. Why is this rubber soft? Does its softness vary with the age of the tree, between individuals, or between species? Answers to these questions would show how to control this valuable property.

Castilla latex is sufficiently stable so that it could probably be shipped to the United States without change. It has been flown from Ecuador to Washington and kept in Washington for two weeks or more without apparent change. It does, finally, coagulate spontaneously. The latex particles go to the cathode on electrolysis. This is the opposite of the behavior of ammonia-preserved Hevea latex, the particles of which go to the anode on electrolysis. The particles of Castilla latex are somewhat larger than Hevea particles and more nearly uniform. Each of these differences might develop into a special use for this latex. Certainly the utilization of rubber as latex will expand when peace returns and transportation is again available. For this reason alone, if for no other, Castilla deserves consideration.

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