ducted by A. D. Little, Inc., of Cambridge, Massachusetts and the John A. Manning Paper Company of Troy, New York.

The research and development of applications of okra in the fisheries aspect of the food industries was conducted by the author at The Marine Laboratory of the University of Miami, Miami 49, Florida.

The Morningstar-Paisley Company, Inc., New York, is the distributor.

Krome Section

CAN ANNATTO (BIXA ORELLANA L.), AN OLD SOURCE OF FOOD COLOR, MEET NEW NEEDS FOR SAFE DYE

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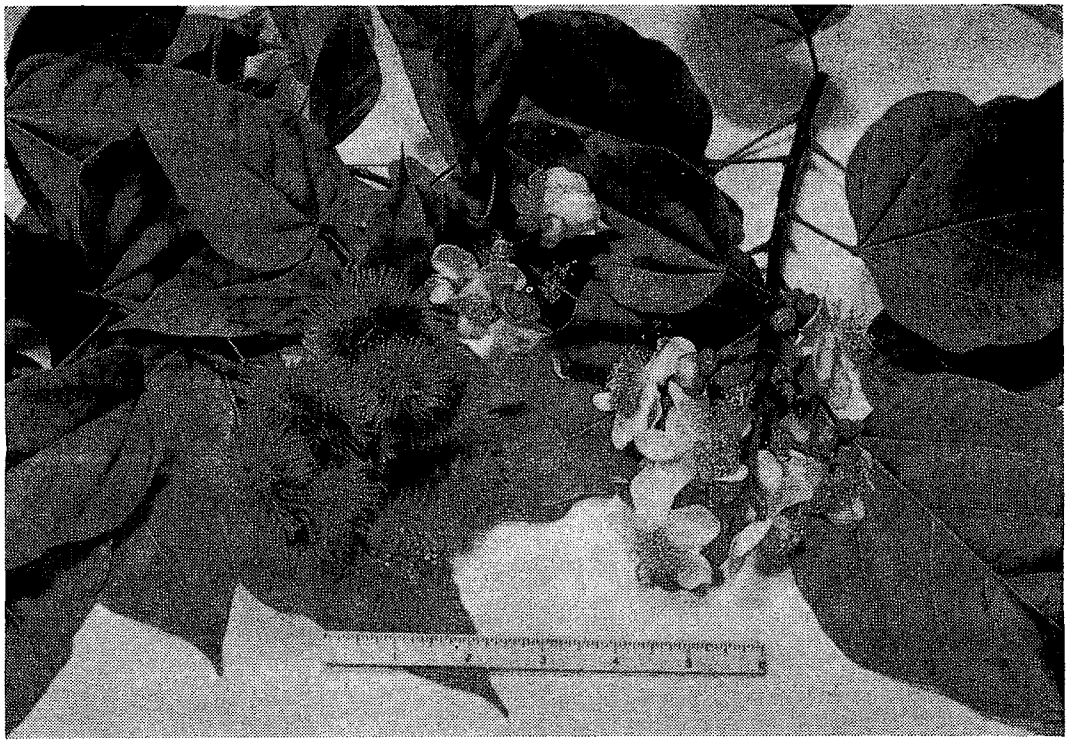
During the past few years, critical investigations of the use of chemicals in foodstuffs and the decertification of certain food colors as carcinogenic have revived interest in natural plant colorants such as annatto, derived from the seed-covering of the tropical American tree, *Bixa orellana* L.

The botanical name of this plant is entirely historical in its significance. The genus perpetuates the aboriginal Taino word, *"bixa"*, which was pronounced by the Indians, *"bisha"*. The specific epihet was bestowed in honor of the celebrated discoverer of the Amazon, Don Francisco Orellana. Colloquial names shared by the plant and dye product alike are numerous and include variants of annatto such as anatto, arnatto, arnotto and onoto, as well as achiote, or achote, used through much of Spanish America, urucu, roucou, bija, bijo and orlean. The nickname, "lipstick tree", was apparently facetiously conceived and popularized by the late Col. H. W. Johnston, proprietor of one of the early exotic plant collections in Homestead, Fla.

The origin of the species is uncertain. To quote de Candolle: ". . . it is said to be indigenous by Seemann on the northwest coast of Mexico and Panama, by Triana in New Granada, by Meyer in Dutch Guiana, and by Piso and Claussen in Brazil." It is found growing both wild and cultivated in southern Mexico, Central America, northern South America and the West Indies. Plantations were common in Brazil in the 16th century and in Jamaica in the 17th. The annatto was one of the first American plants to be introduced into southern Asia and tropical Africa and it soon became naturalized in these areas and in the East Indies.

The shrubby tree, reaching 25 to 30 feet in height, has tender, alternate leaves, heart-shaped at the base and pointed at the apex, 3 to 8" long and 2 to 5½" wide, palmately veined, and with slender, 2" long petioles. The hermaphrodite flowers, resembling single brier roses, borne in showy terminal clusters, are 5-petaled, 1½" to 2" wide, pink or white, with a large tuft of yellow stamens in the center. Only a few open at a time, the unopened round, rosy buds adding to the beauty of the cluster. The fruits, in compact, upright clusters of sometimes a dozen or more, are burr-like capsules, up to 2" long, rounded or pointed-oval, in some forms smooth but usually covered with soft spines, and varying in color from brownish-green or maroon to a brilliant scarlet or even yellow when fresh; turning reddish-brown when dry. Within, the capsule is divided into two semi-hollow cells by a parchment-like placenta, to the exposed surface of which are attached a few dozen small, obpyrimidal seeds much like grape seeds. Each seed is coated with a pulpy aril, moist and orange-red in the unripe pods and drying to a deep-maroon. As the seed pods dry on



Foliage, immature seed pods and flowers of the maroon-bristled annatto long grown as a curiosity in South Florida. Photo by Julia Morton.

the plant, they split open like clam shells and the seeds, by then semi-detached from the placenta, are easily shaken out.

Since ancient times, the Indians of tropical America made extensive use of the colorful arils, apparently gathering the moist seeds from the unripe capsules and pressing them into balls. If the hands were first oiled, the pulp would blend with the oil and form a paste which was scraped from the skin. The paste would be packed into gourds or sections of hollow stems for carrying on the person or storing away in the hut. Dr. Paul C. Standley, in his *Trees and Shrubs of Mexico,* calls attention to the following account by Oviedo (Lib. VIII, Cap. VI): " . . . the Indians . . . mixing the dye with certain gums . . . make a fine vermilion color with which they paint the face and body in such an elegant fashion that they resemble the devil himself. The women do likewise when they hold their feasts and dances, and the men when they wish to appear well and when they go to war; in order to appear fierce. It is very hard to remove the *bixa* until many days pass, but it is astringent and they say very comfortable, and even beneficial in this way, that when they are thus painted if they are wounded, since the paint and the blood are of the same color, the men are not frightened as much as they would be if they were not painted red, but this they attribute to the virtues of the *bixa*. The paint, besides its evil appearance, has a disagreeable odor because of the gums and other things mixed with it." From the headhunters of the Amazon to the remote Colorados of Ecuador, they revered the annatto as a magical plant with a female soul. Some still plaster the coloring matter on their hair and all over their bodies to ward off evil spirits and also consider it an effective love charm. It apparently serves, too, as a protection from insects and from the ultra-violet rays of the sun.

In Colombia, the Indians painted their faces and legs with annatto, then used plant resins to glue to their calves the softened floss from the pods of balsa (*Ochroma lagopus* Swartz) or wild cotton (*Cochlospermum vitifolium*

Spreng.) trees, and strutted around in proud display of their adornment.

Some West African tribes adopted annatto as self-decoration for folk dancing. Natives of the Caroline Islands and Samoa mix annatto with turmeric to color their bodies. The Mayas used annatto for painting pottery; the Samoans, for designs on tapa cloth; other peoples, for coloring feathers, sheepskin, ivory, bones, bamboo mats and rattan. The color may be fixed with tamarind leaves or with barks containing tannin. A pale mauve hue is obtained by adding lime juice, or durian wood ashes, to annatto.

The South American Indians also used annatto to color their food, but it was as a potential dye for textiles that it was first brought to the attention of Europeans by the early explorers. In 1775, an English dyer named Bancroft obtained a patent to import and use annatto. It was used to a limited extent for silk, cotton and wool but found unsatisfactory since the color is not durable in fabrics. While resistant to soap, alkali and acids, exposure to sunlight may cause fading in two days.

However, widespread adoption as a food color quickly followed. In tropical America and the West Indies, annatto became primarily valued for coloring rice, but also served to enhance soups and chocolate, giving to the latter the rich tone favored by the Aztecs. The economic importance of annatto increased rapidly with its recognition as a highly desirable colorant for cheese, butter and margarine, affecting neither the flavor nor the aroma of the product, and 1 oz. of dye sufficing to color 100 pounds. In 1828, the Dutch government ordered the planting of annatto trees along the roadsides in Java so that the dye could be exported to Europe. The dairy industry in Europe, England and the United States consumed great quantities of annatto for many years prior to the First World War. In 1899, the United States imported over 700,000 lbs. from Puerto Rico, alone. In 1917, the total amount from all sources imported into the United States was reported to have declined considerably and was at that time averaging 800,000 lbs. a year. Brazil and French Guiana, leading in production, were exporting $500,000 worth annually to the United States and Europe. In 1928, the world supply of several hundred tons a year was derived mainly from Brazil, India and Puerto Rico. In 1934, Peru was exporting some 2,200 tons and in 1935 Ecuador about a tenth as much. In 1940, India was said to be shipping 200 tons annually. Not all was employed in the food industries. Other commercial uses included coloring of ointments, hair oils, shoe polish, floor wax, varnish, candles and soap.

In 1884, the aniline dye "Congo Red" was introduced and began to displace the less versatile annatto. As other aniline dyes came more and more into prominence and proved to be more soluble, more stable, vastly cheaper as well as offering a greater range of hues, annatto, along with many other natural plant colorants was largely replaced by synthetics, except in some countries where annatto has remained the standard colorant for dairy products.

In the early 1930's, there was a surge of interest among chemists and nutritionist in annatto as a possibly rich source of carotene. Research, however, proved that, while annatto is related to the carotenoids, it has no vitamin A activity. The commercial status of annatto as a world commodity continued to wane until just the past few years when the negative revelations regarding some coal tar colors supplied new stimulus to annatto utilization.

Varieties

Bixa is often cited by botanists as a monotypic genus represented solely by *B. orellana* L. (syn. *B. purpurea* Hort.) However, Record and Hess, Le Cointe and some others give recognition to a second species, *B. arborea* Huber, as a medium to large forest tree of the Amazon region. And Macbride, in *Flora of Peru* (Vol. XIII, Pt. IV, No. 1, 1942) describes the following:

B. excelsa Gleason & Krukoff, urucurana da matta; tree, 35 to 100 ft.; having spherical, reniform, reddish-brown pods, 1¼" wide, 1" long; "the fragile but thick-based spines breaking off in age . . .";

B. orellana L. (syn. *B. odorata* R. & P. ex G. Don); shrubby or low, spreading tree; pods ovoid-conical, often pointed, longer than broad, densely spiny, or smooth;

B. orellana L. forma *leiocarpa* (Kuntze) Macbr. (syn *Orellana americana* var. *leiocarpa* Kuntze); a small tree with smooth pods. (This form is cited also by Allen, in *The Rain Forests of Golfo Dolce* (Costa Rica);

B. platycarpa R. & P. ex G. Don, achote de monte; tree to 100 ft. . . . "pods are strongly

Dried, reddish-brown pods of the maroon-bristled annatto, together with dry, aril-coated seeds, loose and as retailed in glass jar (labeled "Achiote"), also a packet of orange-red "Bijol" powder prepared in Cuba, and a "Naturella" lipstick, colored with annatto. Photo by Julia Morton.

flattened and merely roughened with scattered spinulose-tuberculate scabrosities . . .";

B. arborea Huber, "with regular reniform, strongly compressed pods merely muricate in age . . .";

B. urucurana Willd. (syns. *B. orellana* L. var. *urucurana* (Willd.) Kuntze ex Pilger; *B. sphaerocarpa* Triana). Achiote blanco. Tree to 25 ft. . . . resembling *B. orellana* but "pods spherical or flattened spherical and smaller, densely to sparsely spiny . . .";

Paul LeCointe, in *Arvores e Plantas Uteis* (Brazil), describes *B. orellana* L. as the principal species with two varieties, one having vermilion fruit and the other, yellow fruit, the latter being the richer in dye. In addition, he briefly describes *B. orellana* var. *urucurana* Willd., urucu bravo, and lists *B. arborea* Huber, urucurana de mata.

The records of the several introductions of *Bixa orellana* into Florida by the United States Department of Agriculture (No. 44954 in 1917, from Brazil, No. 50222 in 1920, from Belgian Congo; No. 51910 in 1920, from Uganda; No. 76416 in 1927, from Uganda; No. 92343 in 1931, from Mexico) include no varietal characteristics of the seed pods. The variety that has been grown as an ornamental in South Florida for the longest time has blunt pods that are green with maroon bristles when immature; of more recent introduction is the very showy variety having point-

ed, scarlet pods with softer concolorous bristles. E. A. Menninger, of Stuart, catalogs, in addition to these, a yellow variety which he received from Kenya. O. W. Barrett reported in *Tropical Crops* in 1928 that there were in cultivation in Puerto Rico 5 varieties varying in the amount of coloring principle in the arils.

Propagation and Culture

The annatto may be propagated by seed, or by cuttings of mature wood placed directly in the field. Seedlings are planted out when 4 months old and, when set 12 to 15 feet apart, number 300 to 435 to the acre. In Malaya, they are spaced 18 to 20 feet apart. Twelve months after setting out they may be 10 feet high and beginning to bloom. In Africa, small plantings are often in the form of hedges or windbreaks. Judicious pruning will keep the trees shrubby and encourages flowering.

The tree thrives best in rich, loamy soil with adequate moisture but has been successfully cultivated in soil exhausted by coffee growing. Plantations generally receive no care other than weeding.

Hardiness, Diseases and Pests

The annatto can be grown wherever the climate is favorable to the sweet orange. It is sometimes injured by frost in South Florida; has been killed to the ground in Central Florida but readily sprouts again from the roots. The principal affliction observed in Florida is mildew which may kill young plants but can be controlled by spraying with Captan. New foliage frequently shows insect damage, though no specific pests have been reported.

Season, Harvesting and Yield

In South Florida, flowering usually occurs in September and October. There may be a second bloom in the spring. In Mexico, flowering takes place in November, with the fruit maturing in March and April. In the American tropics, the tree blooms three times a year. In Malaya, flowering and fruiting is almost continuous. The seed pods are ready for harvesting in eight months. They are cut from the plant when slightly immature, spread in the sun to dry until they split open, and then threshed or flailed to release the seeds, which are finally separated from the husks by sifting through screens and fanning.

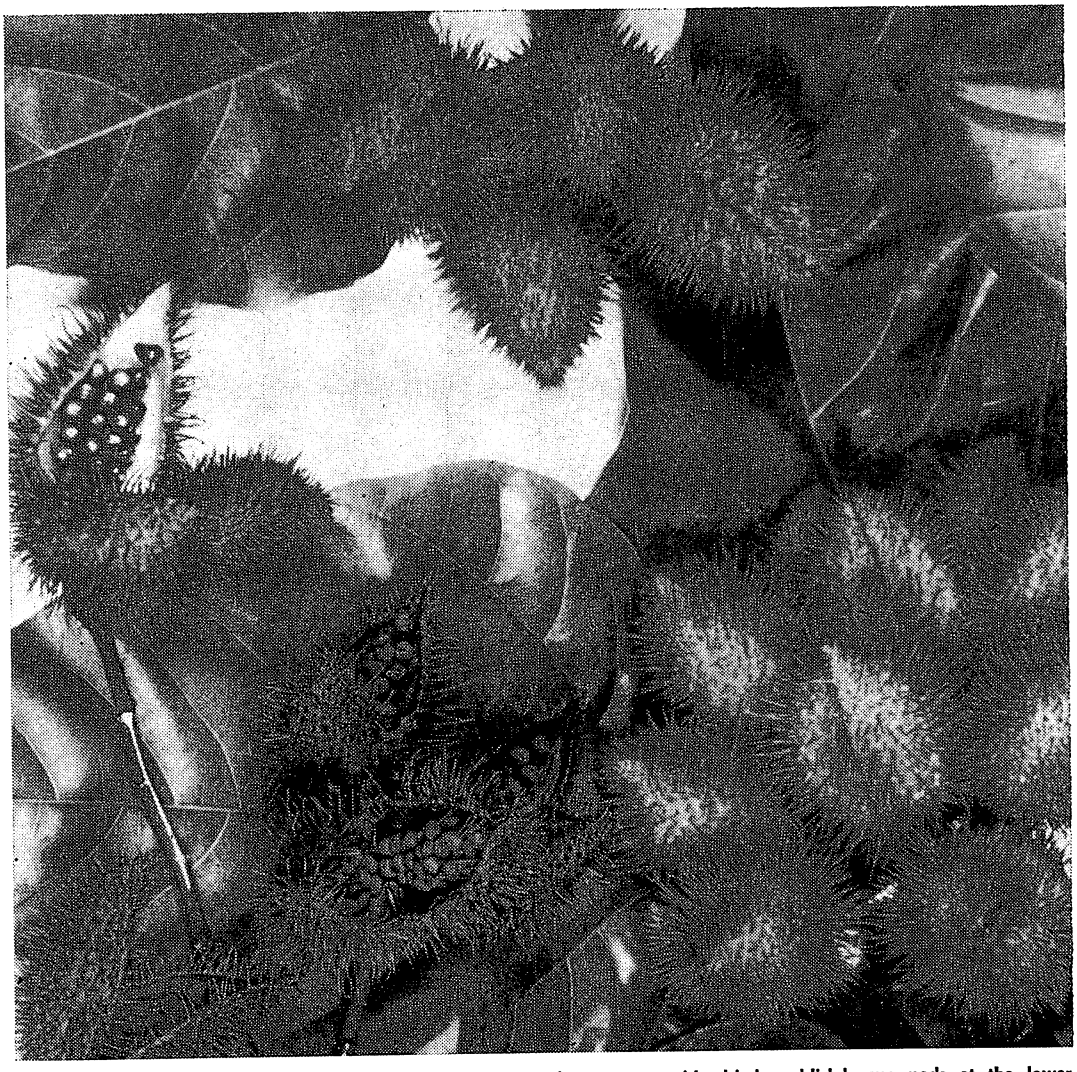
An annual yield of 11 to 13 lbs. of dried seeds per tree, or from 300 to 600 lbs. per acre may be anticipated according to the number of trees per acre and various factors affecting productivity.

Marketing and Processing

Large burlap sacks of dried seeds are commonly seen in native markets in tropical America and the West Indies. Small quantities of seeds in glass jars are sold in Latin American markets in northern cities. For home use, a few seeds may be fried in fat with which the coloring matter readily blends. The colored fat may be used to tint rice or may be added to gravies, stews or used for basting meats. Or the seeds may be placed in a wire sieve held over a kettle of cooked rice or other food and melted lard poured through to convey the coloring to the food, into which it is then stirred.

To obtain the coloring matter for the domestic market or export, the seeds may be merely put in hot water and allowed to soak for 2 days, when the water and seeds are strained off and the sediment recovered. The process may be hastened by crushing and boiling the seeds, straining them off and then continuing the cooking until the pulp is reduced to a paste. In some localities, the seeds are allowed to soak for a week but this invites fermentation and results in an unpleasant odor in the coloring matter. It was formerly a common practice to partially dry the sediment and press it into square cakes of 2 or 3 lbs., which were wrapped in banana leaves for shipment. In Brazil, it was, to some extent, prepared in small rolls of 3 oz. In Mexico, it is preferred to quickly and thoroughly dry the sediment and pulverize it to avoid undesirable odor. At one time, there was so much adulteration of locally prepared products that the demand shifted to dried seed from which the aril would be recovered by the importers.

The ultimate processor eliminates impurities from the cakes, bricks or rolls of pulp by treatment with alcohol, weak alkali carbonates, or other means. If he is handling the dried seeds, he may boil them in a sodium carbonate solution, filter, and then acidify the filtrate. The coloring matter may be coagulated by boiling with common salt, then filter-pressed, washed and dried. The refined dye is marketed in the form of powder, tablets, paste, or in solution. Pfizer Vegetable Color, formerly available, was an oil-soluble, microcrystalline annatto compound suspended in cottonseed



Showy, immature, pointed pods of the highly ornamental scarlet annatto, with dried, reddish-brown pods at the lower right. Photo by Julia Morton.

oil, and was designed especially for coloring margarine.

Powdered annatto is mixed with cornstarch in Cuba and sold in small folded paper packets labeled "Bijol".

Chemical Components

The coloring principle in annatto dye is bixin (C_{25} H_{30} O_4), insoluble in water, fairly soluble in chloroform, ethyl acetate and alcohol. Bixin usually constitutes 10 to 12% of annatto preparations but may be as high as 15 to 30%. Pure bixin may be extracted and formulated as a dye under various trade names. Annatto contains another component, orellin, which is a yellow substance soluble in water. In addition, there are some fat, resin and a bitter principle. It has been reported that annatto has a 3% content of a wax-like material that paralyzes intestinal parasites. The seeds contain a little fatty oil with palmitin, a small amount of stearin and phytosterol. There is a toxic property in the embryo. The aril has been definitely established as non-toxic.

Official and Folk Uses in Tropical Medicine

Annatto is widely employed in tropical

medicine, being regarded as haemostatic, astringent, antidysenteric, diuretic, aphrodisiac and an effective febrifuge, digestive and gentle purge. It is prescribed also for epilepsy, erysipelas and sundry skin diseases. The fresh pulp is immediately applied to burns to prevent blisters and scars. An ointment for this purpose may be prepared by frying one part of dried seeds in four parts of oil, or the seeds may be ground and boiled in oil, as is done in Uruguay. Annatto is considered an effective antidote for poisoning by bitter cassava (*Manihot esculenta* Crantz) and physic nut (*Jatropha curcas* L.), a decoction of 30 gr. of seeds in 1000 gr. of water being administered three times at 3-hour intervals.

In Central America and Mexico, it is believed that an oil pressed from the seeds may be useful in treating leprosy. In Caracas, a preparation derived from the twigs of the tree is given for diseases of the liver. The stems, when crushed and soaked in water yield a gum arabic that serves as an emollient. The gum like bark is employed in febrile catarrhs. In Cuba, an infusion of the roots in water is taken for nine consecutive days to alleviate attacks of asthma. The root bark is reportedly antiperiodic and antipyretic and highly regarded in treatment of fevers.

A decoction of the leaves is used as a gargle for sore throat; an infusion is given in jaundice, and as a purgative in cases of dysentery. A poultice of leaves is placed on the head to relieve headache and an infusion of the leaves is applied to the head to allay fevers. A decoction of annatto leaves, citrus leaves and indigo is given after childbirth. The leaves are also employed as an antidote for snakebite and have been found curative in experimental treatment of lepers. The leaves, pounded and then macerated in a little water, release a gummy substance that is diuretic and given in cases of gonorrhea, also administered as a purgative and to relieve inflammation.

Honey made by bees from the nectar of annatto flowers has a dark, reddish color and is thought to have medicinal value. Madagascans take an infusion of the leaves to give themselves courage before public speaking or dancing exhibitions. In Brazil, bulls are fed the seeds in the belief that the red pulp makes them more ferocious fighters in the arena.

Other Products and Uses

The bark of the annatto tree is commonly made into coarse twine; sometimes it is used for making cloth. The bark contains a small amount of dye; the roots, apparently more, for they are said to impart the color and flavor of saffron to meats. The wood is pinkish-yellow, soft, porous and of little use except for starting fire by friction, two pieces rubbed briskly together producing fire quickly.

Clusters of the fresh seed pods, especially of the crimson variety, are prized for floral arrangements, though they wilt in a short time. Dried pods, used similarly, last indefinitely.

Current Status

On May 24, 1955, Dr. R. S. Harris, Professor of Biochemistry of Nutrition, Department of Food Technology, Massachusetts Institute of Technology, stated in a letter to the writer: "One by one the coal tar dyes, which have long been certified by FDA for use as food colors, are being shown to be toxic. FDA Orange No. 1 and No. 2 and Red No. 32 are on the way out (see Federal Register, Dec. 10, 1954, pages 9352-3). Recently Yellow No. 2 was shown to be toxic (Fed. Proc. 14, 314, 1955). Others are under test. This is creating a demand for 'harmless' colors.

The British Committee on Food Colours recommended in 1954 that the coal tar colors Yellow 3 (or Yellow AB) and Yellow 4 (or Yellow OB) be prohibited in food. In the United States, these colors were, in 1959, pronounced unfit for use in food or in drugs taken internally, but were permissable dyes in products for external application. These moves inspired new comparative studies of the effects of coal tar and annatto colorants on butter, margarine and cheese in storage. While some of the older annatto products had previously been found unsatisfactory in this respect, producing red and other off-colors, and were used only in the cheaper brands, the improved solutions functioned as well as the synthetics.

The banning of seventeen coal tar colors used in cosmetics was temporarily in effect in the forepart of the current year but was later reversed, with the responsibility for proving harmlessness placed on the users of these colors in the cosmetic industry. On the possibility that some or all of these dyes might yet be rejected, a Miami chemist has begun experimental, small-scale manufacture of lipsticks colored with annatto instead of the customary coal tar dye, Red 32.

Red 32 has been commonly used to enhance the skins of Florida oranges, most of which cannot satisfactorily compete on the market without added color, even after exposure to ethylene gas. The Valencia orange does not reach its highest quality until a new crop is forming on the tree and at this time the maturing fruit may lose some of its orange color and develop splotches of green, or may re-green completely. Thus, the dyeing of the rind is essential to represent the fruit as mature, as it truly is. Red 32 can no longer be used for this purpose. Red 2 is permitted tentatively for a limited time. Extensive toxicity tests are under way to determine whether its use may be continued. If this color should be prohibited entirely, the citrus industry might turn again to annatto, which was used for coloring oranges long ago. Mr. H. J. Keller of Keller Sales and Engineering, Dunedin, Florida, working jointly with S. B. Penick & Co., manufacturing chemists, has obtained U. S. Patent No. 2,943,943 for the coloring of citrus fruit with *Anattene*, a newly developed annatto product, available in both water-soluble and oil-soluble, microcrystal, powder and liquid forms. While this material is more costly than the coal tar dyes, Mr. Keller reports that less of it is required to color the same amount of fruit, providing the greenness can first be sufficiently bleached. This last may be a difficult problem to overcome.

Annatto, or bixin extracted from it, is considerably less expensive than the blend of *alpha-* and *beta-*carotene from palm oil which is now supplanting coal tar colors in many products. Ample supplies of annatto seed are presently available from tropical America and other areas to meet present demand and production can readily be increased should there develop greater utilization.

There is some confusion as to Federal regulations relating to the employment of annatto as a food additive. According to the Federal Register of Feb. 27, 1960, annatto solids are limited to 35 parts per million. This proportion would not be sufficient for some purposes. Again, if annatto is extracted with alkaline potash solutions it is admissible, but if crystalline bixin is dissolved in caustic potash it is subject to restriction until tests prove there is no likelihood of acute or chronic toxicity.

The chief retarding factors, however, are the reluctance of the food, drug and cosmetic industries to abandon the advantages of the coal tar dyes and the consequent reluctance of dye manufacturers to invest too heavily in the development of annatto and bixin preparations and methods of application that might eventually make the use of these natural colorants more economically and practically feasible.

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THE MYSTERY OF THE MULGOBA

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The writer has long been puzzled by the almost complete absence of the Mulgoba mango from lists of superior varieties prepared by many different authorities in India. It is such a delicious fruit that it is hard to see why it should be so ignored when many varieties much inferior to it are listed and described. As the result of much searching of the literature and considerable contemplation, the conclusion has been reached that this variety may not be known in India except as imported from Florida.

The original shipment of Mulgoba trees (2) was made by G. Marshall Woodrow, who was then Professor of Horticulture at the Agricultural College, Poona, India. The description which was published in the report of Pomologist Van Deman in the 1889 Report of the Secretary of Agriculture reads as follows:

"Mulgoba—very large fruit, averaging about one pound. Skin greenish yellow, rarely with any blush."

One recognizes at once that this description does not fit the variety we know by that