characteristic of each individual system, for steam distillation and its specialized forms, such as deodorization and stripping. It is suggested that the principles involved are applicable to continuous or batch systems of any size.

A simple method of determining this optimum rate is described and illustrated with data from a commercial batch deodorizer.

It is proposed that, under optimum conditions:

a) the ratio of absolute pressure (P) to the blowing steam rate (R) is at a minimum;
b) total distillation is at a maximum;
c) the linear velocity of the vapor is at a maximum; and
d) entrainment is disproportionately high.

It is recognized that this technically optimum blowing steam rate may not coincide with the most economical conditions of operation, depending on the characteristics of the system.

It is concluded that operation at rates appreciably above the optimum can in no way be justified.

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REFERENCES

1. Bailey, A. E., "Industrial Oil and Fat Products," 2nd Ed., Interscience, New York City, 1951.
2. Moser, H. A., Jaeger, C. M., Cowan, J. C., and Dutton, H. J., J. Am. Oil Chem. Soc., *24*, 291 (1947).
3. Markley, K. S., "Soybeans and Soybean Products," Interscience, New York City, 1950.
4. Wolf, I. W., and Rushton, J. H., J. Am. Oil Chem. Soc., *30*, 147 (1953).
5. Bailey, A. E., Ind. Eng. Chem., *33*, 404 (1941).

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A New Source of Carotene: Palm Fiber Oil From Elaeis Guineensis

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FOR several years our laboratories have been very much interested in the study of extraction methods and the physical and chemical properties of carotene from palm oils which are produced in the French Overseas Territories, such as the Ivory Coast, Dahomey, and the Cameroons. Carotene is the ideal coloring agent for margarine. It is indeed the natural pigment of butter and moreover plays a specific role in the animal organism as provitamin A. Thus its superiority over coloring agents without vitaminic power is obvious (1). Carotene was discovered more than a century ago in carrots which still are, besides alfalfa, an important raw material for the industrial preparation of carotene. However carrots and alfalfa, are very poor sources of carotene as compared to African palm oil.

Furthermore a difference must be made among palm oils according to their origins. Oils produced in the Far East and most of the oils from the Belgian Congo contain about 0.05-0.06% of carotene,[1] while palm oils from the Ivory Coast, especially from Dahomey, contain as much as 0.1-0.16%.

Palm oil consumers prefer the lightest colored oils for soap and margarine manufacture in order to avoid the expensive and difficult bleaching treatment. Oil palm growers have thus been brought to select palm trees capable of producing high yields of light-colored oil. In French Africa palm oil is produced exclusively from natural wild palms, which are likely to produce highly colored oils. Especially in Dahomey climatic conditions are very favorable for the development of pigment. The oil yield per acre, in this last case, amounts to only one-third or one-fourth of the yields obtained on the estate plantations of Malaya, but this oil, strongly colored is an excellent material for the industrial production of carotene.

During our investigations we have been led to study the constitution of the oil which remains in the cakes of the fruit fibers. These fibrous oil cakes generally contain about 10% of glycerides. Because of their high cellulose and lignin content and their low percentage of protein, they have no food value for animal feeding. In Africa they are used for fuel. Thus they are an almost valueless by-product. When the oil is extracted by means of a suitable solvent, such as petroleum ether or chlorinated solvents, it is very highly colored.

TABLE I

Average Total Carotene Contents

Source	Mg./pound (estimated as beta-carotene)	
	Fresh	Dry
Carrots (4)	12	110
Sweet Potatoes (5)	14	64
Alfalfa (5)	28	118
Barley (5)	21	140
Clover (5)	....	153
Rye (5)	38	203
Sweet Clover (5)	15	89
Wheat (5)	20	118
Estate palm oil (Belgian Congo, Far East)	225	
Wild Palm Oil (Ivory Coast, Dahomey)	450- 800	
Estate Palm "fiber oil"	650-1,100	
Wild Palm "fiber oil"	1,300-2,200	

After numerous tests we have found that the carotene content of "fiber oil" from either wild or cultivated trees is much higher (about three to four times more) than it is in the corresponding "expression oil." For instance, from palm fruits from the Ivory Coast the expression oil has 0.1-0.14% of carotene while the corresponding "cake oil" or fiber oil generally shows a carotene content of 0.3-0.4% and sometimes even more. While the expression oils obtained from fruits from estates of the Belgian Congo or Malaya contain approximately 0.06% of carotene, the fiber oil shows a content of 0.15-0.25% (2).

By assay on young rats the biological value of the carotene containing concentrates from expression palm oil corresponds with the carotene content found by spectrophotometry (3). The absorption spectra of

[1] Total content of all isomers.

palm fiber oil and expression palm oil are quite similar so the carotene content and its biological value may be assumed to be the same. The carotene of palm oil contains about 60-65% of beta-carotene and 35-40% of alpha-carotene, besides a variable quantity of lycopene and gamma-carotene.

Table I shows the carotene content of the various sources including palm fiber oil.

Palm fibers represent important tonnages. In the oil mills of French Africa 800 to 1,000 tons of fibers remain after the production of 1,000 tons of expression oil. These contain 15% of water and 10% of oil. The new mills, in the Ivory Coast, Dahomey, and the Cameroons alone, have a potential yearly output of nearly 5 tons of carotene pigment. If the total available palm fibers were processed, the carotene thus produced would be an important asset to the food and pharmaceutical industries.

REFERENCES

1. Luckmann, F. H., Melnik, D., Vahlteich, H. W., J. Am. Oil Chem. Soc., *29*, 321 (1952).
2. Cuvier, P., and Servant, M., Compte rend., *233*, 1386 (1951).
3. Blaizot, J., and Blaizot, S., Oleagineux, *5*, 634 (1950).
4. Shearm, W. H. Jr., and Gee, O. F., Ind. Eng. Chem., *41*, 218 (1949).
5. Harper, R. H., and Zscheile, F. P., Food Res., *10*, 84 (1945).

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Tung Oil Review, 1951-1952

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DURING 1951 and 1952 more than 250 books, articles, and patents dealing with the chemistry and technology of tung oil and other tung products appeared in the technical and trade literature. The pertinent information culled from these numerous sources comprises this review.

General

The first comprehensive book on tung products, Fonrobert's "Das Holzöl" (70), was published in 1951. It covers the source, extraction, trade, properties, chemistry, testing, and uses of tung oil. A comprehensive "Abstract Bibliography of the Chemistry and Technology of Tung Products, 1875-1950" (160), which appeared in 1952, contains nearly 3,000 abstracts of articles and patents dealing with all phases of the tung industry.

Botany

Aleurites fordii, the tung oil tree grown in the United States, has been compared with *A. montana* and other related species grown abroad in regard to morphology of its parts, growth characteristics, and distribution (42, 54).

Culture of the Tung Tree

Recommended procedures for use in solving the numerous problems involved in tung culture are presented in Farmers' Bulletin No. 2031, "Tung Production" (168) by Potter and Crane, and in the new book "Successful Tung Farming" (27) by Beebe and Greer. For the farmer interested in establishing a tung orchard there appeared articles on land selection and preparation (59, 166), selection of planting stock (42, 141-2, 165), transplanting seedlings (5, 108, 149), and studies on plant growth (80, 150, 181), and diseases (32, 175). Numerous reports were published on fertilizing with balanced proportions of N, P, and K (58, 162, 183), with liquid ammonia (8, 73, 109, 118), with lime (56), and with the minor elements (57-8, 78, 127, 143, 179-80). Related to fertilizing are the articles published on leaf analysis (58, 148) and the practice of planting cover crops (117, 151, 167). Good farm management practices have been discussed (46, 59, 103, 117, 151, 164, 167) and measures for minimizing frost damage described (21, 155, 166, 183). Potter (163) reviewed 13 years of research on tung culture by the U. S. Department of Agriculture. Other writers have described tung production in Argentina (11, 12, 136), Brazil (9, 11, 136), Paraguay (136-7), Nyasaland (91, 107), Madagascar (33, 66, 82), Portuguese Africa (46), and still other countries (28, 36, 42, 172).

Tung Fruit

A mechanical harvester (picker) has been improved by Jezek (6, 26). Tung fruit have been analyzed, using a modified Hamilton-Gilbert method wherein the oil is extracted from ground fruit in a Waring Blendor (79). Fruit grown in the United States in 1951 was found to be abnormally low in oil content by 1-2% (169). This phenomenon was attributed to unfavorable weather conditions. For the determination of moisture in tung fruit, kernels, and hulls, the Seed and Meal Analysis Committee (134) of the American Oil Chemists' Society recommended that the forced-draft oven method (Ad 2-48) (17) be adopted as an official method. However Holmes *et al.* (100) considered drying in a vacuum oven to be the most accurate of the six methods they compared for determining moisture in tung fruit and seed. Moisture contents determined in the vacuum oven were found to be 0.4-0.8 percentage units higher than those measured in a forced-draft oven. The Seed and Meal Analysis Committee also recommended that present tentative methods (17) for sampling tung fruit and for determining oil in whole fruit and in kernels be made official methods. Equilibrium moisture contents at 25°C. were determined on tung fruit and its components at various relative humidities (99). Cutting (50) found that efficient drying of tung seed is a prerequisite for efficient oil expression. Detailed analyses for organic and inorganic constituents were made on tung fruit and press cake (101). McKinney (133) has reviewed work done at the U. S. Tung Oil Laboratories at Bogalusa, Louisiana (active) and at Gainesville, Florida, (closed) on drying, analysis, storage, pressing, and solvent extraction of tung fruit and on the composition and utilization of tung oil and its by-products, hulls and press cake. Medical reports have been published giving symptoms and treatment of people poisoned by eating tung fruit (22-4, 74). Hexane extraction of kernels to give shell-free meal for toxicity and detoxification studies was reported (145).

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